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A Review of DAO Governance: Recent Literature and Emerging Trends

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Abstract

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Keywords: Corporate governance, Decentralized autonomous organization (DAO), Blockchain, Smart contracts, Voting models, Conflicts of interest, Ownership concentration, Participation, Whales, Dual-class voting, Governance token, Vote-escrow token, Investor activism

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Decentralized autonomous organizations (DAOs) have emerged as a new organizational structure that leverages smart contracts and blockchain technology. Academics and practitioners have paid significant attention to DAOs, yet DAO decision-making processes and the broader implications remain under-studied. This paper aims to fill this gap in the literature. First, we compare the proposal- and voting-based governance mechanisms of DAOs with those of traditional corporate governance. Second, we introduce various novel voting models adopted by DAOs. Third, we discuss DAOs' drawbacks and highlight a unique agency problem arising from large token holders, termed "whales," within these organizations. The concentrated ownership such whales, whose interests may diverge from those of smaller token holders (i.e., users), obtain can result in governance vulnerabilities. After discussing recent instances of investor activism and contentious votes involving DAOs, we conclude by surveying the literature on the optimal DAO design.

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1. Introduction

Decentralized autonomous organizations (DAOs) have emerged as a new model of governance in the digital age, fundamentally altering how organizations are created, managed, and operated. DAOs leverage blockchain technology to facilitate a collective decision-making process, the governance rules of which are encoded into smart contracts, reducing the need for intermediaries and making management more transparent and self-executing (Harvey, 2016; Yermack, 2017; Cong and He, 2019).

DAOs provide a range of governance advantages over traditional corporations. First, DAOs enable users to exert greater direct control while reducing reliance on agents such as managers and directors, mitigating agency conflicts. Second, DAOs can reduce information asymmetry by enhancing transparency. Under a DAO, all transactions, modifications, and audits appear on the blockchain immediately, discouraging individuals from concealing fraudulent transactions and illicit activity in general. Third, DAOs also enhance efficiency as they allow for ongoing proposal submissions and community engagement—the feedback loop between governance and community sentiment can produce more effective decision-making (e.g., improving proposal quality). By eliminating intermediaries from traditional proxy voting, blockchain-based voting systems can also address inefficiencies that Kahan and Rock (2008) call "pathologies," including uncounted or unverified votes, confusion regarding who owns lent shares, over-voting, and misalignment of voting rights and economic interests.[1]

Token-based voting systems employed by most DAOs are, however, no panacea. Although the DAO organizational structure in part mitigates principal–agent problems that are common in traditional corporations, DAOs cannot avoid another fundamental trade-off with which traditional firms must contend: conflicts of interest involving large token holders, or "whales," and small token holders (i.e., users). As conceived in traditional finance, whales are individuals or institutions that wield market power thanks to their substantial holdings. Leveraging their large holdings, whales can sway votes in favored directions while dispersion prevents small token holders from doing so individually. Therefore, through open-market trading in governance tokens, whales can potentially accumulate sufficient voting power to

[1] The traditional proxy system consists of intermediaries such as custodians, broker-dealers, banks, transfer agents, proxy service providers, proxy advisory firms, proxy solicitors, and vote tabulators (SEC, 2010) that form a complex system. This web of intermediaries often generate inaccuracies and inefficiencies (Kahan and Rock, 2008; Jiang and Li, 2024).

manipulate votes. The ensuing governance attacks can yield short-term gains at the expense of minority token holders (Han, Lee, and Li, 2023). Such conflicts, coupled with blurred lines between users and owners, call for innovative voting models, such as quadratic voting and conviction voting, within the DAO ecosystem as a means of addressing the shortcomings of traditional "one share, one vote" models.[2]

We emphasize that a critical aspect of DAO governance is often misunderstood: the notion that these organizations are entirely decentralized and free from oversight. In practice, many DAOs operate within complex webs of associated entities, such as Uniswap Labs behind the Uniswap DAO, which significantly influences operations without direct input from a DAO itself. Off-chain governance solutions, such as Snapshot, still need trusted parties to verify votes and implement proposed on-chain changes. In other words, while DAOs aspire to decentralization, they often rely on centralized bodies when making critical decisions and developing protocols (Makarov and Schoar, 2022).

This paper provides a comprehensive overview of DAOs, focusing on their creation, proposal and voting processes, and governance vulnerabilities, and conducts a comparative analysis of major voting mechanisms and their implications, paving the way for future research in this rapidly evolving domain. Through these discussions, we offer both practical and theoretical perspectives on DAO governance, highlighting key distinctions between this emerging organizational structure and traditional corporations. In so doing, we contribute to a broader and deeper understanding of both the extensive and intensive margins for adopting a DAO as a new organizational structure.

2. An Overview of DAOs

2.1 How DAOs are created

Many DAOs are launched by existing platforms. For example, in September 2020 Uniswap, a leading decentralized exchange, "airdropped" UNI, its governance token, to more than 250,000 addresses that had previously interacted with the protocol. The Uniswap DAO was born shortly after this event, with the DAO representing the ownership of Uniswap's smart

[2] In addition to governance issues, DAOs also face a number of challenges, including a lack of legal status and the potential for unlimited liability as well as security-law non-compliance. See Weinstein, Lofchie, and Schwartz (2022) and Jiang and Li (2024) for details.

contracts (once deployed). Similarly, Bancor, the first-ever automated market maker (AMM), established a DAO in the second half of 2020 after administering an airdrop earlier that year. Among BancorDAO's first votes were those on the issuance of the Bancor Network Token (BNT) to fund BNT staking rewards (i.e., BNT "liquidity mining") and the BNT inflation rate.

