The Economics of Decentralized Autonomous Organizations*

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ABSTRACT

The advent of blockchain, smart contracts, and Web3 has empowered new concepts for equity partnerships with autonomous operating systems and democratic corporate governance. This paper explores 2,377 of such new partnerships and uses detailed transaction data (from 2017 through 2022) to examine the performance of so-called *decentralized autonomous organizations* (DAOs) on Ethereum. As a result, I find that DAOs with greater participation rates in voting are associated with superior performance. Small members are a prevalent and important class of investors, while the degree of decentralization in DAOs (ownership concentration) plays only a minor role in firm valuation. Overall, DAOs are an effective organizational structure, when members take an active interest in the venture.

Keywords: Corporate Governance, Ownership, Shareholder democracy, Wealth management, Decentralized autonomous organizations (DAO), Decentralized Finance (Defi), Ethereum

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1 Introduction

Decentralized autonomous organizations (DAOs) have recently emerged as a new alternative management structure for innovative FinTechs companies that operate on the blockchain.[1] A rich feature of these organizations is that their operations are entirely transparent and fully automatized by computer algorithms that are jointly owned and managed by investors. While traditional organizations are hierarchical in structure, DAOs forego the need for executives through the processes of majority voting and coalition building. This unique democratic structure enables coordination without central authority and may eliminate traditional agency costs, since shareholders become the managers of their own corporation (Jensen and Meckling, 1976; Fama and Jensen, 1983b).

Although the concept is pre-mature, DAOs have skyrocketed in popularity in the past two years, to $12 billion in assets under management (AUM) and with more than 2 million users within the past two years. This dramatic increase raises questions on the efficacy and persistence of DAOs: Can a shared and digital community of anonymous people establish a fully functioning company? Does *shareholder democracy* add more value to firms, and to what extent does this active participation pay off for investors?

This article answers these questions by constructing the most extensive and thoroughly documented set of managerial decisions of 2,377 DAOs on the Ethereum blockchain to date. The sample period extends 5 years, from February 2017 to December 2022. Although DAOs have gained increased prominence over the last few years, there has been only limited empirical work on individual cases.[2] To the best of my knowledge, this is the first large sample study to concentrate on three different business types, including FinTechs and other platforms, venture capital and investment funds in 11 market sectors.

[1] These FinTech companies offer financial services to blockchain users, such as lending, saving, exchanging and investing, through their platforms. The difference between them and to traditional FinTechs is the involvement of distributed ledger technology. Other types of (platform) businesses, which use blockchain for daily operations, include, e.g., the music recording industry, health care, real estate, logistics, and the management of intellectual property.

[2] See e.g. Nadler and Schär (2020); Jensen et al. (2021); Barbereau et al. (2022a,b); Fritsch et al. (2022); Sun et al. (2022).

Because DAOs keep fully transparent records, shareholders' incentives, commitment, and economic consequences within and across organizations become observable. This new data availability may advance the understanding of firm performance and corporate governance, and contributes to current research questions in traditional finance, such as, when the combination of ownership and control is efficient (see e.g. Ivashina and Lerner, 2019), whether shareholder activism benefits the company, and how large the costs and gains of such engagement are, particularly for different investor groups with diverse risk and return profiles, investment horizons, and cross-ownerships among rival firms (see e.g. Azar et al., 2018; Chen et al., 2019; Gryglewicz et al., 2020; Lewellen and Lewellen, 2022).

This paper extends the corporate finance literature on firm and fund performance, partnerships, shareholder activism, agency costs, and ownership structure while also drawing on the emerging academic research on blockchain economics and crypto-assets (Yermack, 2017; Cong and He, 2019; Cong et al., 2021b, 2022; Makarov and Schoar, 2022). The first part of the paper explores the economic activity within DAOs and provides descriptive evidence on proposals, voting, ownership, funds, business, and growth. For example, most of the DAOs are composed of FinTechs, that are majority-owned by about 5,000 members, on average. The voting participation rates are generally low and volatile over time. Nevertheless, DAOs manage considerable sums, while DAO participants vote mostly on the development and improvement of their platforms and services. Although investments in DAOs likely contribute to innovation and economic growth, they are extremely risky, in the sense that only 13 DAOs achieve excess returns of 10% on average.

The second part of the paper investigates the performance of DAOs in relation to ownership structure and voting participation (equivalent to the degree of hierarchy or centralization in DAOs). Using accounting and market measures of firm performance (measured by AUM and market capitalization in $), I first conduct a cross-section regression to compare the firm value of centralized and decentralized governed DAOs. Next, I investigate the impact of active/passive owners, voting activism, and the discrepancy in voting outcomes on firm per-

formance. Because of endogeneity issues, I also employ a panel vector autoregression (VAR) model to consider interrelations between concentrated ownership, voting participation and firm value.

Similar to the corporate finance research, I hypothesize that DAOs' performances are associated with size, age, asset structure, and productivity. In particular, large DAOs may perform better than small DAOs because of greater financial support and more skilled members. However, it is also plausible to assume that large DAOs incur diseconomies of scale because more members may need to take more time and effort to coordinate themselves. A larger membership in DAOs can therefore have its limitations when it comes to time-critical decision-making, and I expect the relationship between DAOs' performance and size to be nonlinear. Furthermore, I control for the length of time that a DAO has been in existence because firm age proxies for the work experience and team learning of members. In addition, I control for DAO asset structure (value of cryptocurrencies in $ divided by fixed assets in $) to proxy for DAO liquidity. Finally, I hand-collect information on DAOs' operating activities, measured by the number of network revisions on GitHub.

As a result, I find that DAOs' ownership structures become more diversified (decentralized) over time, but they do not affect firm value. Instead, DAO firm valuation is a function of its members' voting activism, firm size, age and GitHub activities. These results are striking because economic theory and corporate finance literature suggest that large partnerships are extremely fragile and inefficient. Because of free-riding problems, it is necessary to engage partners with incentives and reward for activity. But if ownership is only marginally important, why do members participate in DAOs?

Intuitively, it could be argued that payoffs are independent from ownership and tied to active participation. Moreover, large memberships allow to raise additional capital, even though the ownership structure is unequal. Similar reasoning is provided by Fahlenbrach and Stulz (2009), who argue that young and small businesses use managerial ownership as a cheap form of financing. When the company grows and becomes more profitable, managers

decrease their stakes without compromising their positions or the firm's valuation.

The results are statistically and economically significant and robust to endogeneity. Moreover, the study is not subject to survivorship bias, reporting/filling errors, or selection bias, because blockchain data provide actual returns of successful and non-surviving DAOs.

This paper is structured as follows. Section 2 provides background information on DAOs and reviews literature. Section 3 introduces the data and constructs useful metrics for the analyses. Section 4 reviews methodology and discusses results. Section 5 concludes.

