DAO Governance*

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Abstract

Decentralized autonomous organizations (DAOs) operate based on a set of decision-making rules encoded into smart contracts utilizing blockchain technology. They lack a central point of authority in contrast to traditional corporations. In our paper, we develop a theoretical model of DAO governance featuring strategic token trading and a token-based voting system to investigate potential conflicts of interest between a large participant ("whale") and many small participants. Our results show that ownership concentration is negatively related to platform growth, but platform size, token illiquidity, and long-term incentives can mitigate the negative effects. We confirm these predictions using novel voting data on more than 200 DAO projects from July 2020 to July 2022.

JEL Classifications: D21, D26, G34, G38, O33

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1 Introduction

The widespread use of the internet and mobile technology has significantly lowered the cost of coordination and decision-making. The recent development of blockchain, a decentralized ledger technology, has popularized decentralized autonomous organizations (DAOs), a new kind of organizational structure that run as “smart contracts” (open-source code) on the blockchain. Unlike traditional companies, in which managers and boards run a business on behalf of shareholders, DAOs are entities without a central leadership and are instead collectively owned and managed by their members, who hold tokens that provide both decision-making and economic rights. Decisions are made through proposals the group votes on during a specified period.

While DAOs offer benefits such as increased transparency and democratic decision-making, which help address the principal-agent problem, there is mixed evidence about their effectiveness in practice. Examples of successful DAOs include Uniswap, a decentralized exchange (DEX) that uses a two-step governance structure to make decisions on new liquidity pools and fee structures. Participants first discuss and debate proposed changes in an off-chain “temperature check” before voting on a proposal via the Ethereum blockchain. This bottom-up governance structure allows for harnessing collective wisdom that enables the platform to evolve and grow. However, there have also been instances of governance failure on DEXs, notably “rug pulls,” where large holders of a newly issued token bid up the token price, and subsequently dump them, harming minority token holders (Li et al. (2022)). Notorious cases of such rug pulls include the YAM Finance and SushiSwap incidents.[1] These incidents highlight the risks associated with various governance issues in

[1] In the YAM Finance incident, the developers behind the project created a bug in the smart contract that caused the entire project to collapse and resulted in significant losses for investors. The SushiSwap incident involved the original developer of the project, known as "Chef Nomi," abruptly leaving and selling all of their SUSHI tokens, causing the price to plummet and leading to investor losses.

decentralized projects and the importance of conducting thorough due diligence before investing in DAOs.

An important but understudied problem in the existing literature is the potential conflict of interest between DAO's large token holders (known as "whales") and small token holders. The lack of regulation and traditional corporate defense mechanisms, such as poison pills, makes it relatively easy for a whale to amass a large amount of governance tokens issued by a DAO. Whales may use their superior voting power to manipulate the market at the expense of minority token holders and gain short-term rents. Such governance risks can harm platform growth. This is the first paper that conducts both theoretical and empirical investigations of such conflicts of interest between whales and small investors in the DAO setting, which include studying their adverse effects and mechanisms that mitigate such negative consequences.

To formalize the aforementioned argument, we study an equilibrium model that features a platform with a voting event and dynamic trading of tokens. There is one unit of tokens issued upon the establishment of the platform, and voting rights are equally distributed across all units of tokens (i.e., "one token, one vote"). The platform has a token-based voting system that decides whether to implement a proposal based on voting outcomes according to token ownership. There is a continuum of small participants (henceforth "users") and a big participant (henceforth "whale"). The platform generates utility flows for participants according to their token ownership. If the incentives between the users and the whale are misaligned, the whale will benefit privately from implementing a value-destroying proposal for users. Because users are against implementing the proposal, the whale has to acquire enough tokens to win in the voting (e.g., half of the tokens in the case of the majority rule) even with their own voting power. However, such token acquisitions could be costly due to the significant pricing impact that the whale has to internalize in open market trading.

Under this setup, our first theoretical result states that the whale tends to destroy the value of the platform when they possess more concentrated voting power (Prediction 1). The whale trades off their private benefit against the cost of implementing a rug-pull strategy. The cost comes from two sources: the loss in platform service value caused by the whale's own stake in the platform and the transaction costs incurred by the strategic acquisition of tokens to win the proposal. When the private benefit of the whale dominates their loss in service value, ownership concentration by the whale always increases the likelihood of value-destroying voting outcomes.

We further explore the impact of other key characteristics of a DAO that alter this negative correlation between ownership concentration by the whale and the growth of the platform's value. First, the impact of the whale's ownership concentration on the value-destroying voting outcomes is mitigated if the platform already has a higher service value (Prediction 2). Because the whale already has a stake in the platform, they do not want to incur a loss by passing the value-destroying proposal. Next, the impact of ownership concentration on the platform value is mitigated by token illiquidity (Prediction 3). For illiquid tokens, the whale finds it more expensive to acquire extra tokens to implement self-serving proposals. This insight is in line with that of quadratic voting schemes, which discourage a single participant from achieving dominant voting power. Because users' participation is endogenous, the service value of the platform could be destroyed if the whale's self-serving proposal is more likely to be implemented in equilibrium. Therefore, according to our theory, if the platform has a higher ex-ante service value (Prediction 2) and if its tokens are more expensive to sell in open market trading, its value will be shielded against the effects of bad governance (Prediction 3).

Finally, our model suggests that if a whale also pursues the platform's long-term growth, a platform may expand more swiftly and increase in value. Therefore, a different governance mechanism that rewards the whale for making long-term commitments could resolve any potential governance concerns in decentralized digital organizations (Prediction 4).

We bring these predictions to the data, uncovering consistent evidence that largely supports our theory. We begin with the 460 largest DAOs that sponsored proposals through a popular off-chain voting platform during the period running from July 20, 2020 through July 31, 2022. Our final sample includes 207 DAOs that have non-missing price and volume information for their governance tokens as well as non-missing data on total value locked (TVL), a proxy for platform size. Importantly, we manually collect data on the various governance mechanisms used by these decentralized platforms, such as governance tokens, staking, and vote escrow/locking strategies, the latter of which reward investors greater voting power and yields for locking their governance tokens. Our sample includes most major DAO platforms and is more comprehensive than those used in the literature. For example, Fritsch, Müller, and Wattenhofer (2022) features only three platforms.

We perform weekly panel regressions to examine the relationship between platform growth and two proxies for voting power concentration. Since proposals typically are not made every day, we convert the voting data to weekly series. If multiple proposals are sponsored in a given week, we use weekly averages of voting power concentration. Our dependent variable is the weekly growth rate of TVL and our independent variables of interest are the Herfindahl-Hirschman Index (HHI) of voting power and the total voting shares controlled by the top three voters in each DAO. These independent variables are lagged by one week. We control for DAO and week-fixed effects, with standard errors being clustered at the DAO level.

We find a significant and negative correlation between TVL growth and the HHI of voting power. A one standard deviation increase in HHI is associated with a 1.1 percentage-point decrease in weekly TVL growth. The magnitude is economically significant given that the average weekly TVL growth is only -0.9%. Similarly, we show that the top three voters' ownership negatively influences platform growth, with the marginal effect being significantly greater than the average weekly TVL growth. These results are consistent with our first theoretical prediction, which states that platform growth accelerates when voting power is more decentralized.

We further test our second prediction that the negative effect of the HHI of voting power on TVL growth would be reduced if a platform has a wider user group hence a higher network value. We expect a similar dampening effect of token illiquidity (Prediction 3), which leads whales to suffer a significant price impact when they attempt to amass a large stake. To potentially manipulate the price of a token, a whale can accumulate significant voting power to pass a proposal that generates private benefits to the whale (e.g., a proposal that drains the funds of a liquidity pool) while hurting other investors. Such actions are ex-ante more costly when tokens are illiquid, prompting whales to align their incentives with minority token holders. We use the Amihud (2002) illiquidity measure as our empirical proxy for token illiquidity.

We test these predictions by adding an interaction term between the HHI of voting power and platform size (proxied by lagged TVL) to our baseline regression specification. We find a positive and statistically significant coefficient on the interaction term, suggesting that higher valuation indeed reduces the negative relationship between platform growth and ownership concentration. We find a similar result when using an interaction term of HHI and token illiquidity instead.