Since 2017, a number of platforms that enable users to create, customize, and govern their own DAOs have arisen, with Aragon, DAOstake, and XDAO among the most popular. In addition to designing the "tokenomics," such as a revenue model and token distribution for a DAO, a key step is to specify the governance structure. This includes choosing a voting mechanism (the classic "one token, one vote" model or an alternative mechanism), establishing member roles and responsibilities, and defining quorum requirements.[3]

We emphasize a common misconception according to which platforms utilizing DAOs are fully decentralized and there are no agents managing these DAOs. On the contrary, many such platforms use somewhat complex organizational structures that extend beyond the DAOs themselves. For example, major Uniswap updates, such as Uniswap V3 and UniswapX, were not proposed, voted on, or developed by the Uniswap DAO. Instead, they were developed mainly by Uniswap Labs, a company that generates revenue based on user transactions, with the Delaware non-profit organization Uniswap Foundation supporting the developer community. The Uniswap DAO operates independently of both Uniswap Labs and the Uniswap Foundation.

Centralized human agents might still play a role in DAOs, as they generally do not involve transitioning to entirely decentralized human-free structures. Certain decisions—in particular those requiring specialized technical expertise, rapid execution, or regulatory accountability—might bypass DAO governance for the sake of practicality and efficiency. Second, legal complexities may arise that are challenging to address without human involvement. Third, the presence of human agents can facilitate interactions with the off-chain world. For instance, centralized entities like Uniswap Labs can act more decisively in areas where a DAO's decentralized structure might struggle to respond effectively or align with long-term strategic goals.

2.2 DAOs' governance process

[3] See https://docs.xdao.app/guides-for-gt/create-a-dao for the steps involved in creating a DAO using XDAO.

A DAO is typically governed through a process of developing and advancing proposals that implement changes to the DAO. At a high level, this process is similar to the corporate proxy voting process during which stockholders vote on management- and shareholder-sponsored proposals at shareholder meetings (SEC, 2010; Bolton et al., 2020; Giannetti and Gantchev, 2021). Corporate bylaws usually require firms to hold annual meetings, during which stockholders vote on director elections, attend to executive compensation, and entertain governance and shareholder proposals. Special meetings are also held when directed by a board of directors or when requested in writing by significant shareholders with voting rights. For DAOs, however, there are no annual or special meetings. Rather, users sponsor proposals throughout the year, and token holders can vote on those proposals during predetermined periods. In this section, we describe DAOs' proposal and voting processes and compare them with those typical of traditional corporations.

2.2.1 The proposal process

To better understand the proposal process with DAOs, we first briefly discuss the parallel process at corporations. In the traditional corporate setting, in addition to management proposals, such as director elections, qualifying shareholders can submit proposals to be included in proxy statements and voted on at shareholder meetings. To qualify, a shareholder must have owned some voting shares and must submit a proposal 120 days before the annual meeting of a U.S. company.[4] The proposer must also hold her shares until after the shareholder meeting. Importantly, a proposal cannot exceed 500 words and generally must take the form of a precatory petition to a firm's board of directors. In addition, proposals cannot touch on ordinary business matters. Once a firm receives a shareholder proposal, it can choose to include the proposal in its proxy materials, work with the proposer to arrive at a mutual agreement (which may include withdrawing the proposal), or submit a no-action request to the Securities and Exchange Commission (SEC) to exclude the proposal from the company's proxy statement if the proposal is deemed to fall outside the rules governing shareholder proposals. Shareholder proposals are usually non-binding, which means that shareholders cannot force a board to implement passed proposals, while management proposals are binding except for advisory votes on executive compensation (i.e., "Say-on-Pay" proposals).

[4] Qualifying shareholders must own $2,000 of the company's stock for at least three years, $15,000 of the company's stock for at least two years, or $25,000 of the company's stock for at least one year.

In contrast, there is currently no regulatory framework that governs the proposal process for DAOs. Most DAOs do not feature management or boards, so there is no concept of management proposals. Rather, DAO users submit proposals to be voted on by other users. Broadly speaking, most DAOs have adopted a two-step process.[5] In the first step a user publishes a new proposal on the protocol's governance forum, often a Discourse page or a Discord server. Before the proposal can move to the voting stage, the proposal must be available for review by the community for a period of time, the length of which depends on the protocol. Other users will provide community feedback under the proposal, which is dubbed a "temperature check." The sponsor often is under no obligation to incorporate proposed changes. After the review period, the sponsor can create a formal proposal either on-chain or off-chain, depending on the protocol (see Section 2.2.4 for additional details regarding the trade-offs between on-chain and off-chain voting). Some DAOs require a minimum number of governance tokens to create proposals (e.g., a minimum of 2.5 million UNI for Uniswap and 25,000 vBNT for Bancor). With the necessary stake, the sponsor initiates the voting process essentially unassisted.

While the above description of a two-step process is a useful generalization, some DAOs require additional steps. A case in point is Ethereum Name Service (ENS), a decentralized domain-name system that translates blockchain wallet addresses into human-readable names. First, a proposer can pose a general question to the community on the ENS governance forum about a potential change. Second, if the proposer decides to proceed, she needs to create a draft proposal in the governance repository on GitHub, which also establishes a formal discussion of the proposal. Third, once the proposer flags her proposal on GitHub as "ready for review," a "contributor" who receives compensation for her work will check to confirm whether the proposal meets ENS's requirements and if so schedule the proposal for an off-chain vote via Snapshot. Snapshot, used by 96% of DAOs, is a voting platform that allows DAO members to vote without paying gas fees (Nijkerk, 2024).[6] Fourth, a proposer must submit an "executable proposal," which involves making changes to smart contracts, such as upgrading an ENS core contract, to ENS's "governor" contract for voting on-chain *after*

[5] Some DAOs utilize a more complex proposal process, such as the system used by Uniswap. For more details, see Uniswap's governance documentation via https://docs.uniswap.org/concepts/governance/process.

[6] "Gas fees" are paid for executing transactions or smart contracts on a blockchain, where "gas" denotes a unit of measure for the effort involved in executing transactions or contractual operations.

passing a Snapshot vote.[7]

Shareholders' voting options vary depending on what is up for a vote and the associated voting standards. For management-sponsored proposals, including director elections that apply majority voting standards, and shareholder-sponsored proposals, shareholders can vote "for," "against," or "abstain." When voting for directors with plurality voting, they can choose between only "for" and "withhold." Although token holders can vote "for," "against," or "abstain" on most proposals, some proposals entail additional choices.[8] For example, in early September 2021 a user of Aave, a leading decentralized lending platform, sponsored a proposal, titled "What should be the LTV/Liquidation Threshold level for Aave V2?," which gives token holders four choices: Aggressive, Moderate, Conservative, or Abstain.