2 Related literature and development of hypotheses

Institutional background

In technical terms, DAOs are networks of several interconnected computer codes, commonly referred to as *smart contracts* or protocols, which utilize blockchain as an infrastructure layer in order to operate a (FinTech) platform business (Vergne, 2020; Langley and Leyshon, 2021). The creation of DAOs requires specialized programming skills to automatize processes and link firm operations (e.g. voting schemes, structural decisions, or investment management) together. Several platforms emerged to facilitate the deployment of smart contracts on open-source blockchains, which, consequently, led to a surge in new DAO creations over the past few years (Faqir-Rhazoui et al., 2021; Hassan and De Filippi, 2021).[3]

In general terms, DAOs are pooled crypto-funds for a specific mission. Usually, a group of stakeholders team up and distribute voting (and/or dividend) rights among the organization through the issuance of *governance tokens*, i.e. self-generated (so-called native) cryptocurrencies with stock-like properties. The distribution depends on the size of the members' stakes and secures a company's funding. Like traditional equity, governance tokens are offered for sale in the primary market (e.g. through token offerings), or are traded on exchanges. Usually, each governance token entitles their owners to one vote for or against a

[3]Famous platforms to create DAOs are e.g. Aragon, Compound, DAOhaus, and DAOstack, which are themselves governed by a DAO community.

timely limited proposal. Similar to shareholders, DAO members can submit ideas, requests, or recommendations, on which the community will decide. All voting and decisions are taken openly on the blockchain and require majority approval or a pre-defined quorum of votes. The voting logic is fixed and inscribed in the smart contracts, which manage the democratic decision-making process autonomously. Other decentralized organizations enable the voting off-chain, e.g. the ability to accept proposals from anyone outside the DAO, in order to minimize transaction costs or to limit visibility.

Since every DAO participant is financially involved and bears the risk of default, all agents ideally share the same organizational objective and have an incentive to increase firm value. By assigning control to ownership, members can run the organization collectively, prioritize mutual interests, and mitigate the classic owner-manager conflicts described in Jensen and Meckling (1976); Fama and Jensen (1983b). Yet, why could DAOs still fail?

The Free Rider Problem in DAOs

In economic terms, DAOs can be described as *deterministic* equity partnerships, where (i) specific knowledge relevant to decision-making is spread among many participants (Fama and Jensen, 1983b), and (ii) participants' actions jointly determine production output and their payoffs (Alchian and Demsetz, 1972; Holmstrom, 1982). This organizational structure is closest to that of venture capital, consultancy, accounting firms, for instance, with up to a thousand partners (Huddart and Liang, 2005).

Literatures in economics have long debated the functioning of such partnerships and constructed theoretical models to solve for an optimal structure design. The main issue in partnerships is that individuals have incentives to shirk their responsibilities (e.g. team production, mentoring peers). This problem results in inefficiencies and become especially severe in large partnerships (Holmstrom, 1982; Huddart and Liang, 2005). Hence, hierarchy is needed to increase monitoring efforts and productivity.

Another option is to impose an equal profit and risk-sharing between partners to en-

sure that individuals do not free ride (Alchian and Demsetz, 1972). However, even without distributing equal stakes, partnerships can be sustainable when group penalties are sufficiently large.[4] Because partners' payoffs are interdependent, individuals would engage in monitoring, dissolve inefficiencies and increase productivity (Legros and Matthews, 1993).

In contrast to traditional partnerships, DAOs are transparent and have liquid shares. Furthermore, DAO's participants can be anonymous and they decide democratically (without having senior partners). These significant differences contrast with the assumptions of previous theoretical models and may lead to other results. For example, monitoring can be less costly because it is possible to observe the firm's output, individual contributions, and the quality of teamwork. Participants of DAOs do not have to commit themselves long-term and exit the organization quickly (without the consent of other peers) when inefficiencies and losses abound (Morrison and Wilhelm Jr, 2004, 2008).

Agency conflicts in DAOs

In traditional firms, agency costs arise when managers (agents), acting on behalf of shareholders (principals), behave opportunistically and in a self-serving manner. Unless interests are not perfectly aligned or agents are not monitored, managers can take hidden actions and exploit them to their advantage. In DAO firms, the primary agency problems arise between principals (investors acting as managers) because of heterogeneous preferences and privileges. For example, insiders and powerful token holders can advance their personal interests at the expense of the community, while minority owners are outweighed by the asymmetric power distribution (Morck et al., 1988; Shleifer and Vishny, 1997; La Porta et al., 1999, 2002). Similar agency-related conflicts between principals can intensify between different types of investors with diverse levels of cross-holdings, such as mutual funds and family owners (see e.g. Chen et al., 2019; Lewellen and Lewellen, 2022), risk and return profiles, and investment horizons (see e.g. Azar et al., 2018; Gryglewicz et al., 2020).

[4]For examples, fines, (see e.g. Legros and Matthews, 1993) or corporate reputation, (see e.g. Morrison and Wilhelm Jr, 2004, 2008).

To alleviate agency costs, investors should hold equal ownership stakes with equal control rights. This self-monitoring partnership structure provide optimal incentives for team productivity and commitment (Alchian and Demsetz, 1972; Morrison and Wilhelm Jr, 2008). Yet recent academic literature on DAOs shows a striking degree of centralization in the distribution of governance tokens, i.e. ownership concentration (see e.g. Nadler and Schär, 2020; Jensen et al., 2021; Barbereau et al., 2022a,b; Fritsch et al., 2022; Sun et al., 2022). While much of the previous research efforts on DAOs are preliminary and based on case studies, it remains an open question which ownership structure (as a form of corporate governance) is optimal. If DAOs exhibit such power imbalances, does large ownership of a few powerful owners destroy or create value, and how detrimental are free riders and agency costs?

Optimal Corporate Governance in DAOs

In conventional firms, large institutional shareholders maximize firm value because they have economic incentives to monitor and discipline management (Jensen and Meckling, 1976; Shleifer and Vishny, 1986; Demsetz and Lehn, 1985).[5] In contrast to traditional firms, DAOs are special zero-debt organizations with direct incentives (i.e. equity-based compensation), but with no internal monitoring system, legal status, or investor protections in place. Because governance mechanisms, such as debt-holders, board oversight, or regulation are absent, agency theory predicts that large controlling owners will engage in managerial opportunism and become more entrenched (see e.g. Demsetz, 1983; Fama and Jensen, 1983b; Morck et al., 1988; Stulz, 1988). Yet, these effects may be offset.

While it might be not in the spirit of a blockchain-based community, centralization offers well-known benefits by trading managerial autonomy for faster coordination and scale efficiencies. This debate is fundamental in the literature on traditional organizational struc-

[5]While small shareholders have low incentive to oversee management, large institutional ownership can reduce agency frictions and solve free-rider problems (Grossman and Hart, 1980; Admati et al., 1994). Moreover, Shleifer and Vishny (1986, 1997); La Porta et al. (1999, 2002) argue that concentrated ownership can substitute legal protection for minority shareholders in countries with weak regulation, while they can also benefit firm value due to reputation.

ture (Boot et al., 2006, 2008; Boot and Thakor, 2011), blockchain governance, and mining research (Cong et al., 2021a; Gan et al., 2021; Makarov and Schoar, 2021).[6]

At the corporate level, retail investors might be too uninformed to make effective business decisions. Concentrated ownership, for instance, by founders, families, activists or corporate insiders can therefore improve decision-making and increase firm value, even though minority owners can be outweighed (Fama and Jensen, 1983a; DeAngelo and DeAngelo, 1985).[7]

Another argument in favor of centralization is that DAOs with diffuse ownership are more exposed to hostile takeovers and security threats than DAOs with large token holders. For example, malicious actors could acquire sufficient stakes to corrupt protocols and impose changes to the DAO network to which other members do not consent to. In the worst-case scenario, a central authority would obtain full corporate control and take over all codes and funds.[8]

The mindful examination of Barbereau et al. (2022a) illustrates that the rights of governance tokens can be highly individual and immediate comparisons between governance tokens and should be handled with great care. In this context, DAOs can remain a diffuse ownership structure without diluting insiders' control.[9] It is therefore essential to distinguish the actual power to alter a DAO's protocol (e.g. in order to allocate resources) from

[6]Blockchain networks, such as Bitcoin or Ethereum, can be considered as DAOs that are coordinated by freely accessible protocols. Altough no central entity controls the networks, empirical research finds a high degree of centralization in generating (mining) and owning cryptocurrencies.

