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Governance impacts of blockchain-based decentralized autonomous organizations: an empirical analysis

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ABSTRACT

The rapid rise in blockchain-based Decentralized Autonomous Organizations (DAOs) offers policy-makers and decision-makers new opportunities to automatically execute decisions and processes that help enhance transparency, accountability, participation and trust. Yet, many DAOs have a limited lifespan. There is little empirical evidence of the effect of governance elements on the viability of DAOs. Using 220 on-chain governed DAOs, this paper analyses how governance elements (accountability, decision/voting, and incentives) influence the viability of DAOs in the long-term. The findings show that DAOs without weighted decision-making and without incentive structures are more viable than those with weighted decision power and incentive mechanisms. This suggests that financial and share-like DAO governance elements do not or may even negatively contribute to the long-term viability of DAOs. Also, voting power distribution is found to have a statistically significant influence on DAOs' viability. We further propose a preliminary theory that relates governance elements to the long-term viability of DAOs. These insights will help policy-makers in designing more viable DAOs. Future research should investigate how DAO objectives, the chosen deployment infrastructure and the type of users can impact the long-term viability of DAOs.

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Blockchain; decentralized autonomous organization (DAO); governance; policy design; public administration

1. Introduction

Companies and policy-makers favor transparent and accountable governance. Decentralized autonomous organizations (DAOs) are organizations using blockchain to store and execute governance decision-making rules. DAOs can democratically manage an asset (e.g., money spending by organizations, stocks, shared treasuries for subsidies, management of commons) without the need for a central governance authority. In this way, decision outcomes of proposals initiated by a community of tokenholders can be automatically executed. A DAO records, guards, and executes

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the processes, decision rules, and decisions made in an almost immutable way, resulting in higher levels of transparency and accountability (Berdik et al. 2021; Cagigas et al. 2021; Chen and Bellavitis 2020; De Filippi and Hassan 2020; Jing, Liu, and Sugumaran 2021; Rikken, Janssen, and Kwee 2023).

In public administration, DAOs can create many opportunities for policy-makers. DAOs can increase citizen participation in community-owned and participative budgeting projects. Implementing a DAO for community-owned funds creates transparency, direct community involvement, control, and trust. These added values of DAOs have proven to be problematic in traditional participative budgeting projects (Rikken, Janssen, and Kwee 2022). The foresight of DAOs is to become the backbone of governance of future political parties, i.e., enhancing direct democracy (Sergeenkov 2021). Also, in e-government, DAOs are expected to further improve transparency and efficiency and prevent human error and corruption (Diallo et al. 2018). DAOs in public management could replace current forms of public-private partnerships by redefining control and coordination (Tan, Mahula, and Crompvoets 2022). According to the World Economic Forum, DAOs may also be used in funding public goods and investments and potentially lead to even broader societal innovations (Gogel et al. 2023).

DAOs were first described by Daniel Larimer and later by Vitalik Buterin, as organizations that exist based on smart contracts with various goals, including the transfer of cryptocurrency (Buterin 2014; Larimer 2013). This vision was built upon blockchain technology introduced by Satoshi Nakamoto (2008) through the introduction of Bitcoin. Blockchain technology provides key features of decentralization, cryptography, and transparency. The technology provides an electronic, public transaction record in which the integrity of the content no longer needs to be guarded and guaranteed by a trusted third party (TTP), like a bank or a notary. This leads to increased transparency, accountability, control, and efficiency (Beck et al. 2016; Rikken, Janssen, and Kwee 2019; Swan 2015). At the same time, new forms of democratic cooperation are enabled. Overall, blockchain and DAOs have created new ways of governance.

Nevertheless, what decentralized and autonomous means is often unclear (Hassan and De Filippi 2021). In an attempt to describe what a DAO is, Hsieh et al. (Hsieh et al., 2018) emphasize on digitalization of democratic processes in DAOs, i.e., when DAOs organize themselves on a peer-to-peer network that is cryptographically secured. Hassan and De Filippi (2021) describe DAOs as a blockchain-based system for coordination and self-governance using self-executing rules independent from a central authority. Based on the key characteristics of DAOs, Rikken, Janssen, and Kwee (2023) provided a definition of a DAO: "A DAO is a system in which storage and transaction of value and notary (voting) functions can be designed, organized, recorded, and archived and where data and actions are recorded and autonomously executed in a decentralized way" (13).

