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Control of Decentralized Autonomous Organizations†

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Recently, blockchain has been used to develop a new organizational form: decentralized autonomous organizations (DAOs). DAOs are organizations that facilitate coordination between large numbers of individuals. The objectives of DAOs can be either for profit or nonprofit, with most focusing on activities related to cryptocurrencies or Web3. In contrast to corporations and other types of business entities, DAOs typically do not have managers or directors with formal decision rights. Rather, decisions are subject to a vote by the DAO members. This community-based approach to decision-making is a critical aspect of a variety of DAO functions (e.g., product design, treasury management).

As their name indicates, DAOs seek to avoid centralized decision-making. The extent to which this is achieved is unclear. If voting rights are concentrated, a DAO may be controlled by a small number of users. Indeed, an important regulatory concern in this space is how to police misleading characterizations, particularly regarding the extent of decentralization (Grennan 2022). In this study, we examine 10,639 proposals across 151 DAOs to assess the degree to which decision-making in DAOs is decentralized.

I. Background

Activities of a DAO are governed by a "smart contract," a code programmed on a blockchain that automatically executes when predefined conditions are met. DAOs use a smart contract to define their governance structures. For example, a smart contract can define, among other things, how many tokens must be held to create a proposal, when a quorum is reached for a vote, and the support required for a proposal to pass.

Control of a DAO ultimately rests with the holders of its governance token. Tokens allow for members of a DAO to offer proposals and vote for their implementation. In some cases, token holders are entitled to fees/revenue generated by the DAO or to receive other perquisites (e.g., access to events). The initial allocation of tokens is typically split between the founders of a DAO, large investors (sometimes VCs or other institutions), the public, and the DAO's treasury. Tokens for many DAOs trade on secondary markets (e.g., Coinbase).

The growth of DAOs as an organizational form has been rapid. The first entity organized as a DAO, an investor-directed venture capital fund ("The DAO"), was created in 2016 (Huberman, Leshno, and Moallemi 2019). As of mid-2022, there are 4,000 active DAOs with aggregate treasury assets of $20 billion (Cointelegraph 2022). The economic activities pursued by DAOs are varied in nature. DAOs are most commonly used in decentralized finance (DeFi) (Harvey, Ramachandran, and Santoro 2021; Makarov and Schoar 2022). In the following section, we provide examples of DAOs and the activities they undertake.

II. DAO Examples

A. *Uniswap DAO*

The Uniswap DAO controls Uniswap (UNI), a decentralized exchange (DEX) based on self-executing (i.e., smart) contracts (Lehar and Parlour 2022). Governance decisions (e.g., fees charged to users) are made by the DAO based on the holdings of the UNI token. As of November 2022, the market capitalization of UNI tokens is approximately $5 billion, down from its all-time high of over $20 billion the previous year. The largest holders of UNI (by

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voting power) include the venture capital firm Andreessen Horowitz (a16z).

B. *BitDAO*

BitDAO is an investment fund that provides funding to crypto-related projects via grants and seed capital. BitDAO's governance token, BIT, allows users to approve potential projects. Major investors in BitDAO include the cryptocurrency exchange Bybit as well as venture capitalists such as Founders Fund and Peter Thiel. As of November 2021, BitDAO's treasury exceeds $2 billion.

C. *LinksDAO*

LinksDAO was created to fund and purchase a country club. The DAO raised $10.4 million in January 2022 by selling NFTs that entitle holders to governance rights but not membership in the purchased course. The members of LinksDAO primarily consist of golf enthusiasts.

III. Characterizing DAO Control

Several reasons are typically cited for why DAOs seek decentralization, including better decisions, censorship resistance, and fairness.[1] While the structure of DAOs mitigates the need for managers and directors with decision-making authority, the extent to which they achieve decentralization also inherently depends on their ownership structure. That is, if token ownership is highly concentrated, a small number of members can control and influence decisions.

It is helpful to consider the control of DAOs in the context of standard agency theory. A rich literature in financial economics studies the relationship between ownership structure and monitoring. If ownership is dispersed, individuals have weak incentives to monitor, as they capture a small portion of the effort they expend. If ownership is concentrated, monitoring incentives are stronger (e.g., Shleifer and Vishny 1986; Grossman and Hart 1980).