2.2.2 The voting process

Corporate bylaws generally define a quorum as a majority of voting shares, represented in person or by proxy, at shareholder meetings. A quorum is needed to pass proposals. For DAOs, the governance documentation also specifies quorum requirements. Reflecting voter apathy, participation in DAO voting is generally limited and on par with retail proxy voting (Laturnus, 2023; Brav, Cain, and Zytnick, 2022), so quorum thresholds typically are lower or do not exist.[9] When a quorum is required, it often varies across proposal types for the same DAO. For example, the quorum for Bancor's proposals related to pool fees is 20% while it is 35% for governance proposals and those on token emissions/inflation. For MakerDAO, however, a decentralized lending protocol that powers the DAI stablecoin, no quorum is required to pass a vote. According to MakerDAO (2018), "the lack of [a] quorum implicitly incentivizes all MKR token holders to be involved."[10]

For shareholder voting, only shares owned as of a record date are entitled to vote.

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[7] To submit an executable proposal, a proposer must ensure that at least 100,000 ENS tokens are delegated to her address or find a delegate who has sufficiently many delegated ENS tokens to sponsor the proposal. The *propose()* function of the ENS governor (at governor.ensdao.eth) needs to be called to deploy the proposal. A Governor smart contract, which currently accounts for most on-chain voting activities, enables a DAO's token holders to exercise full control over on-chain voting. Token holders use Governor to make, pass, and execute proposals. For additional details on ENS's governance process, see https://docs.ens.domains/dao/governance/process.

[8] Snapshot and many on-chain voting mechanisms enable users to adopt alternative voting schemes. Snapshot also allows users to request a new voting scheme if it does not already feature it. See https://docs.snapshot.org/user-guides/proposals/voting-types for additional details.

[9] It is often challenging to pinpoint an appropriate quorum. Requiring more members to vote may mean that the majority of proposals fail because of low participation. However, setting a low quorum runs the risk that bad practices occur and makes passing a proposal extremely easy, which could result in development of a DAO in the wrong direction.

[10] MKR refers to MakerDAO's governance token.

Shareholders of record can vote any time through a meeting date by proxy or in person on the meeting date. Inasmuch as proposals for DAOs are not technically voted on at "token-holder meetings," the concept of a record date does not apply to DAOs. Instead, DAOs specify a start date/time and end date/time for each proposal. Token holders' voting power is typically determined at the creation of a proposal, which also applies to delegated voting,[11] with many protocols requiring token holders to own a minimum number of tokens to cast valid votes. This arrangement purportedly prevents double voting (e.g., Alice sending 10 tokens to Bob for him to vote after voting them first herself) and other vote rigging schemes. The voting start date is usually set shortly after proposal creation.

Shareholders are allowed to change their votes at any time before or on a meeting date. Many DAOs, including MakerDAO and Aragon, the latter of which enables developers to build and manage DAOs, also allow users to "revote" their tokens on a proposal by revoking their original votes. Shareholders do not observe an aggregate voting outcome until after a shareholder meeting concludes or after individual institutions report their voting records.[12] Blockchain-based voting is, however, transparent—for both on-chain and off-chain voting, individual token holders' votes are observable in real time.[13] This feature may motivate certain whales to influence a vote either early in the process or at the last minute (see Deshpande (2024) for discussion of a last-minute surge in votes for a proposal targeting Compound, a major lending protocol).

2.2.3 Post-voting implementation

When on-chain voting ends, a smart contract verifies the voting outcome before automatically executing the proposed protocol update(s) if a proposal passes. A "timelock delay" between vote conclusion and execution often occurs, preventing the proposal from being executed immediately. Most successfully passed proposals experience a short delay of up to

[11] Delegated voting, which is also called "liquid democracy," allows voters to delegate their voting power to a trusted party, enabling those without the time or expertise nevertheless to influence decisions. Such a voting method increases participation, leverages expertise, and offers flexibility, enabling adaptation to changing circumstances and member preferences. See https://blog.colony.io/delegated-voting-empowering-decentralized-decision-making for further discussion of delegated voting.

[12] Each year, mutual funds and other registered management investment companies are required to disclose their complete proxy voting records by August 31, covering the period from July 1 in the previous year to June 30. Beginning August 2024, institutional investment managers that file on Form 13F must also make public filings on Form N-PX to report their proxy voting records for certain executive-compensation matters.

[13] A small number of DAOs employ a confidential token to keep token quantities and individual votes secret. See https://www.zama.ai/post/confidential-dao-voting-using-homomorphic-encryption for details.

several days, but proposals that involve updating core contracts can be delayed seven days or longer. These delays presumably enable a platform's development team to adopt emergency measures, including nullifying a vote, to address security concerns caused by malicious proposals. Figure 1 illustrates the governance process for on-chain voting.

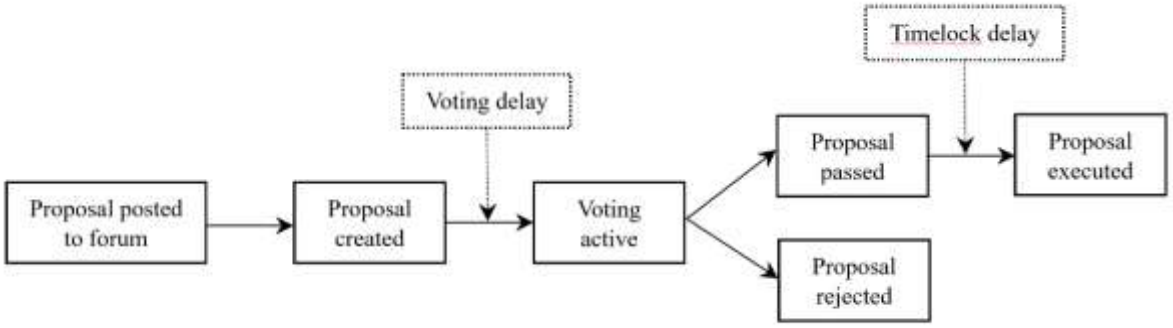

Figure 1: A typical governance process for on-chain voting

Proposals passed off-chain, such as those facilitated by Snapshot, generally involve no on-chain, binding execution. For votes on low-stakes topics, voters need to trust that the core team, which typically consists of a group of developers, technical leads, or trusted contributors to a DAO (e.g., Uniswap Labs), will implement the changes. Relatively important proposals often use a multisig setup, with elected representatives or a predetermined core team acting as multisig signatories who will execute the proposed changes.[14] As an emergency measure against malicious proposals, however, multisig signatories can ultimately choose not to enact voting results.