There is an exponential growth in the number of DAO initiatives for all kinds of purposes, as shown in Figure 1. The number increased slightly above 12,000 projects by the end of Q3 2022. According to deepdao.io, in April 2023, DAOs hold more than $24 billion in assets under management. The rapid increase in the number of

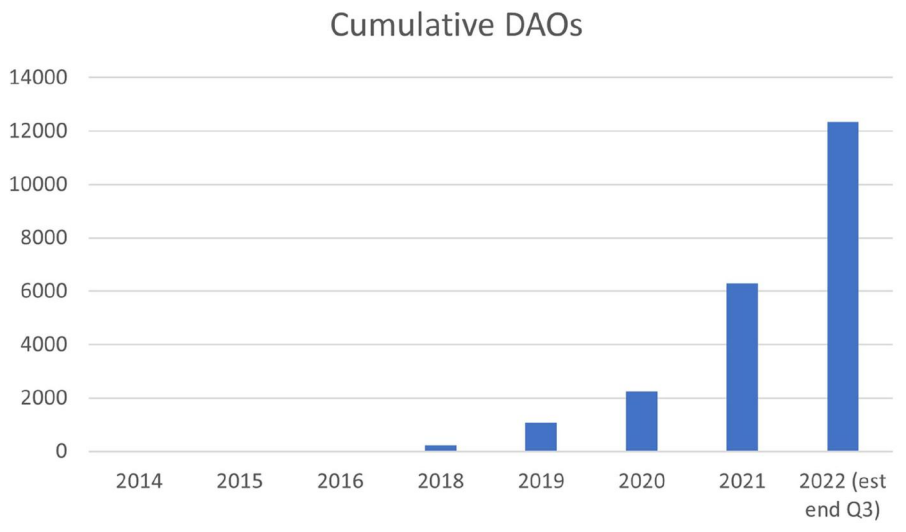

Figure 1. Cumulative DAOs (period 2014 – 2022) – Empirical research by Rikken, Janssen, & Kwee.

DAOs is, because nowadays, it is much easier to create DAOs. Before 2018, coding was needed to create a DAO. However, as of 2018, parameterized DAO deployment platforms came into existence. Since then, DAOs can be created by configuring a few parameters which can automatically be deployed (Baninemeh, Farshidi, and Jansen 2023; Rikken, Janssen, and Kwee 2023).

This exponential rise of DAO projects and the increasing amount of assets under management also led to large hacks, security incidents, voting misuse, and execution incidents. These incidents indicate that research on the governance of DAOs is crucial (Cryptopedia 2022; Lawler 2021; Wan 2022). Yet, DAO governance is still an under-researched area that needs further study. Most research on DAO governance has predominantly focused on theoretical descriptions of (potential) DAOs, describing governance elements like decision models, accountabilities, and incentives (Emmett 2019; Kondova and Barba 2019; Kotsialou and Riley 2017; Parton 2021; Thibauld 2018), or the opportunities of DAOs for (corporate) governance in general (Kaal 2019). There are discussions that current governance theories could potentially not suffice for DAOs (Morrison, Mazey, and Wingreen 2020). Rikken, Janssen, and Kwee (2023) suggest a connection between the level of decentralization and the long-term viability of DAOs. This paper answers the call for further empirical research on governance elements of DAOs and their influence on the long-term viability of DAOs.

Empirically, there is limited research on DAO governance. The little empirical research on DAO governance only focuses on a comparative analysis of governance models between DAO deployment platforms (El Faqir, Arroyo, and Hassan 2020; Faqir-Rhazoui, Arroyo, and Hassan 2021), the governance around "the DAO" incident of 2016 (Dhillon, Metcalf, and Hooper 2017; DuPont 2017), and a study of individual cases of different DAO governance models (Sims 2021). The study by Sims (2021) focuses on a descriptive analysis of governance models, which is useful for classifying possible governance models. However, the descriptive approach does not give any insights into the long-term viability of certain governance models. DuPont

(2017) finds that the governance of DAOs could not yet be evaluated meaningfully due to insufficient data available at that time. This situation, however, has changed since then. Faqir-Rhazoui, Arroyo, and Hassan (2021) and Rikken, Janssen, and Kwee (2023) suggest that further empirical research is needed regarding the effectiveness of various governance models. Obscurity regarding the relation between various governance elements and the long-term viability of DAOs can hinder policy-makers and decision-makers in the adoption of new innovative organizational forms like DAOs. Under this circumstance, they could miss out on opportunities to increase transparency, trust, and citizen participation in public administration.