Finally, we test our last prediction by examining events where platforms shifted from the one-token-one-vote model, which is used by most DAOs such as Lido and Uniswap, to a staking model. Pioneered by Curve Finance, a DEX launched in January 2021, a growing number of protocols have adopted a staking model, which assigns vote weights and yields that are generally proportional to a "locking period." That is, investors can lock their governance tokens to gain more voting power and enhance their investment yields. Using an event-study framework, we compare the TVL growth of a set of DAOs that switched to a staking model during our sample period with that of a control group of DAOs that did not adopt staking models. To sharpen identification, we use a relatively short event window of Day -6 to Day 1 around the adoption date of the new governance model. Treated platforms exhibit an 8.3 percentage-point higher growth rate during the event window compared to control platforms. This is an economically significant effect given that our sample DAOs on average generate a slightly negative weekly growth rate.

Our study contributes to the literature on the governance of DAOs. To the best of our knowledge, we are the first to theoretically examine DAOs' governance issues and derive equilibrium implications, whereas the few studies in this literature primarily provide empirical descriptions of the distribution of votes (Fritsch, Müller, and Wattenhofer, 2022; Appel and Grennan, 2023). A contemporaneous theory paper by Aoyagi and Ito (2022) is a notable exception. They, however, focus on competition among DAOs rather than conflicts of interest among DAO investors, which we analyze in this paper.

We are also the first to provide empirical evidence linking decentralization to platform growth and token valuation, expanding the theoretical intuitions proposed by Cong, Li, and Wang (2021) and Sockin and Xiong (2023). We theoretically demonstrate how minority token investors in a DAO can endogenize their participation decision to prevent being harmed by whales. We also show how costly token acquisition by whales can improve DAO governance. We provide empirical evidence that supports both intuitions using our novel voting data on DAOs. Furthermore, our event-study setup reveals that alternative governance mechanisms, such as staking and vote escrow systems, as opposed to the typical one-token-one-vote model, can increase long-term incentives of whales and hence platform growth. Overall, our study provides a comprehensive analysis of DAO governance issues and their potential solutions, both theoretically and empirically, thus filling an important gap in the literature.

Related Literature Our work is broadly related to the literature on the wisdom of crowds, information cascade, and decentralization in cryptocurrency markets. Notable theoretical contributions to token-based platforms include Cong and Xiao (2019), Li and Mann (2020), Chod and Lyandres (2021), Lee and Parlour (2021), Gan, Tsoukalas, and Netessine (2021), and Cong, Li, and Wang (2022). A string of empirical studies in this area also contribute to our understanding of the issues at play during and after platforms' fundraising (Howell, Niessner, and Yermack, 2020; Lee, Li, and Shin, 2021; Bourveau et al., 2022; Lyandres, Palazzo, and Rabetti, 2022; Davydiuk, Gupta, and Rosen, 2023). Our study is also related to the burgeoning literature on blockchain economics and its governance implications of firms in the new digital era (Harvey, 2016; Yermack, 2017; Malinova and Park, 2017; Cong and He, 2019; Saleh, 2021; Roşu and Saleh, 2021).

Our work provides governance implications for decentralized finance (DeFi) platforms, and thus, is related to the emerging literature on DeFi (e.g., Harvey, Ramachandran, and Santoro, 2021; Makarov and Schoar, 2021; Cong et al., 2022; Augustin, Chen-Zhang, and Shin, 2022; Park, 2022; Capponi and Jia, 2021; Lehar and Parlour, 2021; Aoyagi and Ito, 2021; Barbon and Ranaldo, 2021; Sockin and Xiong, 2023). For example, Sockin and Xiong (2023) find that tokenization through utility tokens can be a commitment device that prevents the owner of a platform from exploiting its users. By contrast, our paper focuses on the strategic trading of a whale for accumulating voting power under a token-based voting scheme.

Our theory also extrapolates key intuitions from the long lasting literature on organizational economics, corporate governance and shareholder voting, and blockholder governance (e.g., Holmstrom and Tirole, 1989; Harris and Raviv, 1989, 2006; Burkart and Lee, 2008; Lalley and Weyl, 2018; Shleifer and Vishny, 1986; Levit, Malenko, and Maug, 2019).

2 Institutional Background

A corporation is a legal structure that separates its owners (shareholders) from its managers (agents). It operates on a top-down governance model where agents are given authority to manage the company on behalf of shareholders, who expect to receive earnings based on their ownership in the business. However, under this centralized governance structure, agents may prioritize their own interests over those of shareholders if proper monitoring mechanisms and incentives are not in place. This is known as the managerial agency problem. Several approaches have been proposed to address it, such as blockholder ownership, managerial stock options, board independence, and markets for control and competition (Bebchuk and Weisbach, 2010; Adams, Hermalin, and Weisbach, 2010). Additionally, when shareholders' interests diverge from those of other stakeholders, such as employees, customers, and suppliers, the company may not be able to withstand extreme market risks (e.g., climate risk, reputational damage, pandemic events) or achieve sustainable growth (Edmans, 2011, 2021; Lins, Servaes, and Tamayo, 2017; Albuquerque et al., 2020; Ding et al., 2021).

An alternative to this structure is a DAO. Unlike a corporation, a DAO is not managed by a single person or team but rather governed by all its members through a token-based voting system. Members discuss and make decisions online and implement changes using smart contracts on a decentralized ledger. This allows for immediate implementation of new policies once consensus is reached among members who hold tokens issued by the platform.

DAOs are fundamentally different from corporations in terms of control and decision-making. Below we delve deeper into the key distinctions between these two organizational structures.

Automation and Decentralization-based Economies of Scale

DAOs can leverage automation and decentralization to achieve economies of scale. By eliminating traditional overhead expenses such as staff salaries and office rent, DAOs can operate with a leaner and more efficient structure. Additionally, the decentralized governance structure allows for participation from anyone holding tokens and an interest in the organization, giving DAOs the potential to reach a global audience more efficiently and respond to global needs more quickly than centralized organizations. Decisions are made through online voting and recorded on a public blockchain, allowing for collective management of resources. Network congestion and the resulting excessive gas fees, especially on the Ethereum blockchain, have popularized voting through off-chain platforms that connect to participants' digital wallets or layer-2 blockchains.[2] Smart contracts are used to implement the agreements made through voting and blockchain technology ensures transparency and immutability of a platform's policies, which contribute to the efficiency and scalability of DAOs.

Direct Token-Holder Democracy

In a DAO, decisions are made through direct token-holder democracy, where token holders have a vote proportionate to their token ownership. This allows small token holders to have a say in the organization's management. In a corporation, the board, on behalf of shareholders, selects managers, who are the agents, to run the company. In a DAO, however, there are no agents. This lack of intermediaries raises questions about how to define agency problems and what governance mechanisms are required to address them.

An important issue is the potential conflict of interest between a DAO's minority token holders and large token holders, the latter of whom are known as "whales." These conflicts may arise if whales prioritize short-term capital gains over long-term development of the platform's services, potentially harming the interests of the minority holders. This concern is reinforced by the prevalence of fraud and manipulation by platform insiders and whales

[2] For more information on specialized off-chain voting platforms, see Snapshot (https://docs.snapshot.org/).

in the cryptocurrency industry (Li, Shin, and Wang, 2021; Xia et al., 2021; Li et al., 2022; Phua et al., 2022). Therefore, to achieve efficiency, DAOs need governance measures that align whales' interests with those of minority token holders.

The Absence of Regulations

Initial coin offerings (ICOs) and initial DEX offerings (IDOs) are commonly used by DAOs to raise capital but they lack sufficient regulatory oversight and intermediaries to safeguard the interests of minority token investors. In the absence of these safeguards, it is crucial for DAO members to share information and collaborate to improve the organization's operations. The literature suggests that the crowd's wisdom can help overcome information asymmetry and associated governance issues in ICOs (Lee, Li, and Shin, 2021; Bourveau et al., 2022). As DAOs operate under a bottom-up control structure, the larger the token-holder base is the more wisdom the crowd can generate, potentially leading to sustainable long-term value.

The following sections theoretically explore the potential conflicts of interest between whales and minority token holders in a DAO and offer potential solutions to align the incentives of these two groups. In Section 6, we empirically test the resulting predictions using novel data.

3 Model

3.1 Setup

Consider an infinite-horizon model with a platform that provides services, such as bilateral or multilateral transactions among users. Using the platform's services requires tokens (or coins) that are issued by the platform at its establishment in $t = 0$, and subsequently traded in an exchange every period from $t = 1$ onward.