2.2.4 Trade-offs between on-chain and off-chain governance

As mentioned above, votes can be cast either on-chain or off-chain. The main advantage of on-chain governance is that it utilizes an integrated voting system for managing and implementing changes to DAO protocols, obviating the need for a trusted third party (e.g., a core team) to enact voting results. In contrast, for off-chain governance solutions, such as Snapshot, a trusted third party is still needed to accurately count the votes and enact the results

[14] A multisig, or multi-signature, setup is a blockchain process that requires multiple private keys to execute a transaction. Multisig transactions provide greater security than single-signature transactions. Balancer, a decentralized exchange and portfolio management tool, is an example that uses a multisig setup for post-voting execution; see https://docs.balancer.fi/concepts/governance/process.html.

on-chain using administrator privileges. Therefore, on-chain governance is generally more highly decentralized and secure than off-chain voting.[15] On-chain voting incurs gas costs, however, as individual votes are submitted as transactions and recorded on the blockchain. During periods of high network traffic, blockchain gas fees can spike. For example, Li, Shin, and Wang (2018) estimate that the average gas fee for transactions taking place on the Ethereum blockchain was about $10 in 2021. Off-chain governance, however, is gas-free, which has attracted many DAOs to switch to off-chain voting. For example, Bancor transitioned to "gasless" voting via Snapshot in March 2021, before which voting was conducted on-chain and cost money.[16] Snapshot determines a token holder's voting power when a proposal is created.

As gas fees on Layer-2 chains, which are secondary protocols built on top of a blockchain (known as a Layer-1 network) to enhance scalability and efficiency, have become significantly cheaper,[17] the importance of Snapshot and other centralized off-chain solutions might diminish for some DAOs.[18] While Snapshot's ability to offer gas-free voting remains appealing for low-stakes proposals, the reduced cost of on-chain transactions could encourage DAOs to shift towards fully on-chain governance, ensuring greater security and decentralization without the financial burden of gas fees. Indeed, an increasing number of DAOs have adopted hybrid governance models, using off-chain solutions like Snapshot for community feedback and low-stakes voting, while reserving on-chain voting for major, binding decisions. An example is the ENS DAO, which we have detailed above in Section 2.2.1.

2.2.5 Governance vulnerabilities

DAOs can be vulnerable to governance attacks or takeovers, in which an entity acquires sufficient voting power or influences sufficiently many token holders to ram through proposals that serve their private interests, often gaming the permissionless and tradable nature

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[15] When using off-chain voting platforms like Snapshot, users are prompted to sign messages with their wallets to vote. The resulting data are stored via a decentralized file-storage system, such as the Interplanetary File System (IPFS) or Arweave, which reduces the risk of vote tampering.

[16] For details about the proposal for this transition, see https://gov.bancor.network/t/bip12-gasless-voting-via-snapshot/1017/19.

[17] See, for example, https://www.coindesk.com/markets/2024/03/14/layer-2-blockchains-become-cheaper-after-ethereums-dencun-upgrade.

[18] Recognizing the growth potential in the on-chain voting market, Snapshot Labs unveiled a new on-chain governance protocol, Snapshot X, in September 2024. Snapshot X verifies token balances across chains, which allows users to vote tokens held on a Layer-1 network on a Layer-2 chain. This method is cost-efficient because users no longer need to hire third parties to move their tokens between chains. For additional details, see https://snapshot.mirror.xyz/F0wSmh8LROHhLYGQ7VG6VEG1_L8_IQk8eC9U7gFwep0.

of governance tokens. Feichtinger et al. (2024) attempt to classify various governance attacks into several categories, including vote buying, bribing, and exploiting code vulnerabilities.

Vote buying is a broad category that includes cases in which malicious parties amass a large number of voting tokens through open-market purchases, collateralized loans, flash loans, or "Sybil" attacks, with flash loans and Sybil attacks representing relatively novel methods for gaining control. Flash loans are uncollateralized loans that are approved, executed, and paid back all in one transaction (see Lehar and Parlour (2022) for details on flash loans), while Sybil attacks involve the creation of multiple fake identities, commonly known as "Sybils," to gain voting control of a DAO. In 2022, for example, a whale used a flash loan worth $1 billion to gain a 67% voting stake in Beanstalk, a decentralized stablecoin protocol, and passed a malicious proposal to drain $182 million in crypto assets from Beanstalk's asset pools (see Jiang and Li (2024) for additional details).[19] In 2020, the Ethereum Classic blockchain was repeatedly struck by a Sybil attack that resulted in multiple block reorganizations and millions in stolen funds (Chainlink, 2024).

It is worth emphasizing that, because off-chain voting systems do not involve direct transactions on the blockchain, they are potentially less vulnerable to flash loan attacks. Such attacks, however, could still target off-chain systems such as Snapshot. Because Snapshot determines voting power based on a snapshot of token balances at a specific block height, if the snapshot aligns with the block where the attacker holds the borrowed tokens, the attack would still be successful.

In a bribing attack, an attacker pays token holders or delegates to pass a malicious proposal, which can be performed either off-chain (the old-fashioned way) or on-chain through smart contracts (Buterin, 2021). Daian et al. (2018) introduce a smart-contract-based bribing protocol: a Dark DAO. To receive a bribe, a voter deposits her voting tokens on the Dark DAO, which allows the protocol operator to vote the tokens and pay the voter a one-time fee. While there are no known cases of active Dark DAOs at the time of writing, they have been studied theoretically by Austgen et al. (2023).