Concentrated ownership may also be costly given that there are incentives to "tunnel" assets to gain private benefits (e.g., Bertrand, Mehta and Mullainathan 2002). For example, DAOs are susceptible to "governance attacks," an extreme form of tunneling. In a governance attack, a bad actor legally acquires (by buying/borrowing tokens) voting power and uses this power to manipulate the DAO's governance rules for a private benefit. For example, attackers could vote to pay themselves a large dividend from the DAO's treasury. Given that such attacks stem from manipulation of encoded rules, they cannot be addressed through cryptography or cybersecurity.

Appel and Grennan (2023a) examine several additional trade-offs associated with decentralized governance. Aspects of governance that promote broad participation in decision-making or enhance security are associated with positive outcomes. In contrast, barriers to the adoption of improvement proposals are associated with negative outcomes. The findings are consistent with the notion that under an agency framework, concentrated decision-making can lead to the expropriation of minority token holders.

In Table 1, we characterize the control of DAOs. The top of the table focuses on three broad categories of DAOs: DeFi, infrastructure, and Web3. We manually classify each DAO in our sample into one of these broad categories. DeFi accounts for approximately 61 percent of DAOs and proposals in our sample. Infrastructure DAOs, which create/manage tools to help scale the crypto industry (e.g., Ethereum Name Service), account for 7 percent of DAOs and 3 percent of proposals in our sample. Web3 DAOs, which engage in a variety of activities related to new internet services (e.g., gaming, social clubs), account for 32 percent of DAOs and 36 percent of proposals in our sample.

Our analysis indicates that decision-making in DAOs is highly centralized. The mean Herfindahl-Hirschman index (HHI) across all three DAO categories is high, exceeding 0.29. The average voting power of the largest address is sizable, ranging from 39 percent (Infrastructure) to 45 percent (DeFi). For the top three voting addresses, power ranges from 67 percent to 71 percent, and the top three voters cast the majority of votes for more than 69 percent of proposals. The top three token holders also tend to vote in unison; between 61 percent and 79 percent of votes cast by top three token holders are unanimous. Our findings indicate that most DAO

[1] See Vitalik Buterin, "DAOs Are Not Corporations: Where Decentralization in Autonomous Organizations Matters," available at https://vitalik.ca/general/2022/09/20/daos.html.

Table 1—DAOs and Token Holder Control

	DAOs	Proposals	Mean HHI	Mean power top 1	Mean power top 3	Pct. top 1 control	Pct. top 3 control	Pct. top 3 unanimous
Panel A. DAOs by mutually exclusive category								
DeFi	93	6,518	0.334	45%	71%	35%	78%	79%
Infrastructure	10	267	0.298	39%	68%	25%	69%	61%
Web3	48	3,854	0.310	42%	67%	31%	72%	72%
Panel B. DAOs by nonmutually exclusive functionalities								
DeFi								
Borrowing/lending	27	1,189	0.337	45%	73%	36%	82%	81%
DEXs and AMMs	44	3,797	0.338	47%	73%	37%	81%	73%
Liquidity staking	61	3,496	0.294	40%	68%	27%	72%	77%
Stablecoin	20	1,603	0.361	48%	74%	40%	82%	81%
Infrastructure								
Tooling	38	1,912	0.389	47%	73%	37%	79%	84%
Web3								
Asset management	25	1,695	0.319	44%	69%	33%	78%	81%
Gaming	13	1,902	0.372	49%	73%	45%	80%	69%
Media and curation	18	2,227	0.345	46%	72%	39%	79%	70%
Public goods	28	1,084	0.297	41%	68%	29%	73%	76%
Social clubs	21	1,097	0.198	30%	57%	13%	60%	74%
Talent and gig work	29	1,087	0.318	41%	65%	29%	65%	81%
Web3 miscellaneous	55	4,067	0.304	41%	66%	31%	70%	73%