We consider a situation where the platform has proposed changes to its services, but there are potential conflicts of interest among participants, as the benefits and costs of the proposed changes vary across participants. The platform's decision will be determined by the outcome of a vote according to a pre-specified rule.

The timeline is as follows: In $t = 0$, the platform is established and one unit of tokens is issued. Potential users decide whether to participate in the platform's activities by paying the initial participation cost. In $t = 1$, all participants vote for or against the proposal based on their token ownership. The proposal is then implemented according to the voting result. From $t = 2$ onward, the platform provides utility flows to participants based on their token ownership.

In this model, there are two types of participants: small participants, whom we will refer to as "users," and a larger participant, whom we will refer to as the "whale." All participants are assumed to be risk-neutral, and their discount factor is denoted by δ. The risk-free rate is given by $r_f = 1/\delta - 1$.

We assume that there is a continuum of users uniformly distributed on the interval $[0, 1]$ who derive utility from using the service on the platform. Without loss of generality due to risk neutrality, we can normalize their initial wealth W_0 to zero.

To participate, each user i must pay a one-time participation cost of $\phi_i > 0$ at $t = 0$ and purchase tokens at an exogenously-given initial offering price of $\bar{P}$ without incurring any transaction costs. The cost ϕ_i is individual-specific and has a cumulative density function of $F(\cdot)$ on the interval $[0, \infty)$. We denote the set of participating users as $\mathcal{U}$.

A participating user, indexed by i, with token holdings of $x_{i,t}$ in $t \geq 1$ derives a utility from the platform in the subsequent period $t + 1$ as follows:

$$U(x_{i,t}) = A(a)Nx_{i,t}, \tag{1}$$

where N is the total mass of participating users such that[3]

$$N = \int_0^1 \mathbb{1}\left(i \in \mathcal{U}\right) di, \tag{2}$$

The utility flows can be monetary payoffs or utility of service, and the value of service per unit of tokens is given by $A(a)N$, where $A(a)$ captures the technology (or efficiency) component and N captures the network effect of user participation (see, for example, Cong, Li, and Wang, 2021 and Sockin and Xiong, 2023).

The technology component $A(a)$ is determined by the action $a \in R, I$ where $a = I$ means that the proposal is implemented, and $a = R$ means it is rejected. In $t = 1$, the platform implements the proposal ($a = I$) if the total mass of votes in favor of its implementation exceeds the minimum threshold of $\bar{x}$:

$$\mathbb{1}\left(a_w = I\right) y_1 + \int_{\mathcal{U}} x_{i,1} \mathbb{1}\left(a_i = I\right) di \geq \bar{x}, \tag{3}$$

where $a_i \in I, R$ and $a_w \in I, R$ are the vote of each participating user $i \in \mathcal{U}$ and that of the whale, respectively, which are equal to I if they prefer the implementation of the proposal and R otherwise. The indicator functions $\mathbb{1}\left(a_w = I\right)$ and $\mathbb{1}\left(a_i = I\right)$ are one if $a_w = I$ and $a_i = I$, respectively, and zero otherwise. The threshold $\bar{x}$ is pre-specified upon the establishment of the platform. For example, we can set $\bar{x} = 1/2$ in the case of the majority rule.

We denote by $P(a)$ the intrinsic value of the tokens to users given the status of the proposal implementation a and the mass of participants N. It is given by the present value of utility flows per unit of tokens:

$$P(a) = \sum_{t=1}^{\infty} \delta^t A(a) N = \frac{A(a)N}{r_f}. \tag{4}$$

[3] We denote by $\mathbb{1}(i \in \mathcal{U})$ an indicator function that is equal to one if $i \in \mathcal{U}$ and zero otherwise.

In the absence of the whale, the price would converge to this intrinsic value.

We assume that trading costs are increasing convexly in the amount of trading volumes. Although convex trading costs may arise from various sources, one major source can be the illiquidity of tokens. For tractability, we assume a quadratic function for the trading costs as a function of the amount of traded tokens, ΔX:

$$C(\Delta X) = \frac{\lambda}{2}(\Delta X)^2, \tag{5}$$

where λ is a parameter that captures the magnitude of illiquidity (see, for example, van Binsbergen et al., forthcoming for further discussion). Additionally, we assume that short sales are not allowed.

Upon the establishment of the platform in $t = 0$, the whale receives y_0 unit of the tokens. The whale can be considered as an individual or an institution with special interests in the platform (e.g., founders, developers, and financiers such as venture capitalists). The whale in $t \geq 1$ given y_t unit of holdings of the tokens derives a utility from the platform in the subsequent period $t + 1$ as follows:

$$U(y_t) = A(a)Ny_t. \tag{6}$$

To explore potential conflicts between users and the whale, we assume that implementing the proposal would destroy value for users if $A(R) > A(I) = (1 - \theta)A(R)$ where θ is the parameter that captures the loss in efficiency due to the implementation of the proposal. The whale obtains private benefits in case of implementing the proposal. The expected private benefit increases with the initial holdings of the tokens. Specifically, we assume that the whale's benefit from implementing the proposal is given by By_0, where B is a random variable that is either $\bar{B} > 0$ with probability μ or zero with probability $1 - \mu$. The initial holdings y_0 reflect the degree of special interests in the process of establishing the platform. The parameter $\bar{B}$ represents the size of the private benefit (in monetary terms) per unit of initial holdings in cases where incentives are misaligned between the whale and users.

We assume that the whale needs to liquidate its position before a finite horizon of $T \geq 2$. This assumption reflects short-termism of the whale which may result from agency or financial frictions. For example, the whale can be an institutional investor with financial interests whose compensation is determined by their short-term performance, either implicitly by fund flows or explicitly by their incentive contracts (see, for example, Dow, Han, and Sangiorgi, 2021, 2022, and van Binsbergen et al., forthcoming).

3.2 Optimal Choices

3.2.1 User's Problem

In periods $t = 1, 2, \ldots$, each participating user maximizes their expected utility of enjoying the service of the platform as well as trading gains. Because users are symmetric once they participate in the market, we suppress the index i for notational convenience from now on.

Given the platform's action a in $t = 1$, a user's value function can be written as:

$$V_t^a(x_{t-1}, W_{t-1}) = \max_{\Delta x_t \geq 0} A(a)Nx_{t-1} + \delta V_{t+1}(x_t, W_t), \tag{7}$$

subject to the constraints:

$$\begin{aligned} x_t &= x_{t-1} + \Delta x_t \\ W_t &= (1 + r_f)\left(W_{t-1} - P_t\Delta x_t - \frac{\lambda}{2}\Delta x_t^2\right). \end{aligned} \tag{8}$$

By solving the optimization problem in Eq. (7), we derive the continuation value of a user as an affine function of the current holdings of tokens, and the current level of wealth in t:

Lemma 1 *The value function of a user in $t \geq 1$ is given by*

$$V_t^a(x_{t-1}, W_{t-1}) = \alpha_t + \beta x_{t-1} + W_{t-1}, \tag{9}$$

where α_t is the present value of future trading gains:

$$\alpha_t = \frac{1}{2\lambda} \sum_{s=t}^{\infty} \delta^{s-t} \left(P(a) - P_s\right)^2, \tag{10}$$

and β is the marginal value of tokens:

$$\beta = \frac{1}{\delta} P(a). \tag{11}$$

The optimal trading strategy of tokens in period t given price P_t is

$$\Delta x_t = \frac{P(a) - P_t}{\lambda}. \tag{12}$$

In $t = 0$, each user maximizes their expected utility by choosing to participate or not, as well as buying the tokens at the initially-offered price of $\bar{P}$. User i solves

$$\max\left(V_0, \phi_i\right), \tag{13}$$

where V_0 is the ex-ante value of participating in the platform's activities:

$$V_0 = \max_{\Delta x_0 \geq 0} \delta \mathrm{E}[V_1^a(x_0, W_0 - \bar{P}x_0)] = \max_{\Delta x_0 \geq 0} \delta \mathrm{E}[V_1^a(x_0, -\bar{P}x_0)]. \tag{14}$$

The second equality is due to the normalization $W_0 = 0$. Also, note that there are no transaction costs in $t = 0$ because the tokens are directly acquired from the platform (e.g., ICO).