In this paper, we address the research gap in DAO governance by identifying governance elements (accountability, decision model, and incentives) and conducting an empirical analysis of the effect of these elements on DAOs' long-term viability. First, we zoom in on key elements of DAO governance by adopting the IT-governance theory of Weill and Ross (Weill and Ross, 2005). Using this classification and building further on the research of Sims (2021), we empirically analyze current DAO governance elements and how they are implemented in active DAOs. Second, we analyze the impact of these elements on the viability of DAOs through statistical analysis.

This paper is structured as follows. The next section describes our research method. The third section of this paper zooms in on the various theoretical governance elements, which are subsequently categorized and visualized. We empirically analyze governance elements and their influence on DAOs' long-term viability in the fourth part. In the fifth section, we develop a preliminary theory of governance elements influencing the activity levels of DAOs and their interconnectivity, providing direction of requirements for future DAO (governance) design. The final chapter describes our conclusions and recommendations for further research.

2. Research method

For this research, we employed both quantitative and qualitative analyses involving laborious tasks in data collection. First, DAO governance components were derived using a literature review of 79 papers, transcripts, blogs, and repositories, both scientific and grey literature (over 1,000 pages). Google Scholar search was used using the keywords "Decentralized Autonomous Organization" and "Governance" to identify the literature. Furthermore, this ongoing research project entailed a four-year daily Google alert search. The alerts were scanned daily, and every single DAO hit was read and further investigated. We scanned and read more than 2,000 online news, web articles, and sites on DAOs. We reviewed DAO application codes and live-tested DAO governance in practice to further advance our understanding of DAO governance.

For the analysis of the governance elements and their effect on the long-term viability of DAOs, we identified over 6,000 potential DAOs by using a daily automated Google alert search with the keywords "decentralized autonomous organizations" (alert first initiated in January 2018) and "smart contracts" (alert first initiated mid-2016), both until December 2021. Furthermore, the data was collected from two streams: (1) individual DAOs created using DAO deployment platforms (aragon.org, daostack.io, daohaus.club, colony.io, district0x, scattershot.org, snapshot.org,

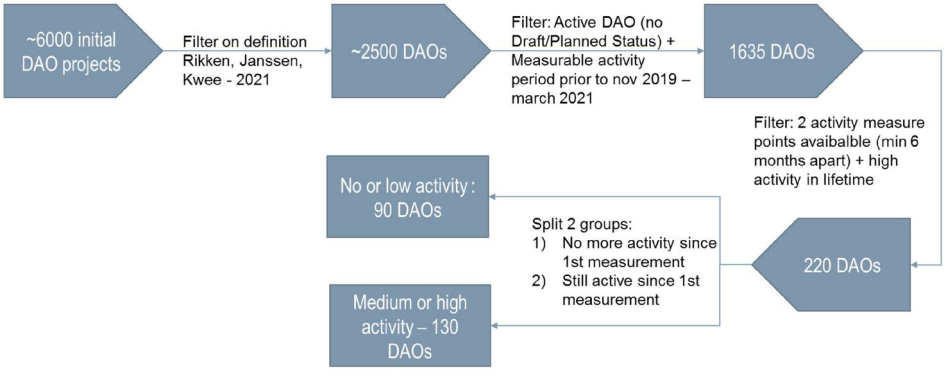

Figure 2. Process of DAO selection for analysis.

boardroom.info, eosDAC.io, withtally.com) using their respective websites and (2) overview websites where the information of these DAOs was displayed (apiary.1hive.org, etherscan.io, and deepdao.io).

Until the end of 2021, more than 6,000 initiatives were claiming to be DAOs. However, for our empirical analysis, we selected (verified[1]) DAOs for the empirical analysis of DAO governance elements and their effect on the long-term viability of DAOs. The reason for making this selection is that many DAO initiatives do not qualify as a DAO, and many DAOs show little or no activity. Most likely, this is because many DAOs are part of experimental projects (e.g., deciphering the possibilities of DAOs) by individuals. Given that many DAOs have "test" in their name does support this assumption (e.g., Mcdtest, Gastest and Mobiletest, all based on Aragon). These "test" DAOs could pollute our analysis as they might not be set up for long-term use. A series of filters (as shown in Figure 2) were used to select the verified DAOs for further analysis. The first filter used was to check if the DAOs meet the main characteristics of autonomy and functional characteristics based on the DAO definition by Rikken, Janssen, and Kwee (2023). Many DAOs are only DAOs in name because they do not autonomously execute decisions made by the respective DAO participants. Simply put, they do not meet the requirements in the definition of DAOs. These DAOs are also referred to as off-chain governance DAOs. This resulted in excluding a large number of potential DAOs like snapshot-based projects (which also call themselves DAOs), which do not execute decisions autonomously. These, therefore, are Decentralized Organizations (but not autonomous) or Pseudo-DAOs rather than Decentralized Autonomous Organizations (Rikken, Janssen, and Kwee 2023; Sims 2021). The lack of autonomous execution can lead to situations where a small group or even a single person can execute a decision that deviates from the decision made by the community of tokenholders or participants in a DAO. Such a deviation has already happened in the past (Staff 2022). We thus only analyzed "on-chain" governance DAOs, where the execution of the decisions by tokenholders is autonomously executed by smart contract code (and thus not prone to manual censorship or tampering). We then filtered on the deployment status, filtering draft, planned, and unknown status DAOs. This resulted in 1,635 DAOs, which were further analyzed.