[7]Related literature on family ownership, insider ownership, and shareholder activism support this prediction. For instance, Anderson et al. (2003); Villalonga and Amit (2006) evidence lower agency costs between different principals despite dominant family ownership. The rationale is that family firm owners are less diversified and largely concentrate their wealth in a single company. This creates unique incentives because family firm owners become more concerned about their firms' long-term survival than other shareholders (Casson, 1999; Anderson et al., 2003; Villalonga and Amit, 2006). Grossman and Hart (1980); Shleifer and Vishny (1986); Denes et al. (2017) discuss that large activists in firms provide an inherent monitoring function of managerial decisions with substantial valuation effects. Small shareholder activism remains most often ineffectual and is associated with minimal value impact. The literature on insider ownership finds firm value to be a non-monotonic function of directors' or CEOs' stock holdings, with firm value appreciation after ownership levels increasing to more than 50%, see Griffith (1999); McConnell and Servaes (1990); Griffith et al. (2002).

[8]See case studies of robbed crypto-exchanges, e.g. Micah Zoltu, 2019, How to turn $20M into $340M in 15 seconds, William Foxley, 2020, Fishy Business: What Happened to $1.2B Defi Protocol SushiSwap Over the Weekend, and Charlie Osborne, 2022, Beanstalk Defi project robbed of $182 million in flash loan attack.

[9]For example, by limiting access with *permissioned* smart contracts, DAO founders can prevent hostile exploits, see (Yermack, 2017; Azouvi et al., 2018).

the (off-chain) voting rights of governance tokens, assuming that DAO members can even decide on important matters.[10] Meanwhile, even without decoupling corporate control from ownership, centralization in DAOs may also arise from passive or unbalanced community engagement over time (Schmidt and Fahlenbrach, 2017).

Ultimately, Nadler and Schär (2020) argue that ownership structure can also be incorrectly computed because raw on-chain data are complex and difficult to process. While a naïve analysis assumes that a significant share of tokens is associated with an exchange wallet address, it is in reality owned by the many investors who trade on this exchange. For this reason, large liquidity, lending, and staking pools in particular need to be adjusted to infer the ownership structure accurately. The absence of such careful treatment could overestimate token holdings in Defi "by approximately 100% and in some extreme cases by up to 700%" (see Nadler and Schär, 2020, p.7). This paper follows this recommendation and adjusts the ownership structure accordingly.

In light of all these findings I hypothesize that, all else equal, DAOs with a *centralized governance* (concentrated ownership) should be associated with a higher firm performance than DAOs with a *decentralized governance* (diluted ownership).

3 Data and descriptive statistics

3.1 Sample construction and summary statistics

The starting point of the sample construction is the data on DAOs provided by the websites DeepDAO and Snapshot. Both databases contain more than 11,878 DAOs (as of December 2022), of which 10,418 are associated with a blockchain address (wallets).[11] For the analysis,

[10] In this context, Sun et al. (2022) explains that the protocol of MakerDAO has two governance mechanisms: off-chain and on-chain. Off-chain governance constitutes a discussion forum, while on-chain governance is used for opinion polls, sentiment surveys, and the execution of technical changes to the protocol. Finally, the authors argue that a greater and faster voting participation on-chain greatly increased transaction volume and the number of members in the MakerDAO.

[11] Ethereum is the most prominent blockchain platform for DAOs (7,940), followed by Solana (1,302) and Polygon (1,176).

I exclude all DAOs without an account on the Ethereum blockchain, while I also discard all implementations of DAOs that have no meaningful proposals or test votes.[12] These filtering steps lead to a final sample of 2,377 DAOs. Table A1 in the appendix presents the sample selection process.

Next, I collect on-chain transactions, which provide information on DAOs' fund characteristics over time, such as cash flows, assets, and ownership structure. Many DAOs possess several blockchain wallets in which to deposit wealth (such as cryptocurrencies, NFTs or other crypto-assets) or manage various governance tokens, e.g., with different dividend and voting rights. To account for all relevant firm information, I aggregate and merge all transaction data per DAO. The sample period spans almost 5 years, from February 2017 to December 2022. During this period, I find that 14% (330) defaulted or ceased their business.

To evaluate DAOs' AUM in $, I use exchange rates from the website CoinMarketCap. The final sample of 2,377 DAOs cumulatively holds more than $8.61 billion under management (as of December 2022). Moreover, I identify a total of 1.98 million users, assuming that one unique user account corresponds to an individual investor. In general, users are allowed to join any DAO without restrictions, except for 185 private organizations. These exclusive DAOs require, for instance, that new members contribute a specific number of tokens to the community or that they are personally invited by a current member.

Among the sample, 151 DAOs have created native tokens and listed them on exchanges. Other DAOs use, for instance, Ether (ETH), Wrapped Ether (WETH), or other stablecoins for daily transactions on Ethereum.

2,289 DAOs use Snapshot for proposal suggestions and off-chain governance. The remaining DAOs operate on specific platforms.[13] In addition, 55 DAOs have implemented an on-chain voting system on the Ethereum blockchain. As an example of on-chain governance,

[12] Initially, I hand-collected a sample of 45,198 proposals, of which about 30% were test or empty implementations. I deleted these observations and excluded in addition all proposals with less than 10 words after pre-processing the proposal description.

[13] For example, Aragon (79), Compound (50), DAOhaus (34), Substrate (24), Realms (16), and DAOstack (13).

Figure A1 illustrates the internal activities within the venture capital firm, such as the LAO, and plots the cumulative AUM in $ over time. The graph provides some first evidence that participation in DAOs can be worthwhile, even though DAOs appear to be only short term in focus.

[Figure A1 about here]

Finally, the majority of DAOs voluntarily disclose private information about the technical source code for their networks or applications on GitHub. One reason for publishing open source and blockchain based protocols is to reduce information asymmetries between DAO participants and enhance informed decision-making. In particular, it is possible to observe DAOs' projects (so-called repositories) and the history of code revisions (so-called commits) over time. In total, I find that 1,039 DAOs of the final sample share their operating activities through accessible project updates on GitHub.

3.2 Variable construction

The following subsection discusses the construction of variables. Table 1 reports descriptive information for two data sets: Panel A provides means, medians, standard deviations, maximum, and minimum values for cross-sectional data. Panel B summarizes descriptive statistics for time series data. Table A2 in the appendix contains the definitions of variables and indicates the respective sources of data.

[Table 1 about here]

Measure of firm performance

The primary measures of performance are the market cap growth of listed governance tokens and the value of AUM for each DAO firm. The average monthly market cap growth is 15.39% (median: 0.07%). There is a large performance disparity among DAOs. On the basis of the

data set, the largest 281 DAOs (or the largest 12%) manage 51% of the total value under management by all DAOs in the sample. This size disparity also can be seen in the large difference between the mean ($32.05 million) and the median ($0.31 million) AUM of DAOs. In December 2022, the mean (median) market capitalization is $97.94 million ($3 million).