The third type of governance attack occurs when attackers exploit existing loopholes

[19] See Qin et al. (2021) and Lehar and Parlour (2022) for the basic workings of flash-loan attacks. Another high-profile flash loan attack involved the team behind Bancor, which used a $7 million flash loan to acquire 13,000 MKR tokens to vote on MakerDAO, enabling Bancor to accelerate election results for a project built on MakerDAO. For details, see https://www.coindesk.com/tech/2020/10/29/flash-loans-have-made-their-way-to-manipulating-protocol-elections. Qin et al. (2021) show that most major flash-loan incidents have involved DAOs.

in a DAO's smart contracts, a tactic that enabled an entity in 2016 to repeatedly withdraw Ether from The DAO, one of the first DAOs (Pratap, 2022). The hack was so severe that it led to a highly controversial hard fork of the Ethereum blockchain.[20] The majority of the Ethereum community decided to fork the chain to undo the hack's damages. The unaltered version of the chain continues to operate as Ethereum Classic. Ma et al. (2024) find that more than 600 DAO governance contracts include privileged functions that can be manipulated by developers.

3. DAO Governance

3.1 Voting models

In traditional corporate governance, a key issue is the allocation of voting rights to shareholders (e.g., Shleifer and Vishny, 1986; Grossman and Hart, 1980). Decision-making authority is often linked to financial stakes, with the "one share, one vote" principle a common approach. In this system, shareholders' influence is proportional to the number of shares they hold. Aligning voting power with ownership can enhance a firm's value by aligning the interests of investors with those of the organization (e.g., Grossman and Hart, 1988; Harris and Raviv, 1988). This principle is frequently violated in practice, however, as firms may opt for alternative mechanisms, such as dual-class shares and complex ownership pyramids (see, for example, Burkart and Lee (2008) for a survey).

DAOs share certain similarities with traditional corporate governance, often adopting token-based voting systems (e.g., "one token, one vote") that mirror the "one share, one vote" approach in the corporate world, but they differ fundamentally from traditional organizations (Han, Lee, and Li, 2023). First, the autonomous nature of DAOs obviates the need for an overseeing agent, reducing principal–agent conflicts (Hsieh and Vergne, 2023). Second, in DAO governance the traditional distinction between users and shareholders blurs, and this, combined with the network externalities of user participation, has significant implications for DAO value. These critical differences necessitate the adoption of distinct approaches to DAO governance in both theory and practice. In this subsection we introduce a variety of new voting models that DAOs use that are not present in traditional corporate governance.

[20] A hard fork splits a blockchain network into two separate chains, with the new blockchain sharing all of its history with the original one but following new rules.

3.1.1 Types of voting models

Most DAOs employ token-based voting models, where a participant's voting power scales with the number of tokens they hold. For instance, Uniswap's governance system grants users with relatively larger numbers of UNI tokens a stronger voice in decisions such as protocol upgrades and treasury allocations. This basic token-based voting structure, in its pure form, mirrors traditional corporate voting mechanisms, following the "one share, one vote" principle, which aligns voting power with financial investments and incentivizes active participation. There are also many variations of token-voting models that incorporate additional features.

Quadratic voting allows voters to express the intensity of their preferences by raising the cost of votes quadratically with the number of votes purchased, addressing problems associated with the tyranny of the majority (see, for example, Posner and Weyl, 2014; Ober, 2017). As a result, quadratic voting reduces the influence of large token holders, fostering purer democratic decision-making by allowing individuals to reflect the strengths of their preferences. This method has been implemented in projects such as Gitcoin (Benhaim, Falk, and Tsoukalas, 2023a).

Conviction voting systems, such as those used by Aragon, provide a way to signal support for proposals over time (Han, Lee and Li, 2023). With this model, participants can commit their tokens to a proposal for an extended duration, with their voting power growing the longer they maintain their commitments. This encourages sustained support for initiatives and enables better-informed decision-making, as participants weigh their choices thoughtfully.

The tenure-based voting model allows token holders to exercise voting rights based on the duration of their token ownership or lock-up period. This model gained prominence in 2020 when Curve Finance introduced the vote-escrow (veCRV) system. On Curve, users can lock their governance tokens (CRV), with both voting power and staking rewards increasing in proportion to the lock-up period. Tenure-based voting in DAOs resembles tenure-based voting systems and Loyalty Shares (L-shares) in the stock-market setting (see Edelman et al., 2018; Bolton and Samama, 2013).

With reputation-based voting, votes are weighted according to a voter's reputation or credibility. This method is designed to improve decision-making quality across contexts, including online platforms, governance, and collaborative projects. For instance, MolochDAO

employs reputation-based voting to guide funding decisions.

With contribution-based voting, voting power is allocated based on participant contributions. This approach was designed to incentivize active participation and ensure that those who have invested considerable time, effort, or resources in a project or community have greater influence on decision-making. For instance, Aragon and DAOstack utilize this system to empower their members by weighting votes according to their contributions to the organization, fostering a culture of engagement and accountability. Gitcoin DAO rewards contributors based on their previous contributions, granting them more significant influence over project funding and governance.

3.1.2 Dual-class voting models

Dual-class models in traditional corporate governance are typically designed to maintain control within a specific group, often founders or long-term investors, while still providing voting rights to other shareholders. This structure can provide stability and a long-term vision, unlike the "one share, one vote" system, which can encourage short-term decision-making (e.g., Bushee, 1998; Kahan and Rock, 2007). Thus, incumbent management can protect shareholders from harm with a relatively small equity stake (Alchian and Demsetz, 1972; Partch, 1987; Anderson and Reeb, 2003).

In the context of DAOs, dual-class voting structures—where distinct types of tokens or assets confer distinct voting rights—are designed to strike a balance between broad participation and concentrated control among stakeholders (Han, Lee, and Li, 2023; Fritsch, Müller, and Wattenhofer, 2024). Many DAOs adopt a structure similar to a dual-class system, where a native token operates alongside a staking or vote-escrow token, but the two do not carry equal voting power (as they would with tenured-based voting). This imbalance enables platforms to encourage longer-term commitments or higher staking by granting greater voting influence to those who lock their tokens for extended periods. Using dual-class models with varying voting-power conversions, platforms can prevent short-term or speculative investors from dominating votes, allowing them to balance the influence between small and large token holders.