3.2.2 Token Prices

The market clearing condition states that the sum of all the trading volumes should be net zero:

$$N\Delta x_t + \Delta y_t = 0. \tag{15}$$

Then, Eq. (15) together with Eq. (12) implies that the inverse demand function of users is given by

$$P_t = P(a) - \frac{\lambda}{N}\Delta x_t. \tag{16}$$

Therefore, when the whale trades Δy_t units of tokens, Eq. (15) implies that the equilibrium price of tokens is a function of Δy_t given a:

$$P(\Delta y_t; a) = P(a) + \frac{\lambda}{N}\Delta y_t. \tag{17}$$

Eq. (17) shows that the price has to increase above the intrinsic value whenever the whale buys more tokens and decrease below the intrinsic value whenever the whale sells the tokens. In the absence of the whale's trading, the price becomes the intrinsic value.

3.2.3 Whale's Problem

In $t = 0$, the whale receives y_0 units of tokens from the platform. In $t = 1$, the whale decides whether to increase their holdings of tokens to implement the proposal or not. In $t = 2, 3, \ldots,$

the whale maximizes their expected utility, by trading tokens similarly to users in Eq. (7). Unlike users, however, the whale can strategically accumulate tokens to change the result of the voting. The value function given y_{t-1} is

$$V_{w,t}(y_{t-1}, a) = \max_{\{\Delta y_s\}} \sum_{s=t}^{T} \delta^{s-t} \left[A(a) N y_s - P(\Delta y_s; a) \Delta y_s - \frac{\lambda}{2} \Delta y_s^2 \right], \tag{18}$$

subject to

$$y_s = -\sum_{u=s}^{T} \Delta y_u \quad \text{for all } t \leq s \leq T; \tag{19}$$

$$y_s \geq 0 \quad \text{for all } t \leq s \leq T. \tag{20}$$

The whale maximizes their expected utility by optimally reducing their position over the given investment horizon, considering the trade-off between the payoffs of the tokens and the trading costs.

Lemma 2 *Given the initial holdings of tokens y_t in period t, the optimal trading strategy of the whale in period $s \geq t$ is given by*

$$\Delta y_s = -\delta^{-(s-t)} \frac{y_t}{\Gamma(t,T)}, \tag{21}$$

where $\Gamma(t,T)$ is a function which is strictly greater than one for all values of t, T:

$$\Gamma(t,T) = \sum_{k=t}^{T} \delta^{-(k-t)} = \frac{1 - \delta^{-(T-t+1)}}{1 - \delta^{-1}}. \tag{22}$$

Furthermore, the value function in $t \geq 2$ is given by

$$V_{t,w}(y_{t-1}, a) = P(a) y_{t-1} - \frac{\lambda_w}{2} \frac{y_{t-1}^2}{\Gamma(t,T)^2}, \tag{23}$$

where λ_w is the effective cost of trading per unit of tokens:

$$\lambda_w = \lambda \left(\frac{N+2}{N} \right). \tag{24}$$

The optimal trading strategy in Eq. (21) reflects dividing the initial holdings among the remaining periods in proportion to the discount factor.[4] The value in Eq. (23) reflects the intrinsic value of the whale's current token holdings less the cost of liquidating them under the optimal trading strategy.

3.3 Equilibrium

3.3.1 Voting and Strategic Trading

In $t = 1$, the value of private benefit B realizes. In the case of $B = 0$, the whale has an aligned incentive with users, and will not want to implement the proposal that destroys value for users. In the case of $B = \bar{B}$, however, the whale has a misaligned incentive and may want to implement the proposal.

Because users do not benefit from implementing the proposal, there is no support from them to implement the proposal. Therefore, in order to implement the proposal, the whale needs to purchase $\bar{x} - y_0$ units of tokens to gain enough voting power to achieve their desired outcome. The whale's value of choosing to implement the proposal can be expressed as follows:

$$V_w(I) = By_0 - P(I)(\bar{x} - y_0) - \frac{\lambda_w}{2}(\bar{x} - y_0)^2 + \delta V_{2,w}(\bar{x}, a). \tag{26}$$

[4] It is intuitive that, in case the discount factor is one, this term simplifies to the total trading volume divided by the remaining number of days before the liquidation:

$$\Delta y_s = -\frac{y_t}{T - t + 1}, \quad \text{for all } t \leq s \leq T. \tag{25}$$

The first term is the private benefit, the second term is the acquisition cost of additional tokens, the third term is the trading cost, and the fourth term is the continuation value.

By substituting Eq. (23) into Eq. (26), we can represent the whale's value in $t = 1$ as follows:

$$V_w(I) = \underbrace{By_0}_{\text{Private benefit}} + \underbrace{P(I)y_0}_{\text{Intrinsic value}} \underbrace{-\frac{\lambda_w}{2}(\bar{x} - y_0)^2 - \delta \frac{\lambda_w}{2} \frac{\bar{x}^2}{\Gamma(2,T)^2}}_{\text{Trading costs}}. \tag{27}$$

The whale's value reflects the private benefit plus intrinsic value under the implementation of the proposal, less the trading costs.

In contrast, Eq. (23) implies that the whale's value of choosing not to implement the proposal is given by the intrinsic value under the status quo, less the trading costs of liquidating the initial holdings:

$$V_w(R) = \underbrace{P(R)y_0}_{\text{Intrinsic value}} \underbrace{-\frac{\lambda_w}{2} \frac{y_0^2}{\Gamma(1,T)}}_{\text{Trading costs}}. \tag{28}$$

Therefore, the whale implements the proposal if and only if the incremental value to the whale $\Delta V_w = V_w(I) - V_w(R)$ is greater than zero:

$$\Delta V_w = \underbrace{By_0}_{\text{Private benefit}} - \underbrace{[P(R) - P(I)]y_0}_{\text{Loss in intrinsic value}} - \underbrace{\frac{\lambda_w}{2}\left[(\bar{x} - y_0)^2 + \delta \frac{\bar{x}^2}{\Gamma(2,T)^2} - \frac{y_0^2}{\Gamma(1,T)}\right]}_{\text{Increment in trading costs}}. \tag{29}$$

That is, the whale trades off between the private benefit and the cost of implementing the proposal, where the cost includes the loss in intrinsic value and the extra trading costs incurred by strategically acquiring more tokens for voting.

When the private benefit dominates the loss in intrinsic value, the ownership concentration always increases the likelihood of value-destroying voting outcomes. That is, whenever $B \geq P(R) - P(I)$, we have

$$\frac{\partial \Delta V_w}{\partial y_0} = (B - P(R) - P(I)) + \lambda_w(\bar{x} - y_0) + \lambda_w \frac{y_0}{\Gamma(1,T)} > 0. \tag{30}$$

The main intuition is that the whale finds it not too expensive to implement the proposal if they already own a large share of tokens. Because the cost of acquiring extra tokens is convex, a relatively small acquisition of tokens is not too costly compared to the private benefit.

The second-order derivative of ΔV_w with respect to y_0 and $A(R)$ reveals that the cost of implementing the proposal increases in the service value:

$$\frac{\partial^2 \Delta V_w}{\partial y_0 \partial A(R)} = -\frac{N}{\theta r_f} < 0 \tag{31}$$

Because the whale has a stake in the platform, they do not want to incur a loss due to the value-destroying change. Therefore, the whale will avoid a value-destroying activity if the platform is already well-established.

The second order derivative of ΔV_w with respect to y_0 and λ reveals that the cost of implementing the proposal can increase in illiquidity:

$$\frac{\partial^2 \Delta V_w}{\partial y_0 \partial \lambda} = -\frac{1}{2}\frac{N+2}{N}\left[(\bar{x} - y_0)^2 + \frac{y_0^2}{\Gamma(1,T)}\right] < 0. \tag{32}$$

As the illiquidity parameter λ increases, the whale finds it more expensive to acquire extra tokens to implement the proposal. This is in line with the insight of quadratic voting schemes that discourage one participant from achieving dominating shares of voting rights.