Ownership structure and on-chain power distribution

The balance of corporate power between token holders is measured by the Lorenz curve. In economics, it is used to measure wealth inequality in a country (Dorfman, 1979). In a crypto-economic context, it indicates the wealth and power distribution among DAO participants. Two essential properties can be derived from this application: the Gini coefficient and the Nakamoto coefficient. The Gini coefficient measures how far the population's wealth deviates from a perfectly equal distribution. In particular, a low Gini coefficient reflects a high degree of decentralization and a low degree of control. The Gini coefficient is given by the following equation,

$$\text{Ownership concentration}_{jt} = \frac{\sum_{m=1}^{n}\sum_{k=1}^{n}\left|\text{tokens}_{mjk} - \text{tokens}_{kjt}\right|}{2n^2\overline{\text{tokens}}_{jt}}, \qquad \text{where } k = m+1$$

where tokens signify the amount of ownership in DAO j of member m at time interval t.

The Nakamoto coefficient represents one specific point on the Lorenz curve and helps us to understand how great a percentage of the population in a DAO constitutes 51% of the total wealth. Naturally, a low Nakamoto coefficient signifies that only a few participants are needed to take over the control of the DAO organization. As an example, Figure 1 graphs the Lorenz curve for three prominent DAOs: Aave, Decentraland, and Uniswap. All three companies are listed on exchanges and generate revenues from different business activities. For instance, Aave is a lending protocol where users can borrow and lend cryptocurrencies, Uniswap is a decentralized exchange that allows users to swap cryptocurrencies, and Decentraland is a virtual reality platform, where users can create content or applications and

monetize them.

[Figure 1 about here]

Figure 1 compares the ownership concentration with the distribution of voting power in DAOs. Perhaps surprisingly, well-established DAOs are more decentralized than previously stated. Furthermore, in all three cases, power imbalance seems to be unrelated to DAO size, because the average Gini and Nakamoto coefficients do not vary significantly over time.

On-/Off-chain voting activity and the content of proposals

DAO proposals are newly submitted tasks that the community can decide and vote on, and which will usually result in changes to the smart contract. They are conceptually similar to traditional shareholder proposals, except for their binding nature (Gordon and Pound, 1993; Gillan and Starks, 2000). Among the sample of 2,377 DAOs, I examine 33,578 proposals, of which 10% (3,380) have been accepted. The proposal texts vary substantially in length (between 11 and 8,068 words) and readability, e.g., in the level of technical language and complexity.[14] DAO members can participate in up to 157 proposals per month. Most of the proposals' content is related to DeFi protocol improvements (36%), development or issue reports (25%), financial management (including compensation and funding requests)(17%), NFTs (15%), and marketing (7%).[15]

Next, I focus on the voting activity of DAO participants over time and construct a series of variables that measure their voting participation, speed, power imbalance, and voting disagreement, to better understand how decentralized governance works. Some DAOs allow for multiple voting channels, i.e. on-chain and off-chain, with the ability to unlock the

[14] Technical language is defined as the count of technical words divided by the total number of words in a proposal description. The dictionary is based on Lyandres et al.'s (2022) *tech* word-list. Complexity is evaluated by the percentage of complex words over the total number of words. The dictionary for complexity is based on Loughran and McDonald's (2011) *complexity* word-list.

[15] Proposal descriptions are evaluated by self-generated word dictionaries that are based on term frequency-inverse document frequency, Latent Dirichlet Allocation, and pre-trained sentence embeddings from a new language representation model, called Bidirectional Encoder Representations from Transformers. See Topic Modeling BERT-LDA [December 15, 2022]. The word-lists are enclosed in Table A3 in the appendix.

off-chain proposal submission and voting also for non-members. This practice is beneficial because off-chain governance does not charge any gas fees and allows for the quick surveying of community sentiment before the actual voting is proposed. Moreover, off-chain voting can encourage participation by a wider range of small token holders and non-members.

First descriptive evidence show that off-chain proposals indeed receive more votes from smaller than from influential members (with more than 51% voting power). The participation is strongly unbalanced; proposals attract, on average, 1,591 voters. To compare the participation rates for different DAOs, I adjust the voting participation (the number of voters per proposal i in DAO j) relative to the total number of members.

$$\text{Voting participation}_{ij} = \frac{\#\text{Voters}_{ij}}{\#\text{Members}_{ij}}$$

Next, I compute the voting speed by the time difference between the proposal start and the actual voting. To compare again the numbers for differently scheduled time intervals, I scale the elapsed time by the proposal duration,

$$\text{Voting speed}_{ij} = \frac{1}{n}\sum_{m=1}^{n} \frac{\text{voting timestamp}_{mij} - \text{proposal start}_{mij}}{\text{proposal duration}_{ij}},$$

where m denotes member and n is the total amount of voters for proposal i in DAO j. Voting power imbalance is measured again by the Gini and Nakamoto coefficients,

$$\text{Voting power}_{ij} = \frac{\sum_{m=1}^{n}\sum_{k=1}^{n}\left|\text{votes}_{mij} - \text{votes}_{kij}\right|}{2n^2\overline{\text{votes}}_{ij}}, \qquad \text{where } k = m+1$$

where *votes* denotes the number of tokens that member m uses to vote in proposal i of DAO j.[16] Some DAOs try to counter *strategic voting* by allocating each member (regardless of their

[16] In some cases, members contribute multiple tokens for voting. For instance, the Decentraland DAO allows users to cast their votes with MANA, NAME and LAND tokens. See https://docs.decentraland.org [15.12.2022]. Because each token represents a different unit and thus a different worth, I value-weight the votes by multiplying each token amount with its respective percentage weight. With this approach, more dominant tokens receive a greater weight.

ownership stake) only one vote (see Maug and Rydqvist, 2009). Although I cannot rule out that members can create separate addresses to obtain more voting power, I find that DAOs generally exhibit very low participation rates (off-chain: 23.9% on average, on-chain: 10.9% on average), while the majority of the communities are passive and non-voting members.

The average duration per proposal is 9 days (median: 3 days), while members usually cast their votes within 2-3 days. Interestingly, each DAO has proposal sponsors who manage and process proposals for which they may receive a remuneration. On average, I identify 5 proposal sponsors per DAO. Furthermore, blockchain data allows the observation of compensation payments per transaction, valued at $527,971 on average (median: $305,909), to members. These numbers can be interpreted as direct incentives to work for DAOs and provide an idea of how much DAO members can earn.

Finally, I investigate voting disagreement between members and calculate average rejection ratios. Additionally, I check whether residual owners voted against the desired outcome of large stakeholder (with more than 51% voting power). Overall, I find higher rejection rates of proposals off-chain (than on-chain), but low discrepancy between the voting outcomes of large and small voters. This observation can be explained with the argument that members only propose off-chain after consolidating with other team members online (Faqir-Rhazoui et al., 2021).

DAO classifications

One challenge in dealing with DAOs is identifying the purpose for which they have been created. This is important because business activities differ significantly by industry and may affect DAOs' wealth, valuation, and members' voting participation. To solve this issue, I use pre-defined classifications provided by DeepDAO and Snapshot. For example, DeepDAO distinguishes between 11 industries: Defi, NFTs, DAO tools for web3 infrastructure, investments, physical assets, gaming, media communications, and work DAOs for freelance and human resource management. Snapshot classifies 5 general types and distinguishes between

protocol, venture, collector, social or creator, and media DAOs.