We then filtered on lifetime activity level. Activity is measured as an incoming or outgoing transaction or a voting proposal that could be voted on by individual tokenholders (hence, not the vote of an individual tokenholder). For the analysis of DAOs' activity levels, we classified them into four categories: none (no activity), low (1 activity), medium (2-10 activities), and high (10+ activities). We further filtered and checked the data to determine whether there were at least two measurements in time on activity level (with at least 6 months in between) to observe any loss or continuation of activity. This resulted in 220 DAOs (see Figure 2). From these DAOs, we studied their governance elements and investigated the link of these elements to the long-term viability of DAOs. This group of 220 DAOs was further divided into two subgroups. One subgroup showed no or low activity between the first and second measurement (90 DAOs), whereas the second subgroup showed continued (medium or high) activity between the first and second measurement (130 DAOs).

The data obtained and the measurements of these DAOs (i.e., the level of activity, the value stored, number of tokenholders, last activity, governance elements) are used for a comparative and statistical analysis of the effect of various governance elements categories on the long-term viability (measured in continued activity levels). This is further described in section 4.

3. DAO governance

Faqir-Rhazoui, Arroyo, and Hassan (2021), as well as other scholars, emphasize the importance of research on DAO governance for long-term viability to create sustainable participatory organizations (Nabben et al. 2021). This research idea is triggered by early crashes of a DAO (DuPont 2017). Additionally, existing research mainly focuses on descriptive or limited detailing case analysis (El Faqir, Arroyo, and Hassan 2020; Sims 2021). Also, the importance of governance or decision-making is linked to potential liabilities resulting from the level of autonomy of a DAO (Wright 2021). In his research on DAO of DAOs, Kaal (2021) identified governance as a key feature of DAO survival. Other researchers (Faqir-Rhazoui, Arroyo, and Hassan 2021; Rikken, Janssen, and Kwee 2023; Zhao et al. 2022) highlighted the need for more empirical and detailed analysis of DAO governance.

Structured literature review on blockchain governance (Chohan 2017; Kiayias and Lazos 2022; Liu et al. 2021; Wright 2021) found accountability, decision-making, and incentives as the top three frequently mentioned elements of blockchain governance. When looking at DAOs in particular, traditional accountability may seem no longer applicable. This leads to the possible revisiting of the IT governance theory of Ross and Weill (Morrison, Mazey, and Wingreen 2020). Furthermore, one might need to consider more elements in relation to DAO governance.

An important element that could influence DAO governance is the specific blockchain infrastructure on which a DAO is built, since the governance of the application and infrastructure can be entangled (O. Rikken, Janssen, and Kwee 2019). Tan, Mahula, and Crompvoets (2022) described a three-level analysis of blockchain governance for the public sector with nine subcategories or elements. They emphasized the choice of infrastructure among elements like interoperability, application

architecture, control of governance and organization of governance. Once deployed, the control of smart contracts' upgradeability and interaction costs with the DAO is largely given and cannot be directly influenced by the DAO participants, especially on permissionless infrastructures. The choice of infrastructure (permissionless versus permissioned infrastructure) can thus be an important factor for the governance of DAOs. However, the DAO dataset for the analysis in this paper only contains DAOs on permissionless blockchain infrastructures. This is because permissioned blockchain infrastructure DAOs are generally not transparent to outsiders. As such, the infrastructure choice is omitted from our analysis. Also, none of the DAOs are controlled by automated agents as tokenholders need to vote on decisions (and thus can be assumed to be human-controlled). Therefore, we do not take control of governance into account. Additionally, off-chain governance DAOs are excluded from our analysis (as explained in our DAO selection process, see section 2).

As DAOs can be seen as IT systems, we decided to use the theory of Weill and Ross (2005) as a basis for the analysis of the governance by the DAOs. Weill and Ross distinguish accountability, decision-making, and incentives as key IT governance elements.