This is summarized by the following proposition:

Proposition 1 *The value-destroying voting outcomes are more likely with higher ownership concentration if the private benefit is sufficiently large. Furthermore, the incremental likelihood decreases in the value of the platform and the illiquidity of tokens.*

3.4 Intrinsic Value of the Platform

The equilibrium price process can be obtained from the inverse demand function Eq. (17) and the optimal trading schedule of the whale. If the whale chooses to implement the proposal, the whale purchases $\bar{x} - y_0$ unit of tokens. Therefore, the price in $t = 1$ is given by

$$P_1 = P(I) + \frac{\lambda}{N}(\bar{x} - y_0) \tag{33}$$

Then the whale's holdings in $t = 2$ becomes $\bar{x}$, which together with the optimal trading schedule in Eq. (21) for $t \geq 2$ implies that the price in $t \geq 2$ is given by

$$P_t = P(I) - \delta^{-(t-2)} \frac{\lambda}{N} \frac{\bar{x}}{\Gamma(2, T)}. \tag{34}$$

If the whale chooses not to implement the proposal, the whale starts liquidating the tokens from $t = 1$. Then, Eq. (17) together with the optimal trading schedule in Eq. (21) implies that the price in $t \geq 1$ is given by

$$P_t = P(R) - \delta^{-(t-1)} \frac{\lambda}{N} \frac{y_0}{\Gamma(1, T)} \tag{35}$$

Using the possible equilibrium price processes in the two possible scenarios, we can derive the following value for users in $t = 0$:

Lemma 3 *The value for users in $t = 0$ when $a = I$ is given by*

$$V_0^I = (P(I) - \bar{P})(1 - y_0) + \delta \frac{\lambda}{2N^2} \left[(\bar{x} - y_0)^2 + \frac{\delta \bar{x}^2}{\Gamma(2, T)} \right], \tag{36}$$

and, when $a = R$, it is given by

$$V_0^R = (P(I) - \bar{P})(1 - y_0) + \delta \frac{\lambda}{2N^2} \frac{\bar{y_0}^2}{\Gamma(1, T)}. \tag{37}$$

Furthermore, V_0^R is strictly greater than V_0^I.

Eq. (29) shows that the whale implements the proposal if and only if the private benefit dominates the cost ($\Delta V_w > 0$) in case their incentives are misaligned with those users ($B = \bar{B}$). In this case, the ex-ante value of users in Eq. (14) is equal to $V_0 = \mu V_0^I + (1-\mu) V_0^R$. If the private benefit is dominated by the cost ($\Delta V_w \leq 0$), the proposal is not implemented. In this case, the expected value of users is equal to $V_0 = V_0^R = \mu V_0^R + (1 - \mu) V_0^R$ regardless of the whale's incentive B.

Because $V_0^I < V_0^R$, the equilibrium mass of participating users N strictly decreases when there is a greater possibility that the proposal is implemented:

$$N^I = F(\mu V_0^I + (1 - \mu) V_0^R) < F(V_0^R) = N^R, \tag{38}$$

where N^I and N^R denote the mass of participating users when there is a positive possibility that the proposal is implemented ($\Delta V_w > 0$), and there is no possibility of that ($\Delta V_w \leq 0$), respectively.

We summarize our results in the following proposition:

Proposition 2 *The total value of the platform decreases whenever the likelihood of value-destroying voting increases.*

3.5 Delayed Liquidation

Some DAOs consider governance mechanisms that lock in token positions for voting participants (e.g., vote escrowed tokens). In this subsection, we implement such a mechanism by delaying the liquidation of the whale by a certain amount of time $T_L < T - 1$ only in case of implementing the proposal. That is, the whale can only start liquidating after T_L following their voting in $t = 1$ if $a = I$ whereas they can start liquidating the tokens immediately in $t = 1$.

Under the delayed liquidation scheme, the whale's value is changed as follows:

$$V_w(I) = \underbrace{By_0}_{\text{Private benefit}} + \underbrace{P(I)y_0}_{\text{Intrinsic value}} \underbrace{-\frac{\lambda_w}{2}(\bar{x} - y_0)^2 - \delta\frac{\lambda_w}{2}\frac{\bar{x}^2}{\Gamma(1 + T_L, T)^2}}_{\text{Trading costs}}. \tag{39}$$

This scheme makes the whale suffer from larger trading costs because of the short horizon before their target liquidation period. Therefore, the whale implements the proposal if and only if the incremental value to the whale is greater than zero:

$$\Delta V_w = \underbrace{By_0}_{\text{Private benefit}} - \underbrace{[P(R) - P(I)]y_0}_{\text{Loss in intrinsic value}} \underbrace{- \frac{\lambda_w}{2}\left[(\bar{x} - y_0)^2 + \delta\frac{\bar{x}^2}{\Gamma(2, T)^2} - \frac{y_0^2}{\Gamma(1 + T_L, T)}\right]}_{\text{Increment in trading costs}}. \tag{40}$$

The right-hand side is clearly smaller than that in Eq. (29), which means that delayed liquidation makes it more difficult for the whale to implement the proposal compared to the case without delayed liquidation.

We summarize our results in the following proposition:

Proposition 3 *Delaying the liquidation of the whale's tokens mitigates the impact of ownership concentration on the likelihood of value-destroying outcomes.*

4 Theoretical Predictions

We now summarize the main predictions relevant to our empirical analyses. The first three predictions are direct consequences of Proposition 1 and 2. The fourth prediction is due to Proposition 3:

Prediction 1 *The growth rate of platforms is negatively correlated with their ownership concentrations, i.e.,*

$$\frac{\partial V_0}{\partial y_0} < 0 \tag{41}$$

Prediction 2 *The higher service value of platforms reduces the negative correlations between the growth rate of platforms and their ownership concentrations, i.e.,*

$$\frac{\partial^2 V_0}{\partial y_0 \partial A(R)} > 0 \tag{42}$$

Prediction 3 *The illiquidity of tokens reduces the negative correlations between the total value of platforms and their ownership concentrations, i.e.,*

$$\frac{\partial^2 V_0}{\partial y_0 \partial \lambda} > 0 \tag{43}$$

Prediction 4 *Long-term incentives of the whale reduce the negative correlations between the growth rate of platforms and their ownership concentrations, i.e.,*

$$\frac{\partial^2 V_0}{\partial y_0 \partial T_L} > 0 \tag{44}$$

5 Data Description

Our empirical analyses draw data from several sources. Individual DAO investors' voting records are obtained from a popular voting platform that allows DAOs and other blockchain protocols (e.g. DeFi protocols) to create proposals and manage votes.[5] Unlike traditional on-chain voting systems, which charge voters gas fees for processing the movement of cryptocurrencies from one wallet to another, this *off-chain* platform enables gas-free voting.

We download all votes cast on proposals that were active during the period running from July 20, 2020 through July 31, 2022. The dataset includes a DAO's name, symbol and contract address of its voting token, proposal name and text, start date and deadline of voting, voter address, vote date, and number of votes cast.[6] Because anyone can create a DAO and feature it on the voting platform, most of the DAOs on the platform are small and do not appear to have any underlying business. Therefore, we start with a subsample of DAOs that are most likely to have underlying businesses: 460 DAOs which had received at least 650 individual votes as of the end of our sample period.

For most DAOs, participants use the underlying governance tokens to cast votes. However, a growing string of DAOs have shifted to a staking model, including the vote escrow/locking model that reward investors greater voting power and yields for locking their governance tokens. For each DAO, we locate the contract detail of its voting token by manually searching its contract address on the corresponding blockchain explorer (e.g. etherscan.io, bscscan.com, or polygonscan.com). The contract detail is used to determine a DAO's voting strategy. That is, whether investors of the DAO cast votes using its governance token

[5] To use the voting platform, a DAO needs to claim a domain on the Ethereum Name Service (ENS), a blockchain equivalent of the internet naming convention known as the Domain Name System (DNS). This voting platform automates key aspects of investor voting, including the selection of the voting mechanism, proposal and vote validation, and real-time vote tally.

[6] Information on voting strategies has been manually collected as the original data from the popular voting platform is incomplete.

or a staked token including a vote escrowed/locked token.

We then manually search these DAO names on CoinMarketCap, a website that is a top source of cryptocurrency market data and that covers most major cryptocurrencies. This step yields 381 cryptocurrencies that are associated with the DAOs. These 381 DAOs received more than 2.3 million individual votes, accounting for 41.3% of all votes in our initial sample. We then download their daily price and volume data. Of the 381 DAOs, 375 have associated price and volume data during our sample period.

Because a number of DAOs adopt staking and vote escrow/locking strategies, ownership of the underlying native governance token is unlikely to capture a voter's economic ownership represented by her votes cast. Therefore, we use the number of voters and the number of votes cast to proxy for the number of DAO members and ownership in the DAO, respectively. Because many DAOs do not feature proposals on a daily basis, we convert the voting data into weekly series. Specifically, for each proposal we first calculate the Herfindahl–Hirschman Index (HHI) of voting power, which is calculated by squaring the share of each individual's votes then summing the resulting numbers, the fraction of votes cast by the top three voters, and the number of voters. We then average each of the three variables for each DAO-week pair using proposals' deadlines.