Such a dual-class voting model, while providing flexibility, also raises concerns regarding the fair distribution of voting power among stakeholders, particularly when large holders (whales) wield disproportionate influence over governance decisions. Evidence from

traditional corporations indicates that managers with greater voting rights often become entrenched, potentially prioritizing their private interests over shareholder value (Gompers, Ishii, and Metrick, 2010). This suggests a risk that similar dynamics could arise within DAO governance structures, where power imbalances might undermine a broader community's interests. In the following subsection, we explore this issue in greater depth.

3.2 Digital democracy and its challenges

3.2.1 Ownership concentration and governance participation

In DAOs, investor participation plays a crucial role in shaping governance and decision-making processes. The distribution of voting power often raises challenges, however, particularly when balancing the interests of small token holders and large stakeholders (whales). This issue is closely tied to voting-model design, where power distribution heavily impacts governance engagement and outcomes. For example, the issue of ownership concentration is evident in high-stakes incidents such as the "Curve Wars," where DeFi protocols competed to accumulate voting power and influence how Curve Finance's liquidity incentives were distributed. As the Curve Wars intensified, major stakeholders such as Yearn Finance, StakeDAO, and Convex Finance locked up CRV tokens to maximize their veCRV holdings and attempted to dominate Curve's governance. These events exemplify how large token holders, such as DeFi protocols, can engage in "excessive governance" by seeking to seize control of a DAO for their own benefit.

Berle and Means (1932) suggest that, in traditional corporate structures, dispersed ownership reduces the incentive to monitor management because shareholder votes are not likely to be pivotal. Such shareholder apathy may harm firm value. That is, an "alignment effect" occurs when concentrated ownership aligns the interests of management and shareholders, fostering a positive relationship between ownership concentration and operating performance. There is also, however, an "entrenchment effect," whereby concentrated ownership can entrench management, making it difficult to challenge managers through proxy fights or takeovers, resulting in a negative relationship between ownership concentration and operating performance.[21]

[21] There is well-documented evidence of insiders' exploiting their advantages in highly contested voting events.

A large body of empirical literature examines the relationship between ownership concentration and operating performance (see Edmans and Holderness (2017) and Dasgupta et al. (2021) for a survey of the literature). For example, Morck, Shleifer, and Vishny (1988) find a nonlinear relationship, where performance, as measured by Tobin's q, initially improves with insider ownership as a result of the alignment effect but then worsens as insider ownership grows further through the entrenchment effect. When insider ownership becomes sufficiently large, however, performance improves again. In contrast, other studies, such as Gugler, Mueller, and Yurtoglu (2008), find only the first component of this relationship, describing an inverse U-shape between ownership concentration and firm performance.

Surprisingly, ownership appears to be quite concentrated in most DAOs. According to Appel and Grennan (2023), the average Herfindahl-Hirschman Index (HHI) across all DAO categories exceeds 0.29, a high score. The top three token-holder addresses on average control more than 67% of voting power. Such a high concentration of voting power is consistent with what Han et al. (2023) find: 179 major DAOs are characterized by an average HHI of 0.29 and an average top-three ownership of 67%. For a large sample of DAOs, Laturnus (2023) finds similarly that the average (median) Gini coefficient for token ownership is 0.39 (0.47), indicating high ownership concentration.[22] Still the ownership structure has become more diversified (decentralized) in the average DAO over time. In addition, Goldberg and Schär (2023), Feichtinger et al. (2023), Fritsch et al. (2024), and Sun et al. (2024) show high voting power concentration in several large DAOs.

Consistent with the entrenchment effect, Han et al. (2023) find that concentrated ownership of tokens has a negative effect on the growth of DAO platforms. Makridis et al. (2023) show that increased decentralization through airdrops, which distribute free governance tokens to community members, is positively associated with growth in token valuation and trading volume.

Such high ownership concentration is likely to marginalize the voices of smaller token holders and discourage them from participating in governance activities. Indeed, low participation rates are common among DAOs. With regard to a typical vote conducted off-

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See, for example, Fos and Jiang (2016) and Bach and Metzger (2019).

[22] A Gini coefficient in this setting is denoted by $\frac{\sum_{i=1}^{n}\sum_{j=1}^{n}|x_i - x_j|}{2n^2\bar{x}}$, where n is the number of token holders, x_i is holder i's ownership share, and $\bar{x}$ is the average ownership share.

chain (via Snapshot), Laturnus (2023) shows that only 24% of token holders cast votes. In addition, only about 11% of token holders participate in on-chain voting, perhaps reflecting reluctance to pay gas fees, which can run as high as $170 for on-chain voting (Tally, 2021).[23] Fritsch et al. (2024) find similarly that fewer than 15% of circulating tokens in Compound and Uniswap vote on proposals. These figures fall well short of the average stock-market voting turnout, which is around 80% for institutional investors and 30% for retail investors (Brav et al., 2022; Brav et al., 2024).[24]

To mitigate this imbalance, several voting models have been developed to either limit the influence of whales or amplify the voices of smaller participants. Examples of such efforts include the abovementioned quadratic voting (e.g., Gitcoin), which reduces the weight of additional votes from whales through a non-linear cost function, and tenure-based models (e.g., Curve Finance's vote-escrow system), which incentivize long-term commitment over sheer token quantity. These mechanisms ensure that smaller participants' voices can be more powerful than their holdings would imply.

Interestingly, large holders, such as founding teams, sometimes explicitly or implicitly refrain from participating in DAO voting. For example, employees of Offchain Labs, the company behind Layer-2 scaling solution Arbitrum, are not allowed to vote on Arbitrum DAO governance proposals, although they can delegate their tokens to like-minded voters.[25] Such an arrangement can temper the dominance of large holders while encouraging broader community participation.