For instance, the main purpose of *Protocol DAOs* is to govern the algorithmic network of decentralized applications, such as that of an exchange or lending application. Members of Protocol DAOs can vote on user requirements, e.g., for borrowing, lending, saving, or exchanging crypto-assets. *Venture DAOs* are designed to fund new ideas of existing DAOs or to invest in early-stage blockchain projects or token offerings, or to participate in other DAOs. Similarly, *Collector DAOs* manage their wealth by acquiring selected assets (e.g. NFTs, cryptocurrencies, or physical assets). *Social or Creator DAOs* are private communities (usually with restricted access) created to connect professionals and investors, while *Media DAOs* create platforms to exchange (crypto-related) news and events with their communities.[17] Table 2 provides a comprehensive overview of the DAO market, including descriptive statistics per category.

[Table 2 about here]

Two problems with the use of these pre-defined labels arise. First, 896 DAOs belong to several industries simultaneously, while 1,406 DAOs are not classified at all. Based on the descriptions provided by DAOs' whitepapers, social media, and company websites, I train a multi-label classification algorithm to assign multiple categories to each DAO according to their contents.[18] The data set is composed of all DAOs that are associated with a set of industry labels (5,550 out of the initial sample of 11,878 DAOs). The overall distribution for training and testing is 70%/30%, respectively. Based on accuracy scores (such as the hamming loss), I choose a linear classifier for the prediction task.[19] To improve accuracy, I aggregate all text information per DAO and pre-process them to handle noise. Furthermore, I employ random oversampling to deal with imbalanced labels. As a result, I recover 489

[17] Further business models of DAOs involve fundraising (*Grant* DAOs). However, this type of DAOs is not represented in the data set. See Bud Hennekes, April 2022 [08.11.2022].

[18] A muli-label classifier is a supervised learning technique that solves the simultaneous labeling by constructing multiple independent binary classification problems (Tarekegn et al., 2021). One possible drawback is that this methodology ignores the potential correlations between categories.

[19] I receive a hamming loss of 0.15, meaning that 15% of the predicted labels were incorrectly classified.

missing observations for further analysis.

4 Empirical methodology and results

Does decentralized governance (ownership with control and voting activism) matter for firm performance? In my first attempt to address this question, I use the following regression model,

$$\begin{aligned} FirmPerformance_j = \beta_0 + \beta_1 \cdot OwnershipConcentration_j + \beta_2 \cdot VotingActivism_j \\ + \beta_3 \cdot VotingSpeed_j + \beta_4 \cdot VotingPower_j + \beta_5 \cdot Controls_j \\ + Year_j + Industry_j + Platform_j + \epsilon_j, \end{aligned} \tag{1}$$

where $FirmPerformance_j$ represents two performance measures: DAO's market capitalization (as of December 2022) and the value of AUM in $ in the DAO. The main explanatory variables are $OwnershipConcentration$ and $VotingActivism$. Ownership concentration proxies for the degree of decentralization in DAOs. The variable is measured by the Gini coefficient, which defines the distribution of power within a DAO j for month t. In cases where DAOs retain tokens, I exclude the token amount from the ownership data. Following Nadler and Schär (2020), I also adjust token holdings by smart contracts (e.g. an exchange) with individual token holdings by users, to correct for the actual ownership structure. Voting activism describes the percentage of active voting participation relative to the total number of members. $VotingSpeed$ measures the average participation time in proposals. $VotingPower$ defines the power distribution of votes during proposals.

$Controls$ is a vector of control variables, such as size, age, asset structure, and Github commits. Size effects are captured by the logarithmic number of active members and the logarithmic number of proposal sponsors. The inclusion of quadratic term allows for non-linearities in the effect of firm size. *Age* is measured by the number of months. It is captured

by the time difference between the creation of a DAO community and their last activity on Snapshot/Ethereum. *AssetStructure* is the share of liquid assets over fixed assets, such as NFTs. The variable *GitHubCommits* proxies for DAO productivity and is measured by the number of code revisions on GitHub. Furthermore, I include dummy variables that flags one when DAO's membership is private, when DAOs have a Twitter, Discord, and Telegram account, and when a DAO has issued a whitepaper. Year-, platform-, and industry-fixed effects account for unobserved heterogeneity between different DAOs over time.

[Table 3 and Table 4 about here]

Table 3 presents result for AUM. Table 4 documents the results for market capitalization.[20] Contrary to the previous conjecture, the overall degree of decentralization in DAOs is unrelated to performance (AUM and market valuation). Although descriptive statistics illustrates that DAO's become more decentralized as they mature, the member participation rate in voting is a more important driver of performance. Interestingly, the relationship is convex, meaning that the effect of voting activism becomes strongly positive when the majority get involved.

Concerning the control variables, I find that AUM and firm growth are positively related to firm size, age, and GitHub commits. These results are generally consistent with the empirical findings of high-growth companies in traditional financial markets (see e.g. Anderson and Reeb, 2003; Ferris et al., 2003). The impact of firm-size is non-linear because a larger membership and more proposal sponsors exhibit higher coordination costs. This effect can also be observed by the positive relation between voting speed, voting power, and firm value. Contrary to the finance literature, asset structure is unrelated to firm performance. With the provided information updates on GitHub, members can monitor the progress of projects and team effort. As expected, GitHub Commits are a necessary component in determining DAO's intrinsic value, despite the risk of losing competitive advantage (Dye, 1985).

[20] Note that only a few DAOs listed their native tokens, which is why the sample size in Table 4 is restricted to 129 DAOs.

Next, I examine whether the results hold when the model is corrected for potential endogeneity issues. Specifically, it remains unclear whether DAO corporate governance improves performance, or whether strong performance incentivizes more members to join and to participate in governance. In Equation 2, I employ a panel-VAR model that treats all key variables as endogenous. Following Love and Zicchino (2006); Abrigo and Love (2016), I specify a first-order model as follows,

$$z_{jt} = \beta_0 + \beta_1 \cdot z_{jt-1} + e_{jt} + f_j + \epsilon_{jt}, \tag{2}$$

where z_{jt} is a vector of $FirmPerformance$ and $OwnershipConcentration$; e_{jt} is a vector of exogenous variables, i.e. market sentiment, defined by monthly Bitcoin returns to control for market hypes with a greater or lower supply of equity in the crypto market, and GitHub commits, to control for productivity; and f_j represents firm and time-fixed effects.

The data set is aggregated on a monthly and daily basis. Because adding more lags to the equation does not improve the models' explanatory power, I choose only one lag for the regression design when using monthly data. With daily data, I set the number of lags to 3 based on the Schwartz Bayesian information criterion. The regression results are presented in Table 5.

[Table 5 about here]

Taken together, the results reject the hypothesis that ownership concentration causes firm performance to increase. This result holds independent of market sentiment and DAO's level of productivity. On the contrary, higher firm valuations improve the power inequality within DAOs, although the effect has a relatively small magnitude from an economic point of view.