Notes: This table reports summary statistics for proposals brought to a vote for 151 DAOs between 2020:II and 2022:III. Panel A reports statistics for DAOs classified into three mutually exclusive categories: DeFi, Infrastructure, and Web3. Panel B reports statistics on DAOs classified by common functionalities. These functionalities are not mutually exclusive and recognize that some DAOs serve multiple functions (e.g., tooling and liquidity purposes or a DeFi DAO with some Web3 functionalities). Mean power top 1 is the mathematical average across the set of proposals in the DAO category/functionality of the percentage of tokens voted by the largest token voter on each proposal. Pct. top 1 control represents the percent of proposals in the DAO category/functionality for which the largest voter of tokens accounted for the majority of total tokens voted. Mean power top 3 and Pct. top 3 are calculated analogously for the top three voters. The final column reports the percentage of proposals with unanimous votes by the top three voters..

Source: Authors' calculations using data collected from 151 DAOs linktrees and then matched to 10,639 proposals and voting records. See Appel and Grennan (2023b) for data and code and Appel and Grennan (2023a) for a more comprehensive discussion of DAOs, proposals, and voting.

proposals are controlled by the top three token holders, highlighting the centralized nature of decision-making in these organizations.

The remainder of Table 1 examines heterogeneity across specific functionalities of DAOs. In this case, we allow for multiple classifications of DAOs. We limit the sample to functionalities with at least 1,000 proposals. We find evidence of significantly different levels of centralization across these types. For example, within Web3, social club DAOs tend to have relatively low levels of centralization (HHI = 0.198), while gaming DAOs tend to have relatively high levels (HHI = 0.372). For DeFi, measures of centralization are similar across the different functionalities (e.g., stablecoins, borrowing/lending), with HHI ranging from 0.29 to 0.36 and the power of the top voter ranging from 40 percent to 48 percent. In Appel and Grennan (2023a), we highlight factors of the governance and voting process that potentially explain the differing levels of centralization across functionalities.

Finally, we analyze the evolution of the control of DAOs over time. Figure 1 plots the concentration of DAOs between 2020:II and 2022:III. Over this period, HHI fell by nearly a third, from 0.45 to 0.30. This drop in concentration coincided with a large increase in the number of proposals. In early 2020, there were hardly any DAO proposals. By 2022, DAOs in our sample voted on approximately 2,000 proposals per quarter. This finding suggests that the concentration of DAOs may continue to decline as the organizational form matures.

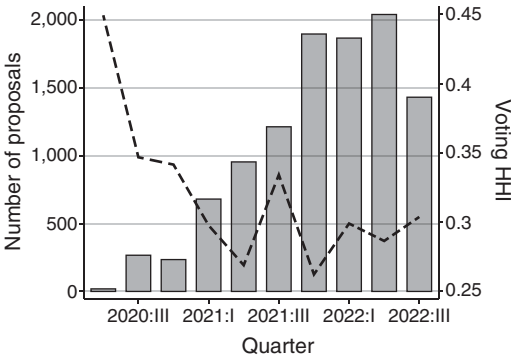

FIGURE 1. TRENDS IN DAO VOTING HHI AND NUMBER OF PROPOSALS

Notes: This figure plots the number of DAO proposals brought to a vote and the voting HHI associated with those proposals from 2020:II to 2022:III. The bars represent the number of proposals with a starting vote date in the quarter. The dashed line represents the average voting HHI associated with those proposals.

Source: Authors' calculations using data collected from 151 DAOs linktrees and then matched to 10,639 proposals and voting records. See Appel and Grennan (2023b) for data and code and Appel and Grennan (2023a) for a more comprehensive discussion of DAOs, proposals, and voting.

IV. Conclusion

DAOs are a new type of organizational form that seeks to decentralize decision-making. Our findings indicate that DAO proposals are typically highly centralized, but the degree of centralization appears to be decreasing as the organizational form matures. Appel and Grennan (2023a) consider the consequences of the unique aspects of DAO governance more broadly. For example, the centralized nature of DAOs may be a consequence of their ability to "fork," which occurs when enough members vote to make a change to the basic set of rules that results in a DAO splitting and creating a second DAO. The relative ease of forking a DAO potentially limits the negative effects of centralization, as dissident members can pursue their objectives independently.

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