3.2.2 Conflicts of interest

DAOs can bring conflicts of interest stemming from diverse and sometimes misaligned stakeholder incentives. These conflicts can occur not only between separate classes of investors

[23] One caveat with these analyses is that token holders who own multiple wallet addresses may delegate voting to only one address, which can bias estimated wallet-level participation rates downward.

[24] DAOs' low voting turnout rates may be related to a lack of coordination facilitated by intermediaries, such as proxy advisors in corporate voting. McCahery, Sautner, Starks (2016) find that 55% of institutional investors state that proxy advisors help them make informed voting decisions. A number of studies find a strong positive association between proxy advisory recommendations and voting outcomes (e.g., Iliev and Lowry, 2015; Malenko and Shen, 2016; Brav et al., 2024). On the other hand, a lack of voting intermediaries minimizes the risk that voting advice is biased (Li, 2018; Ma and Xiong, 2021; Malenko, Malenko, and Spatt, 2023) or is relied on too heavily (Malenko and Malenko, 2019; Shu, 2024).

[25] See, for example, https://www.standardcrypto.vc/thoughts/a-q-a-with-steven-goldfeder/ for additional details on Offchain Labs and Arbitrium governance.

but also between users, developers, and a DAO itself.[26] Identifying and addressing these issues is essential for effective governance, safeguarding decentralization, and maintaining community engagement. In this section we examine in particular conflicts between large and small participants, where large stakeholders (whales) are often individuals or institutions, such as founders, developers, and venture capitalists, with vested interests in a platform.

The influence of large token holders can overshadow smaller investors' voting power, creating a power imbalance that marginalizes the preferences of smaller participants in decision-making processes. Whales may push for proposals that prioritize their short-term gains, potentially undermining the long-term health of a protocol. Mechanisms such as quadratic voting and vote-escrow models are designed to mitigate this imbalance by reducing the voting power of large holders or incentivizing long-term commitments, but these solutions are not foolproof. For instance, the often anonymous nature of DAOs makes them vulnerable to Sybil attacks.

Han, Lee, and Li (2023) present a theoretical model of DAO governance that incorporates strategic token-trading within a token-based voting framework to explore potential conflicts of interest between large stakeholders (whales) and numerous small participants. Their findings indicate that ownership concentration can negatively impact platform growth; however, factors such as platform size, token illiquidity, and long-term incentives can help mitigate this adverse effect. Notably, the authors suggest that token illiquidity can function as a natural quadratic voting mechanism, avoiding issues like Sybil attacks.

Liquidity is generally recognized as beneficial for the governance of traditional corporations, facilitating active monitoring in the face of principal–agent problems between management and shareholders (e.g., Maug, 1998; Bolton and Von Thadden, 1998; Pagano and Roell, 1998). By contrast, illiquidity can also offer advantages. Levit, Malenko, and Maug (2024) demonstrate that trading frictions can enhance shareholder welfare by preventing the shareholder base from becoming overly extreme within a traditional governance framework. Therefore, the seemingly paradoxical notion that illiquidity can benefit DAO governance aligns with traditional governance principles, but this effect is significantly amplified in a DAO

[26] There is a growing body of literature on conflicts of interest in digital platforms in general. See, for example, Chod and Lyandres (2021); Cong, Li, and Wang (2022); Sockin and Xiong (2023).

setting where active monitoring of management is often absent given the autonomous nature of DAOs. Additionally, the distinction between users and shareholders blurs, as mentioned earlier. This blurring, combined with the network externality of user participation, amplifies value enhancement through a feedback effect, where increased participation fosters improved governance. Indeed, Han, Li, and Lee (2023) show that improved governance encourages greater user participation by increasing a platform's service value, generating multiple equilibria through the feedback channel between governance and user engagement.

Incentivizing participants for the long term, for example through tenure-based voting, can help mitigate conflicts between whales and small token holders. Han, Lee, and Li (2023) show that governance mechanisms like staking and vote-escrow systems can prevent whales from exploiting smaller stakeholders, reducing conflicts of interest and eliminating the low-participation equilibrium. Such "targeted illiquidity" through lock-in periods not only protects participants against malicious actors but also fosters genuine participation, enhancing platform value. Their event-study evidence shows in addition that these alternative mechanisms promote robust platform growth, providing an advantage over the traditional "one token, one vote" model. Mohan, Khezr, and Berg (2024) present a theoretical model illustrating how time commitments can serve as a voting resource in decentralized governance without verified voter identities, addressing voter fraud issues such as Sybil attacks.

Braun et al. (2022) build a simple model of a DAO that is owned by a whale (e.g., a service provider who maintains the DAO) and many token holders. The authors show, in their study of voting collusion, that ownership concentration and a stochastic voting scheme can collusion-proof a DAO. With a stochastic voting scheme, which relies on probability, a single decisive vote is drawn from the DAO's voter pool where the probability that that particular vote is drawn is proportional to the voter's token holdings (i.e., large holders' votes are more likely to be drawn than small holders' votes). Braun et al. (2022) do not, however, examine governance issues that a whale might cause.

Strnad (2024) proposes a new form of DAO governance that utilizes sequential auctions to address whales' "entrenched control" by establishing a regime of temporary control. Within this framework, bids for a DAO include a target token price, a surplus claim, and disclosure of toehold positions held by a bidder at the time a bid is submitted. The winning bidder is the bidder who generates the largest social surplus and establishes control over the

DAO, irrespective of her existing holdings.