5 Conclusion

Decentralized autonomous organizations (DAOs) are new platform businesses on the blockchain, whose ownership of capital (in cryptocurrencies) is dispersed among many investors. Similar to an equity partnership, the idea is to split profits, risks, and control (almost equally) between participating members, who coordinate themselves through online voting on corporate actions. These new type of organizations differ in important ways from traditional companies because DAOs try to resolve the agency problem at all levels, avoid hierarchy, and add more democracy to the decision-making process in management. Can this organizational form survive and prevail in future?

Using a very comprehensive data set of 2,377 DAOs, I find that high-performing DAOs are those with an active community. Thus, motivating managerial effort benefits the organizations and creates value, even with varying ownership levels. Future research may investigate the relationships between DAO's ownership structure, the interests and influences of different sets of individuals, and how the entry and exit of new owners affect firm-level outcomes. These results will foster a better understanding of corporate governance and may progress us towards an inclusive and decentralized economy.

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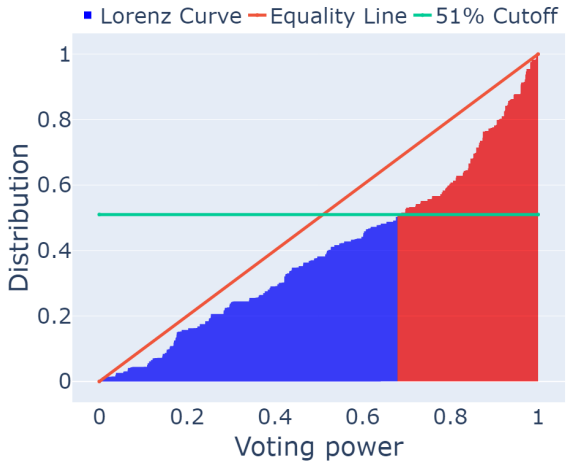
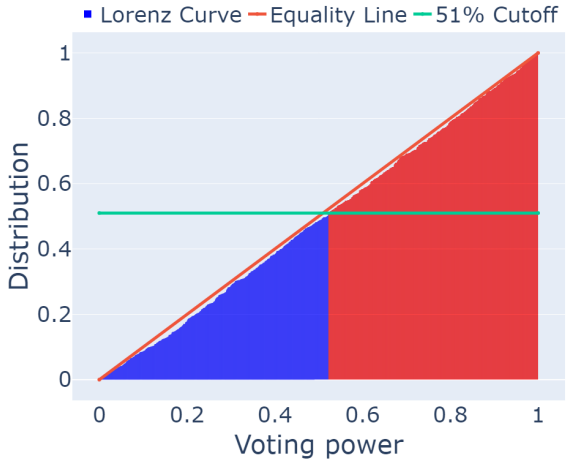
Tables and Figures

Figure 1. Ownership concentration and voting imbalances: Some examples
The figure shows the Lorenz curve for three DAOs: Aave, Decentraland, and Uniswap. The red line is the equality line. The horizontal line in green represents the 51% cut-off.

(a) Aave



(b) Decentraland



(c) Uniswap

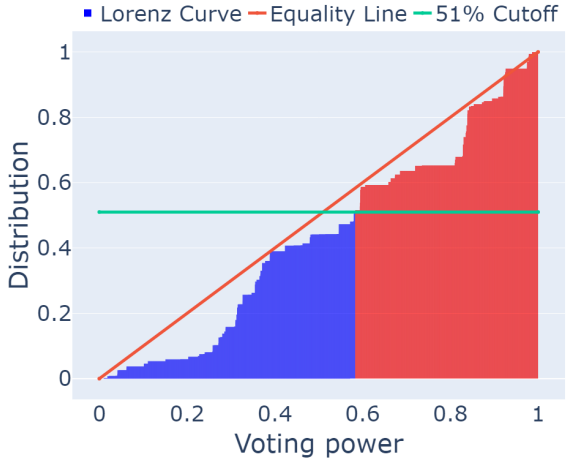


Table 1. Descriptive statistics
This table reports descriptive statistics for DAO performance indicators, characteristics, ownership, and asset structure. Panel A shows cross-sectional data. Panel B demonstrates panel time-series data.

Panel A	N	Min	P25	Mean	P50	P75	Max	Std. Dev.
AUM	2,377	0	.22	5.1	4.5	7.8	22	4.7
$MarketCap_j$	151	0	0	.71	0	0	22	3.5
$OwnershipConcentration_j$	2,377	0	0	.32	.23	.64	1	.33
$VotingActivism_j$	2,377	0	.15	1.8	1.4	3.3	5.7	1.6
$VotingActivism_j^2$	2,377	0	.026	3.3	2.3	6.4	11	3.4
$VotingSpeed_j$	2,377	0	0	.2	.23	.33	.97	.18
$VotingPower_j$	2,377	0	0	4.1	0	1	1,133	34
$\#ActiveMembers_j$	2,377	0	.69	3.2	3.1	5	11	2.4
$\#ActiveMembers_j^2$	2,377	0	.69	6.2	6.1	10	23	5
$\#ProposalSponsor_j$	2,377	0	.69	1.2	1.1	1.6	7.9	1.1
$\#ProposalSponsor_j^2$	2,377	0	.69	2.1	1.6	2.8	16	2.3
$GitHubCommits_j$	2,377	0	0	1.7	0	4.1	9.5	2.6
Age_j	2,377	0	0	117	0	183	518	152
$AssetStructure_j$	2,377	0	0	13	0	.054	10,138	300
$private_j$	2,377	0	0	.05	0	0	1	.22
$OnchainGovernance_j$	2,377	0	0	.05	0	0	1	.23
$Twitter_j$	2,377	0	1	.9	1	1	1	.31
$Discord_j$	2,377	0	0	.56	1	1	1	.5
$Telegram_j$	2,377	0	0	.44	0	1	1	.5
$Whitepaper_j$	2,377	0	0	.14	0	0	1	.34

Panel B	N	Min	P25	Mean	P50	P75	Max	Std. Dev.
AUM_{jt}	1189991	0	.0075	.58	.089	.55	13	1.2
$OwnershipConcentration_{jt}$	741,717	0	.25	.39	.47	.57	.69	.22
$Nakamoto_{jt}$	743,958	0	2	32	6	19	5,984	149
$BitcoinReturns_{jt}$	558555	-.46	-.016	.0013	.0018	.02	.23	.041
$GitHubCommits_{jt}$	558555	0	0	.78	0	0	9.5	1.9
$\#Proposals_{jt}$	743,967	1	2	16	4	10	3,343	82
$VotingActivism_{jt}$	743,967	1	4	82	14	43	84,350	550
$ProposalDuration_{jt}$	743,967	.5	2	8.3	3	7	727	26

Table 2. The DAO landscape

This table reports the cross-section distribution for differently classified DAOs and reports the aggregated number of DAOs, average value of AUM in $, average number of members in a DAO and the percentage of active members thereof, as well as the average number of proposals.