To capture the size and growth of DAOs, we obtain daily total value locked (TVL) for each DAO from DefiLlama, which is a TVL aggregator and analytics dashboard for DeFi protocols. DefiLlama tracks protocols from over 80 blockchains, including major ones such as Ethereum, BNB Chain (i.e. Binance Smart Chain), Polygon, Avalanche, and Fantom. We manually search names of the 381 DAOs on DefiLlama and obtain a list of 248 that are featured by DefiLlama. We then download aggregate daily TVL for each of these DAOs if it is available. We merge week-end price, volume, TVL data into our weekly voting dataset using name and symbol. Our final dataset includes 207 DAOs that have non-missing price, volume, TVL data during our sample period.

5.1 Descriptive Statistics

Before reporting the summary statistics for the key variables in our study, we plot the aggregate TVL for our sample platforms. As shown in Figure 1, during the week of July 20, 2020, our platforms' combined TVL was around $889 million, a relative low starting point. However, TVL grew quickly as the DeFi and cryptocurrency spaces boomed as the COVID-19 pandemic dragged on, likely attributed to easy monetary policy and interest from retail investors. Total valuation surpassed $150 billion in early January 2022, before declining rapidly. By July 31, 2022, aggregate TVL was only $6.2 billion, a fraction of its peak. We note that this boom-and-bust pattern is consistent with the valuation cycle for the whole DeFi industry—the peak TVL of $181 billion was reached in December 2021 before dropping precipitously. This comparison also shows that our dataset captures most major DeFi platforms.

[Insert Figure 1 here.]

As shown in Table 1, during our sample period the average platform has a TVL of $1.2 billion while the median is only $103 million, suggesting the distribution of DeFi valuations is highly skewed. The average and median weekly TVL growth are both -0.9%, with an interquartile range of -8.8% to 7.5%. The weekly returns of the associated (governance) tokens are more negative, with the average and median being -4.3% and -3.5%, respectively. The average weekly HHI of voting power is 0.29 (equivalent to 2,900 points based on a maximum of 10,000 points), suggesting that the market is highly concentrated.[7] The largest

[7]Regulators generally consider markets in which the HHI is in excess of 2,500 points to be highly concentrated. See the Horizontal Merger Guidelines (2010) issued by the U.S. Department of Justice and the Federal Trade Commission.

three whales on average command almost two thirds of the voting power, supporting the notion that the DeFi market is highly concentrated. Remarkably, even at the 25th percentile, the top three whales still dictate 49% of the votes.

[Insert Table 1 here.]

The average (median) number of platform participants is 212 (46) while the average (median) age of platforms is six (five) months. The distribution of the illiquidity measure is skewed, with the average and median figures being 0.112 and 0.017.

6 Empirical Analyses

6.1 Ownership Concentration and Platform Growth

To test whether platform growth is negatively related to ownership concentration, as outlined in Prediction 1, we begin by regressing weekly TVL growth on past week's HHI of voting power, controlling for platform and week fixed effects. As shown in column (1) of Table 2, a one standard-deviation increase in HHI is associated with a 1.1 percentage-point decrease in weekly TVL growth. Given that the average weekly TVL growth is -0.9%, the marginal effect is substantial. To test whether a platform's valuation reduces the negative relationship between platform growth and ownership concentration (Prediction 2), we add to the specification used in column (1) an interaction term of HHI and lagged TVL and re-estimate it. A positive coefficient suggests that for larger platforms ownership concentration affects TVL growth less negatively. Indeed, the estimated coefficient on $HHI \times Lagged\ TVL$ is positive and statistically significant at the 5%, lending support to Prediction 2. Interestingly, platform size itself has a large negative effect on TVL growth, with a one standard-deviation increase in TVL being associated with a 5.1 percentage-point decrease in TVL growth. This is intuitive as larger and more mature platforms tend to grow more slowly (Cong, Li, and Wang, 2021).

Similarly, to test whether token illiquidity mitigates the negative correlation between platform growth and ownership concentration (Prediction 3), we replace the interaction term used in column (2) with an interaction term of HHI and Amihud illiquidity. The estimated coefficient on the interaction term is again positive and significant, consistent with the notion that the more difficult it is for whales to acquire large blocks of tokens the higher the platform growth is. Not surprisingly, token illiquidity negatively affects platform growth, with the marginal effects being 0.9 percentage points when the illiquidity measure increases by one standard deviation.

One concern is that illiquidity may be related to platform size, which is similar to illiquidity being generally negatively associated with a stock's market capitalization (see Amihud, 2002, among many others), causing potential omitted-variable bias. To mitigate such a concern, we further control for lagged platform size in the regression. As shown in column (4), the estimated coefficient on the interaction term becomes slightly larger and more significant. In column (5), we instead control for the number of participants as an alternative measure of platform size, which leads to consistent results.

[Insert Table 2 here.]

6.2 Whales' Ownership and Platform Growth

In addition to the negative correlation between platform growth and ownership concentration, proxied by the HHI of voting power, we explicitly study how ownership by the largest whales may affect platform growth. Whales' ownership is proxied by the fraction of votes cast by the top three voters in a given week. As reported in column (1) of Table 3, whales' ownership negatively influences platform growth, with the effect being significant at the

1% level. A one standard-deviation increase in whales' ownership is associated with a 2.6 percentage-point decrease in weekly TVL growth. This marginal effect is substantially larger than the average weekly TVL growth of -0.9%. Consistent with the results reported in Section 6.1, both platform size and token illiquidity reduce the negative correlation between whales' ownership and TVL growth, as the positive coefficients on the interaction terms in columns (2)-(5) suggest.

[Insert Table 3 here.]

Overall, our results reported in Sections 6.1 and 6.2 lend support to the theoretical prediction that ownership concentration, especially ownership by whales, is negatively related to platform growth. Such a negative effect is mitigated by platform size and token illiquidity.

6.3 Platforms' Long-Term Incentives and Growth

On most DeFi platforms, such as Lido DAO (LDO) and Uniswap (UNI), voters use the native governance tokens to vote on proposals. They use the one-token-one-vote model. However, in recent years a growing string of DeFi protocols have shifted to a staking model, the vote escrow model in particular, which is pioneered by Curve Finance (CRV), a DEX launched in January 2021. Investors would lock their governance tokens for up to four years. Vote weights and share of rewards are generally proportional to the preset time periods, which means that those that lock the governance token for a longer period will accrue greater voting power and enhanced yields. This mechanism potentially provides more long-term incentives to whales, making them more patient. Such a mechanism would boost platform growth, as predicted in Prediction 4.

In this subsection, we adopt an event-study framework to study whether adopting the staking model boosts platform growth. We identify 45 platforms which switched to a staking model during our sample period. For each of these platforms, we calculate TVL growth from Day -6 to Day 1, where Day 0 is the date when the staking model was adopted. The six-day period before adoption captures possible run-up in valuation in anticipation of the adoption. This is our treatment sample. Our control sample includes TVL growth from Day -6 to Day 1 for all the platforms that never adopted staking models. We then regress *TVL growth* on *Staking adoption*, which equals one for platforms that adopted a staking model and zero otherwise, controlling for certain platform characteristics.

As shown in column (1) of Table 4, a platform's TVL growth increased 8.3 percentage points after it adopted the staking model, controlling for lagged TVL, HHI of voting power, and platform and week fixed effects. This is highly significant given the average weekly TVL growth is slightly negative. As reported in columns (2)-(4), we obtain similar results when replacing HHI of voting power with whales' ownership, the number of participants, and platform age, respectively.

[Insert Table 4 here.]

7 Conclusion

In this paper, we explore conflicts of interest among token holders in DAOs, which are powered by open-source smart contracts. We develop a new theory that can explain why whales (large token holders in a DAO) may disrupt the long-term growth of the platform through "rug pulls," in which they inflate token prices before they start unwinding their positions. Our theoretical model features a whale who may enjoy private benefits through controlling the platform. The whale trades off between private benefit and the cost of manipulating voting outcomes; the cost includes a loss in public value as well as trading costs due to token illiquidity.