3.2.3 Investor activism and contentious votes

Activist investors, especially hedge funds, acquire significant stakes in public companies and pressure management to improve performance. Although many institutional investors, including pension funds and mutual funds, do not appear to generate significant benefits for shareholders (Karpoff, 2001; Romano, 2001; Black, 1998; Gillan and Starks, 2007), research suggests that activist hedge funds achieve positive announcement returns and superior operating performance (e.g., Brav et al. 2008; Klein and Zur, 2009). Hedge-fund activism targeting M&As also earns higher returns for shareholders (Jiang et al. 2018a; Jiang et al. 2018b).[27]

In recent years, activist hedge funds have been increasingly targeting DAOs. A prominent case involved Aragon, whose products had fallen behind its competitors' because of team turnover and operational missteps after its initial coin offering (ICO; see Lee et al. (2021) and Howell et al. (2020) for an overview of ICOs). Despite the poor performance, funds managed by Aragon Association (AA), a Swiss nonprofit, grew to over $200 million in value following a rally in Ether. During a planned governance transition from the AA to the Aragon DAO, some activist investors, including hedge funds Arca Holdings and Patagon Management, started a public campaign for the liquidation of the treasury (the "book value" of assets) controlled by the nonprofit. In November 2023, AA announced that it would deploy most of the treasury to allow all token holders to redeem Aragon's ANT tokens for Ether at a fixed rate, dissolve AA, and continue its mission using a new product-focused structure (a product council and a company with some current team members).[28]

Similar campaigns include those targeting the decentralized exchanges Gnosis and FloorDAO, which are deemed arbitrage plays by some observers.[29] Activists could profit by buying a sufficient number of tokens in a DAO to wield a majority say and vote to distribute

[27] If an activist has failed to convince the majority of shareholders to improve or block an M&A, she can seek "fair" value from a court rather than accept the merger consideration. The gain from a successful appraisal petition accrues, however, only to the dissenters who withheld their votes. Jiang et al. (2016) find that appraisals yield sizable excess returns to the petitioners, with the returns sharply lower in more recent years (Jiang et al., 2020).

[28] For additional details about the Aragon announcement, see https://blog.aragon.org/a-new-chapter-for-the-aragon-project.

[29] For additional details about these two campaigns, see https://www.coindesk.com/tag/activist-investment/1/, which also features a number of other activist campaigns.

its treasury pro rata among token holders. If however the market capitalization of the governance token is much greater than the treasury, there will be no incentive for an activist attack.

DAOs have also witnessed contentious votes like those seen in corporate voting (Cunat et al., 2012; Bolton et al., 2020; Brav et al., 2024). Such instances have included one in which many xDAI users opposed the xDAI-Gnosis merger in 2021 and another in which the venture capitalist Andreessen Horowitz (a16z) voted against Uniswap's planned expansion to Binance's BNB Smart Chain in 2023.[30]

3.2.4 Optimal DAO design

The literature includes studies of optimal DAO voting systems. It might seem counterintuitive, but when voters vote strategically to maximize the expected value of their tokens by considering how others might vote, "one token, one vote" generally discourages truthful voting behavior and makes it hard to predict a voting outcome (Tsoukalas and Falk, 2020}. Inasmuch as token holders (shareholders) change voting outcomes only when they see their votes as pivotal, strategic as opposed to sincere voting takes place as strategic voters depend heavily on information they believe others hold (e.g., Maug and Rydqvist, 2009; Matvos and Ostrovsky, 2010).

Optimality in voting can perhaps be restored with quadratic voting when voters' information about the proposals on which they vote is perfect (even if their preferences are diverse; see Lalley and Weyl, 2018). In the presence of imperfect information, however, a "one token, one vote" scheme works better than quadratic voting because it disincentivizes voters who hold abundant information from casting sufficiently many votes to see their beliefs instituted. When the number of voters approaches infinity, the two voting mechanisms approximate optimality. Benhaim et al. (2023a) suggest that, to enhance voting efficiency, DAOs must encourage robust voter participation. Benhaim et al. (2023b) find that major platforms, including Binance and Cosmos, deploy an approval-voting scheme wherein token holders elect block-producer committees that verify and add transactions to blocks, converges to optimality rapidly as the number of voters increases.

[30] For additional details, see https://cryptobriefing.com/xdai-community-alleges-hostile-takeover-by-gnosis/ and https://www.coindesk.com/tech/2023/02/08/contentious-uniswap-vote-highlights-the-opaqueness-of-decentralized-governance/.

An emerging body of literature studies the optimal conditions for decentralization when weighed against the performance of centralized platforms or social planners who maximize an overall user surplus. According to Arrunada and Garicano (2018), decentralized platforms can resolve the hold-up problems that occur commonly on centralized platforms (e.g., by increasing fees, which delays development) as a result of the threat on the part of some participants to force a hard fork. This solution, however, weakens coordination in the adoption of new innovations. Chen, Richter, and Patel (2021) find an inverted U-shaped relationship between decentralization and market capitalization on platforms involving developer attention, development activity, and social media followers, suggesting that an intermediate level of decentralization might be optimal.

Bena and Zhang (2023) find, in a personal data-sharing context, that decentralized platforms yield greater user surpluses than centralized platforms when data enter the production function. In this way the study provides a rationale for founders to set up platforms based on decentralized token-based governance as opposed to adopting a traditional corporate-governance structure. Comparing a distributed ledger that is centrally managed by a single authority with that maintained by a committee of "validators," Auer, Monnet, and Shin (2021) show that the latter method is generally more efficient. It is optimal, though, to use just one trustworthy validator even if there are several such validators involved.

4. Conclusion

We survey the literature on DAOs, starting with an overview of DAOs in which we describe how DAOs are created, operated, and governed. To highlight key DAO governance features, we compare this newly emerging organizational structure with traditional corporations. Unlike delegated control by managers and directors acting on behalf of shareholders in a corporation, a DAO operates as an autonomous entity whose operational decisions are made collectively by token holders through smart contracts.

We discuss both on-chain and off-chain voting procedures and post-voting implementation, including an in-depth account of a DAO's decision-making process. The proposal- and voting-based governance mechanisms underscore the importance of optimal DAO design, which is essential for delivering desirable outcomes. We examine how distinct voting models may mitigate governance vulnerabilities, including those caused by conflicts of interest among token holders (e.g., when the interests of whales and small holders diverge).

Last, we discuss the recent rise of investor activism and contentious votes within the DAO space.

To the best of our knowledge, we provide the first comprehensive overview of various governance issues related to DAOs. We hope that our review will inspire subsequent research on this rapidly evolving yet under-researched topic in the Web 3 era. A promising avenue would involve analyzing the effectiveness of novel voting models adopted by DAOs and assessing whether such models enhance transparency, trust, and automation in governance processes.

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