DeepDAO category	DAOs #	AUM avg. mn in $	Members avg. #	thereof active avg. in %	Proposals avg. #
Defi	448	16.86	5,466	13.09	17,762
NFTs	203	1.39	1,014	19.93	4,202
Infrastructure	48	43.63	21,159	13.11	2,401
Art&Culture	46	2.66	1,693	22.70	1,540
Gaming	33	6,74	10.031	11.60	2,144
Investments	31	158.03	702	44.46	3,360
Dao tool	27	7.61	4,090	25.82	2,847
Physical assets	21	1.50	3,633	14.27	698
Greater good political	15	4.79	2,208	21.04	1,348
Work&Hire	14	5.79	3,817	31.28	1,068
Media communications	13	0.32	1,417	19.31	643

Snapshot category	DAOs #	AUM avg. in $	Members #	thereof active avg. in %	Proposals #
protocol	688	21.72	4,131	18.03	24,696
social	241	1.51	2,545	17.89	5,520
investment	122	5.77	14,785	15.84	3,120
collector	64	0.25	130	22.53	850
media	17	0	0	0	87

Table 3. DAO's assets under management and ownership
This table reports linear regression results for Equation 1. The dependent variable measures the market value of DAOs' assets under management in $. The main independent variables are ownership concentration, voting power, and voting participation. Controls include dummy variables for having (i) a private membership, (ii) an on-chain governance, (iii) a Twitter, Discord, and Telegram account, and (iv) an accessible whitepaper. t-statistics are based on robust standard errors and are reported in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

	AUM_j			
	(1)	(2)	(3)	(4)
$OwnershipConcentration_j$	1.674***	1.106***	0.211	0.054
	(4.40)	(3.09)	(0.53)	(0.14)
$VotingActivism_j$			-5.958***	-6.506***
			(-4.80)	(-5.29)
$VotingActivism_j^2$			2.474***	2.735***
			(4.04)	(4.53)
$VotingSpeed_j$			1.109*	1.476**
			(1.71)	(2.32)
$VotingPower_j$			0.009**	0.008**
			(2.28)	(2.11)
$\#ActiveMembers_j$			11.554***	11.846***
			(7.25)	(7.48)
$\#ActiveMembers_j^2$			-5.690***	-5.835***
			(-7.08)	(-7.32)
$\#ProposalSponsor_j$			0.878***	0.856***
			(4.78)	(4.76)
$\#ProposalSponsor_j^2$			-0.000***	-0.000***
			(-3.18)	(-2.99)
$GitHubCommits_j$			0.187***	0.190***
			(4.72)	(4.76)
Age_j			0.010***	0.008***
			(15.34)	(12.01)
$AssetStructure_j$			-0.000	-0.000
			(-0.03)	(-0.39)
Observations	2377	2377	2377	2377
Adjusted R^2	0.013	0.114	0.272	0.292
Controls	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry FE	No	Yes	No	Yes
Platform FE	No	Yes	No	Yes

Table 4. DAO market performance and ownership

This table reports linear regression results for Equation 1. The dependent variable measures DAOs' market capitalization in $ (as of December 31, 2022). The main independent variables are ownership concentration, voting power, and voting participation. Controls include dummy variables for having (i) a private membership, (ii) an on-chain governance, (iii) a Twitter, Discord, and Telegram account, and (iv) an accessible whitepaper. *t*-statistics are based on robust standard errors and are reported in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

	$MarketCap_j$			
	(1)	(2)	(3)	(4)
$OwnershipConcentration_j$	-4.248**	-3.325*	-3.173	-3.137
	(-2.28)	(-1.79)	(-1.57)	(-1.57)
$VotingActivism_j$			-44.512***	-41.383***
			(-6.47)	(-5.33)
$VotingActivism_j^2$			20.156***	17.972***
			(4.97)	(3.98)
$VotingSpeed_j$			8.785*	1.345
			(1.76)	(0.27)
$VotingPower_j$			0.014*	0.011
			(1.85)	(1.17)
$\#ActiveMembers_j$			-15.640	-31.522**
			(-0.82)	(-2.20)
$\#ActiveMembers_j^2$			7.298	15.321**
			(0.77)	(2.15)
$\#ProposalSponsor_j$			3.967***	3.762***
			(5.27)	(4.03)
$\#ProposalSponsor_j^2$			-0.000**	-0.000*
			(-2.33)	(-1.73)
$GitHubCommits_j$			0.338*	0.343*
			(1.66)	(1.86)
Age_j			-0.003	-0.002
			(-0.85)	(-0.45)
$AssetStructure_j$			-0.009***	0.001
			(-3.05)	(0.11)
Observations	151	151	151	151
Adjusted R^2	0.088	0.209	0.303	0.382
Controls	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry FE	No	Yes	No	Yes
Platform FE	No	Yes	No	Yes

Table 5. DAO performance and ownership: Evidence from Panel-VAR regression
This table reports Panel-VAR regression results for Equation 2 using monthly (Panel A) and daily (Panel B) data. Assets under management (AUM) describe the market value of DAO's investments in $. Ownership concentration is measured by the gini coefficient. t-statistics are based on robust standard errors and are reported in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

Panel A	Hypothesis	AUM_{jt}	$OwnershipConcentration_{jt}$
AUM_{jt-1}	-	0.735***	**-0.005***
		(25.74)	**(-1.78)**
$OwnershipConcentration_{jt-1}$	+	**0.165**	0.725***
		(0.72)	(28.74)
Observations		17110	
Controls		Yes	
Time FE		Yes	
DAO FE		Yes	

Panel B	Hypothesis	AUM_{jt}	$OwnershipConcentration_{jt}$
AUM_{jt-1}	-	0.836***	**-0.001*****
		(80.80)	**(-2.85)**
AUM_{jt-2}		0.082***	-0.000
		(6.56)	(-0.42)
AUM_{jt-3}		0.057***	0.000
		(7.16)	(0.42)
$OwnershipConcentration_{jt-1}$	+	**-0.008**	0.911***
		(-0.59)	(120.00)
$OwnershipConcentration_{jt-2}$		0.021	0.018*
		(1.10)	(1.87)
$OwnershipConcentration_{jt-3}$		-0.006	0.035***
		(-0.32)	(5.45)
Observations		558555	
Controls		Yes	
Time FE		Yes	
DAO FE		Yes	

Appendix A

Table A1. Sample selection

Sample selection	Observations
DAO universe	11,878
less: unidentified treasury account on Ethereum	(3,938)
less: test implementation/no meaningful proposal description	(5,638)
Final sample	2,377
thereof: on-chain governance	55
thereof: off-chain governance	2,289
thereof: accessible GitHub activities	1,039
thereof: DAO token is publicly traded on exchanges	151

Table A2. Variable definitions and sources

Source	Variable	Definition
DAO characteristics		
Snapshot/ Ethereum	#ActiveMembers	Number of active members.
Snapshot/ Ethereum	#Proposal Sponsor	Number of proposal sponsor.
DeepDAO/ Snapshot	#Proposals	Number of proposals.
DeepDAO/ Snapshot	#Votes	Number of votes.
DeepDAO/ Snapshot	Age	Number of months since the DAO is in existence.
DeepDAO/ Snapshot	Business description	Information on DAO's business activity that is provided in whitepapers, social media and firm websites.
GitHub	GitHub commits	Number of project updates/code revisions of a DAO.
DeepDAO/ Snapshot	Off-chain governance	Dummy variable that equals one when votes and proposals are submitted online/off-chain.
DeepDAO/ Snapshot	On-chain governance	Dummy variable that equals one when votes and proposals are submitted on chain.
Ethereum	Ownership concentration	The Gini and Nakamoto coefficient of DAO token holders.
DeepDAO/ Snapshot	Private	Dummy variable that equals one when DAO's membership is restricted to the public.
DeepDAO/ Snapshot	Social Media presence	Dummy variable that equals one if a DAO has a Twitter, Discord, and Telegram account.
DeepDAO/ Snapshot	Whitepaper	Dummy variable that equals one when a DAO has issued a whitepaper.
DAO finances		
Ethereum	Fixed assets	Value of listed crypto-assets (e.g. tokens and NFTs) in $.
Ethereum	Liquid assets	Value of native token/Ether in $.
Ethereum	Asset structure	The share of liquid assets over fixed assets.
Ethereum	AUM	The value of assets under management in $ that equals the sum of fixed and liquid assets.
Ethereum	CashOutflows	The number of tokens (in $) that a DAO disburses.
DeepDAO/ Snapshot	DAO token	Dummy variable that equals one when DAO has a native token.
CoinmarketCap	Market Cap Growth	The monthly growth of market capitalization.
DAO FE		
Snapshot	Business type FE	5 business type classification of DAOs.
DeepDAO	Industry FE	11 industry classification of DAOs
CoinmarketCap	MarketSentiment	Monthly Bitcoin returns.
DeepDAO/ Snapshot	Platform FE	Governance platforms where DAOs have been created