Our model predicts four major results: 1) a negative correlation between whales' voting power concentration and DAO growth; 2) mitigation of such a negative correlation as platforms become larger and more widely adopted; 3) similar dampening effects for platforms with illiquid tokens; and 4) alleviation of these DAO governance issues by shifting toward staking and vote escrow models that encourage long-term commitment incentives among whales.

Our empirical evidence strongly supports these theoretical predictions. Using the proposal-level voting outcomes and trading information of tokens from more than 200 DAOs running from July 2020 to July 2022, we confirm a negative correlation between voting power concentration and platform growth, which is significantly alleviated by large platform sizes and alternative voting mechanisms, including staking and vote escrow models.

Overall, our research fills a significant gap in the literature on DAO governance by incorporating micro-foundations of the conflicts of interest among different token holders and providing insights into alternative voting mechanisms to improve the effectiveness of this new type of digital organization. The effectiveness of DAOs is a crucial economic issue in the digital age, and thus, our research contributes to innovation in organizational economics and its practical implications for corporate finance and governance policies. Further questions remain to be explored in this important research area. We hope to return to these questions in subsequent research.

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Figure 1. Total Value Locked Over Time

This figure plots the weekly combined total value locked (TVL) for our sample DAOs. The sample period runs from July 20, 2020 (the week of July 20, 2022) to July 31, 2022 (the week of July 25, 2022).

Table 1. Descriptive Statistics

In this table, we report descriptive statistics on the 207 DAOs in our sample. The sample period runs from July 20, 2020 to July 31, 2022. *TVL* is total value locked in billions of dollars, reported by DefiLlama. *TVL growth* is the weekly growth rate of TVL. *Crypto return* is the weekly return of the crypto associated with each DAO. For each DAO, *HHI* is the average Herfindahl–Hirschman Index of the number of votes cast for proposals that end in a given week; *Top 3 ownership* is the average fraction of votes cast by the top three voters for proposals that end in a given week; and *No. of participants* is the average number of voters voting on proposals that end in a given week. Age is the number of years since a DAO's inception. *Amihud illiquidity* is the Amihud (2002) illiquidity measure, defined as the weekly average of $100\sqrt{|Return|/Dollar\ Trading\ Volume}$ using daily data.

	Average (1)	25th percentile (2)	Median (3)	75th percentile (4)	Std. Dev. (5)	Obs. (6)
TVL ($ billion)	1.209	0.013	0.103	0.601	3.163	2860
TVL growth	-0.009	-0.088	-0.009	0.075	0.233	2860
Crypto return	-0.043	-0.159	-0.035	0.079	0.265	2701
HHI	0.286	0.119	0.215	0.375	0.239	2860
Top 3 ownership	0.665	0.492	0.680	0.866	0.237	2809
No. of participants	212.1	15.4	46	150.5	556.4	2860
Age	0.508	0.159	0.425	0.781	0.411	2860
Amihud illiquidity	0.112	0.004	0.017	0.054	0.725	2650

Table 2. Ownership Concentration and Platform Growth

In this table, we report results on the relationship between ownership concentration and platform growth. The sample period runs from July 20, 2020 to July 31, 2022. All regressions are performed at the weekly frequency. *Lagged TVL* is total value locked in billions of dollars as of the end of the past week. *Amihud illiquidity* is the Amihud (2002) illiquidity measure as of the end of the past week. All other variables are as defined in Table 1. Standard errors are clustered at the platform level. In each column we report estimated coefficients and their associated t-statistics. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively. Singleton observations are dropped from each fixed-effects model.

	Dependent variable: TVL growth				
	(1)	(2)	(3)	(4)	(5)
HHI	-0.048**	-0.057**	-0.036	-0.038	0.004
	(-2.14)	(-2.35)	(-1.44)	(-1.49)	(0.13)
HHI × Lagged TVL		0.007**			
		(2.28)			
Lagged TVL		-0.016***		-0.013***	
		(-4.72)		(-4.41)	
HHI × Amihud illiquidity			0.029***	0.030***	0.029***
			(2.88)	(3.03)	(3.14)
Amihud illiquidity			-0.013***	-0.013***	-0.013***
			(-2.79)	(-2.86)	(-2.95)
log(No. of participants)					-0.015**
					(-2.31)
Observations	2,860	2,860	2,650	2,650	2,650
R-squared	0.12	0.13	0.13	0.13	0.13
DAO FEs	Y	Y	Y	Y	Y
Week FEs	Y	Y	Y	Y	Y

Table 3. Whales' Ownership and Platform Growth

In this table, we report results on the relationship between whales' ownership and platform growth. The sample period runs from July 20, 2020 to July 31, 2022. All regressions are performed at the weekly frequency. *Lagged TVL* is total value locked in billions of dollars as of the end of the past week. *Amihud illiquidity* is the Amihud (2002) illiquidity measure as of the end of the past week. All other variables are as defined in Table 1. Standard errors are clustered at the platform level. In each column we report estimated coefficients and their associated t-statistics. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively. Singleton observations are dropped from each fixed-effects model.

	Dependent variable: TVL growth				
	(1)	(2)	(3)	(4)	(5)
Top 3 ownership	-0.109***	-0.124***	-0.087***	-0.090***	-0.067*
	(-3.93)	(-4.11)	(-2.87)	(-2.94)	(-1.79)
Top 3 ownership × Lagged TVL		0.013**			
		(2.42)			
Lagged TVL		-0.023***		-0.013***	
		(-4.28)		(-4.47)	
Top 3 ownership × Amihud illiquidity			0.015**	0.015**	0.015**
			(2.47)	(2.57)	(2.57)
Amihud illiquidity			-0.012***	-0.012***	-0.012***
			(-2.76)	(-2.78)	(-2.84)
log(No. of participants)					-0.008
					(-1.43)
Observations	2,809	2,809	2,612	2,612	2,612
R-squared	0.13	0.14	0.14	0.14	0.14
DAO FEs	Y	Y	Y	Y	Y
Week FEs	Y	Y	Y	Y	Y

Table 4. Platforms' Long-Term Incentives and Growth

In this table, we report results on whether long-term incentives of a platform affects platform growth. The sample period runs from July 20, 2020 to July 31, 2022. *Implementing staking* is an indicator equal to 1 if a platform adopts staking or vote escrow as part of its voting strategy and zero otherwise. *TVL growth* is growth in TVL from Day -6 to Day 1, where Day 0 is the date when staking or vote escrow is adopted. All other variables are as defined in Table 1 and are measured as of the week immediately before the adoption date. Standard errors are clustered at the platform level. In each column we report estimated coefficients and their associated *t*-statistics. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively. Singleton observations are dropped from each fixed-effects model.

	Dependent variable: TVL growth			
	(1)	(2)	(3)	(4)
Implementing staking	0.083**	0.069**	0.080**	0.077**
	(2.44)	(1.98)	(2.35)	(2.39)
Lagged TVL	-0.002	-0.003	-0.002	-0.002
	(-1.05)	(-1.12)	(-0.77)	(-0.89)
HHI	0.009			
	(0.15)			
Top 3 ownership		0.036		
		(0.57)		
log(No. of participants)			-0.005	
			(-0.73)	
Age				-0.025
				(-0.49)
Observations	884	881	884	910
R-squared	0.15	0.16	0.15	0.16
DAO FEs	Y	Y	Y	Y
Week FEs	Y	Y	Y	Y

Appendix A

Proof of Lemma 1:

We conjecture that the value function of the user in $t \geq 1$ is an affine function of x_{t-1} and W_{t-1} as follows:

$$V_t^a(x_{t-1}, W_{t-1}) = \alpha_t + \beta x_{t-1} + W_{t-1}, \tag{A.1}$$

where α_t and β are constants. Note that α_t is time-dependent whereas β is not. We can ignore the short sale constraint because it never binds in equilibrium. Then, Eqs. (7) and (A.1) imply

$$\begin{aligned} V_t^a(x_{t-1}, W_{t-1}) &= \max_{\Delta x_t \geq 0} A(a)Nx_{t-1} + \delta\left[\alpha_{t+1} + \beta x_t + W_t\right] \\ &= \max_{\Delta x_t \geq 0} A(a)Nx_{t-1} + \delta\left[\alpha_{t+1} + \beta x_{t-1} + W_{t-1}\right] + (\delta\beta - P_t)\Delta x_t - \frac{\lambda}{2}\Delta x_t^2, \end{aligned} \tag{A.2}$$

where the second equality is due to Eqs. (8) and the fact that $(1 + r_f)\delta = 1$. The first order condition is

$$\delta\beta - P_t - \lambda\Delta x_t = 0, \tag{A.3}$$

which implies the optimal trading amount:

$$\Delta x_t = \frac{\delta\beta - P_t}{\lambda}. \tag{A.4}$$

Therefore, substituting the solution in Eq. (A.4) into the objective function in Eq. (A.2) yields the indirect value function as follows:

$$V_t^a(x_{t-1}, W_{t-1}) = \delta\alpha_{t+1} + \frac{(\delta\beta - P_t)^2}{2\lambda} + \big(A(a)N + \delta b\big)\, x_{t-1} + W_{t-1}, \tag{A.5}$$