Proposals		
Snapshot/ Ethereum	Complex language	The percentage of complex terms (as defined by Loughran and McDonald's (2011) complexity word-list) relative to the total amount of words.
Snapshot/ Ethereum	Technical language	The percentage of technical terms (as defined by Lyandres et al.'s (2022) tech word-list) relative to the total amount of words.
Snapshot/ Ethereum	Topic: DeFi protocol	The percentage of word items that are related to a self-generated topic on Defi protocol and improvements, relative to the total amount of words.
Snapshot/ Ethereum	Topic: Development	The percentage of word items that are related to a self-generated topic on development and issues, relative to the total amount of words.
Snapshot/ Ethereum	Topic: Financial management	The percentage of word items that are related to a self-generated topic on financial management (including funding and compensation requests), relative to the total amount of words.
Snapshot/ Ethereum	Topic: Marketing	The percentage of word items that are related to a self-generated topic on Marketing, relative to the total amount of words.
Snapshot/ Ethereum	Topic: NFTs	The percentage of word items that are related to a self-generated topic on NFTs, relative to the total amount of words.
Voting		
Snapshot/ Ethereum	Voting disagreement	Share of voters who rejected the proposal i relative to the total number of voters of proposal i.
Snapshot/ Ethereum	Voting activism	The number of active members (voters) divided by the total number of members in a DAO.
Snapshot/ Ethereum	Voting power	The Gini and Nakamoto coefficient per proposal i.
Snapshot/ Ethereum	Voting speed	The time difference between the actual voting time (timestamp in seconds) of a team member and the start of the proposal, relative to the duration of the proposal.

Figure A1. On-chain voting: An example
The following figures plot blockchain transactions and the cumulative sum of assets under management in $ of one DAO example: The LAO. The LAO is a venture capital firm that supports early-stage companies and uses on-chain governance.

On-chain governance

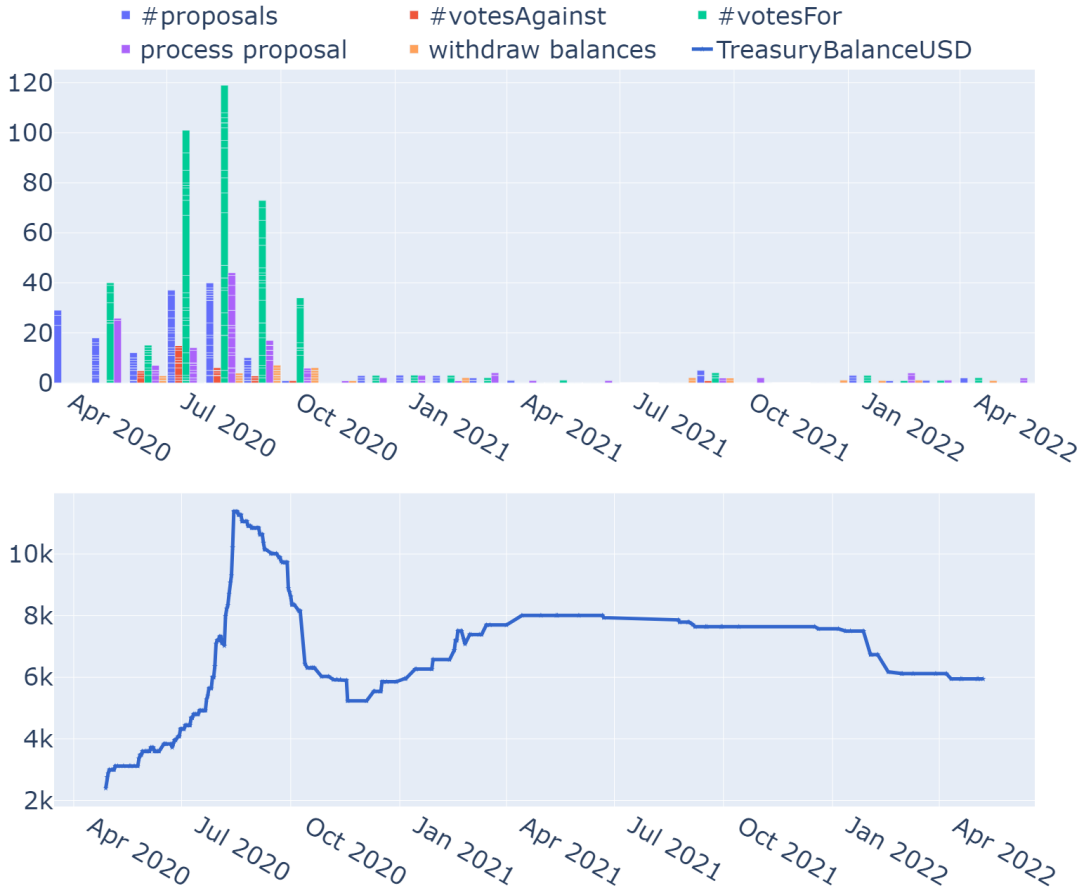


Table A3. LDA topics distribution in whitepapers

This table shows the for self-generates dictionaries based on term frequency-inverse document frequency, Latent Dirichlet Allocation, and pre-trained sentence embeddings from a new language representation model, called Bidirectional Encoder Representations from Transformers. See Topic Modeling BERT-LDA [December 15, 2022].

Topics	Key words
Financial management	fund, treasury, team, investment, management, need, protocol, development, pay, operation, cost, funding, project, request, asset, risk, allocation, time, budget, contributor, request, compensation, lead, governance, balancer, goal, expense, work
Defi protocol	reward, day, stake, price, increase, change, rate, pool, time, holder, current, high, reduce, period, value, supply, option, liquidity, incentive, fee, increase, farm, liquidity_mining, volume, pair, trading, distribution, add, yield, liquidity, curve, asset, strategy, stake, risk, deposit, collateral, deploy
Marketing	marketing, project, video, team, create, campaign, social_medium, twitter, include, work, new, brand, design, week, event, strategy, post, medium, budget
NFT	nft, project, mint, artist, holder, collection, creator, create, art, eth, new, sell, launch, sale, future, world, space, metaverse, hold, access, acquire, land, decentraland, build
Business development	build, project, work, web, development, team, support, product, ecosystem, network, developer, protocol, new, create, experience, design, develop, feature, include, app