Eq. (A.5) together with the initial conjecture in Eq. (A.1) implies that

$$\alpha_t = \delta\alpha_{t+1} + \frac{1}{2\lambda}\left(\delta\beta - P_t\right)^2, \tag{A.6}$$

and

$$b = A(a)N + \delta b. \tag{A.7}$$

Solving for α_t and β yields

$$b = \frac{1}{1-\delta}A(a)N = \frac{1}{\delta}P(a), \tag{A.8}$$

where the second equality is due to Eq. (4). This together with Eq. (A.6) in turn implies

$$\alpha_t = \delta\alpha_{t+1} + \frac{1}{2\lambda}\big(P(a) - P_t\big)^2. \tag{A.9}$$

By recursive substitution, we obtain the following from Eq. (A.9):

$$\alpha_t = \frac{1}{2\lambda}\sum_{s=t}^{\infty}\delta^{s-t}\big(P(a) - P_s\big)^2. \tag{A.10}$$

Therefore, this verifies our initial conjecture in Eq. (A.1) is indeed true.

Proof of Lemma 2:

Using Eq. (17) and (19), the objective function in Eq. (18) can be rewritten as follows:

$$V_{w,t}(y_{t-1}) = \max_{\{\Delta y_s\}} \sum_{s=t}^{T} \delta^{s-t} \left[A(a)N \left(y_t - \sum_{k=t}^{s-1} \Delta y_k \right) - P(a)\Delta y_s - \frac{\lambda_w}{2} \Delta y_s^2 \right], \tag{A.11}$$

Then, we can maximize the objective function Eq. (A.11) subject to the constraints Eqs. (19)-(20).[8] Because the short sale constraint never binds, the lagrangian of the problem is

$$\mathcal{L} = \sum_{s=t}^{T} \delta^{s-t} \left[A(a)N \left(y_t - \sum_{k=t}^{s-1} \Delta y_k \right) - P(a)\Delta y_s - \frac{\lambda_w}{2} \Delta y_s^2 \right] - \eta \left(y_t + \sum_{s=t}^{T} \Delta y_s \right), \tag{A.12}$$

where $\eta \geq 0$ is the lagrangian multiplier. The first order condition with respect to Δy_s is

$$A(a)N \left[\frac{\delta^{s-t+1} \left(1 - \delta^{T-s}\right)}{1-\delta} \right] - \delta^{s-t} \left(P(a) + \lambda_w \Delta y_s \right) = \eta, \tag{A.13}$$

or equivalently,

$$A(a)N \left(\frac{\delta}{1-\delta} \right) \left(1 - \delta^{T-s} \right) - P(a) - \lambda_w \Delta y_s = \delta^{-(s-t)} \eta. \tag{A.14}$$

The optimal solution for Δy_s given η is given by

$$\Delta y_s = \frac{1}{\lambda_w} \left[A(a) \left(\frac{\delta}{1-\delta} \right) \left(1 - \delta^{T-s} \right) - P(a) - \delta^{-(s-t)} \eta \right]. \tag{A.15}$$

Using the constraint Eq. (19), summing across the first order conditions Eq. (A.14) for

[8] A similar approach is used in Binsbergen, Han, Ruan, Xing (2023), but our model generalizes it by further including strategic trading under price impact (i.e., endogenous prices) as well as utility flows of the investment opportunity.

all Δy_s's yields

$$A(a)N\left(\frac{\delta}{1-\delta}\right)\left(T-t+1-\delta^{T-t}\Gamma\right)-(T-t+1)P(a)+\lambda_w y_t=\Gamma\eta. \tag{A.16}$$

where Γ is a constant strictly greater than one:

$$\Gamma=\sum_{k=t}^{T}\delta^{-(k-t)}=\frac{1-\delta^{-(T-t+1)}}{1-\delta^{-1}}. \tag{A.17}$$

Then, the lagrangian multiplier λ is given by

$$\eta=\frac{1}{\Gamma}\left[A(a)N\left(\frac{\delta}{1-\delta}\right)\left(T-t+1-\delta^{T-t}\Gamma\right)-(T-t+1)P(a)+\lambda_w y_t\right]. \tag{A.18}$$

Using Eqs. (A.15) and (A.18), we derive the closed-form solution for Δy:

$$\Delta y_s=-\delta^{-(s-t)}\frac{y_t}{\Gamma}+\frac{1}{\lambda_w}\left[A(a)N\left(\frac{\delta}{1-\delta}\right)-P(a)\right]\left(1-\frac{\delta^{-(s-t)}}{\Gamma}(T-t+1)\right). \tag{A.19}$$

From Eq. (4), we have

$$P(a)=\frac{A(a)N}{r_f}=\frac{\delta}{1-\delta}A(a)N. \tag{A.20}$$

Therefore, Eqs. (A.19)-(A.20) imply that

$$\Delta y_s=-\delta^{-(s-t)}\frac{y_t}{\Gamma}. \tag{A.21}$$

Finally, substituting Eq. (A.21) into Eq. (A.11) yields the indirect value in Eq. (23).

Proof of Lemma 3:

When the whale implemented the proposal ($a = I$), the value function of users in Lemma 1 together with the equilibrium price process in Eq. (34) implies that the intercept in the value function in $t = 2$ is given by

$$\alpha_2 = \frac{\lambda}{2\Gamma(2,T)} \frac{\bar{x}^2}{N^2}, \tag{A.22}$$

which in turn implies the intercept in the value function in $t = 1$ is given by

$$\alpha_1 = \frac{1}{2\lambda}(P(I) - P_1)^2 + \delta\alpha_2 \tag{A.23}$$

$$= \frac{\lambda}{2N^2}\left[(\bar{x} - y_0)^2 + \frac{\delta\bar{x}^2}{\Gamma(2,T)}\right] \tag{A.24}$$

Therefore the value of users in $t = 1$ is

$$V_1(x_0, W_0) = \frac{\lambda}{2N^2}\left[(\bar{x} - y_0)^2 + \frac{\delta\bar{x}^2}{\Gamma(2,T)}\right] + \frac{1}{\delta}P(I)x_0 + W_0. \tag{A.25}$$

Finally, the value in $t = 0$ becomes

$$V_0(I) = -\bar{P}x_0 + \delta V_1(x_0, W_0) = -\bar{P}(1 - y_0) + \delta V_1(1 - y_0, 0) \tag{A.26}$$

$$= (P(I) - \bar{P})(1 - y_0) + \delta\frac{\lambda}{2N^2}\left[(\bar{x} - y_0)^2 + \frac{\delta\bar{x}^2}{\Gamma(2,T)}\right]. \tag{A.27}$$

When the whale implemented the proposal ($a = R$), the value function of users in Lemma 1 together with the equilibrium price process in Eq. (34) implies that the intercept in the value function in $t = 1$ is given by

$$\alpha_1 = \frac{\lambda}{2N^2}\frac{\bar{y_0}^2}{\Gamma(1,T)}. \tag{A.28}$$

Then, the value of users in $t = 1$ is

$$V_1(x_0, W_0) = \frac{\lambda}{2N^2}\frac{\bar{y_0}^2}{\Gamma(1,T)} + \frac{1}{\delta}P(R)x_0 + W_0. \tag{A.29}$$

Therefore we can obtain the value in $t = 0$ as follows:

$$V_0(R) = -\bar{P}x_0 + \delta V_1(x_0, W_0) = -\bar{P}(1 - y_0) + \delta V_1(1 - y_0, 0) \tag{A.30}$$

$$= (P(I) - \bar{P})(1 - y_0) + \delta\frac{\lambda}{2N^2}\frac{\bar{y_0}^2}{\Gamma(1,T)}. \tag{A.31}$$

Then the difference between $V_0(R)$ and $V_0(I)$ is positive due to Eq. (29).