3.1. Accountability, general DAO governance decision, and incentive models

To analyze the three governance elements, we use the following approach. We developed a categorization for the three governance elements based on literature review and empirical analysis. We then plotted these categories on the DAOs analyzed. Firstly, we analyzed the elements of accountability, followed by analyzing decision-making, and finally, the elements of incentives are identified.

3.1.1. Accountability

Despite being seen as an important element in governance, there is a disagreement on what accountability exactly means (Feigenbaum, Jaggard, and Wright 2011; Weill and Ross 2004). One notion of accountability is about knowing the identities of all participants, so they can be punished for a breach or violation (Feigenbaum, Jaggard, and Wright 2011). Relatedly, Grant and Keohane (2005) define accountability as actors setting rights and judging the fulfillment of responsibilities or sanctions when certain actors do not meet their responsibilities. Research by Morrison, Mazey, and Wingreen (2020) and Rikken, Janssen, and Kwee (2019) even suggest that in DAOs, accountability is diffused and thus could pose a challenge to governance and governance theories of DAOs.

Considering that only in limited cases DAOs are clearly defined, especially with regards to accountability and legal structures (Hoon 2022; Sims 2019), regulators want to attach accountability directly to the tokenholders of DAOs (Commission, 2022; Kharif and Verspille 2022). Accountability, responsibility for activities, and decisions in regular organizational situations are often separated. In DAOs, these seem to be entangled due to direct participation in decision-making by the tokenholders. The ones responsible for decision-making also seem to be accountable. This suggests that tokenholders who are responsible for certain activities in a DAO are

also accountable, with a possible exception in delegated voting structures. Hence, to be able to analyze accountability in DAOs, despite the anonymous or pseudonymous character of DAO participants, we interpret accountability as the combination of the number of tokenholders and voting power distributions. Rikken, Janssen, and Kwee (2023) have analyzed the relationship between the number of tokenholders and long-term viability of DAOs. They find a significant relationship between the number of tokenholders and DAO's long-term viability. Due to the complex and intricate nature of accountability as a construct, in this paper, we operationalize accountability by using one proxy: voting power distributions.

To empirically investigate voting power distributions, we create a categorical measure with three categories: Dictatorship, Semi-Dictatorship, and Democracy (Figure 3). Dictatorships represent DAOs where one particular participant always needs to vote for a decision to be made due to an absolute majority in voting weight and/or quorum requirement. In Semi-Dictatorships, participants can decide independently of the largest voting weight participant as they can jointly reach the minimum required quorum. However, if the largest voting weight participant does vote, its vote will determine the outcome automatically. Democracies require cooperation between participants and will always require multiple participants to agree to come to a decision.

3.1.2. Decision/voting models

A wide variety of governance mechanisms can be used in DAOs (Arsenault 2020). In this section, we develop an overview of possible decision models/voting mechanisms resulting in the taxonomy presented in Figure 4.

The first breakdown in voting mechanisms of DAOs, as described in the literature and by empirical research, can be related to weighted or non-weighted voting. In non-weighted voting, all the participants in a DAO have an equal vote through the one person/account, one vote principle. Existing studies (Fan et al. 2020; HorizonAcademy 2019; Kotsialou and Riley 2017) describe two practical implementations of non-weighted voting: delegated/liquid democracy and direct democracy. In delegated/representative voting (liquid democracy), individuals can delegate votes to a person who then votes on behalf of multiple individuals. The individuals who have delegated their votes can switch their delegation if they want. None of the analyzed DAOs have a delegated structure based on a non-weighted base. Direct democracies represent strict "one account one vote" principle. This is practically implemented in

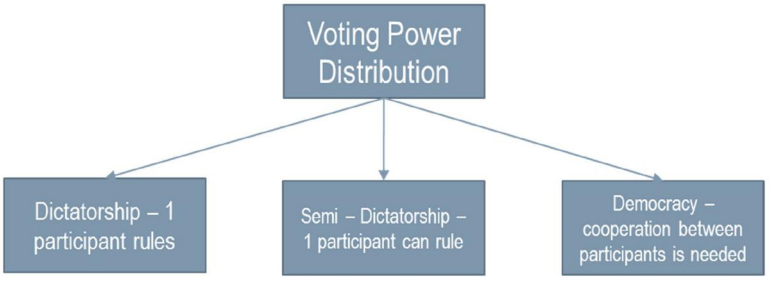

Figure 3. Voting power distribution.

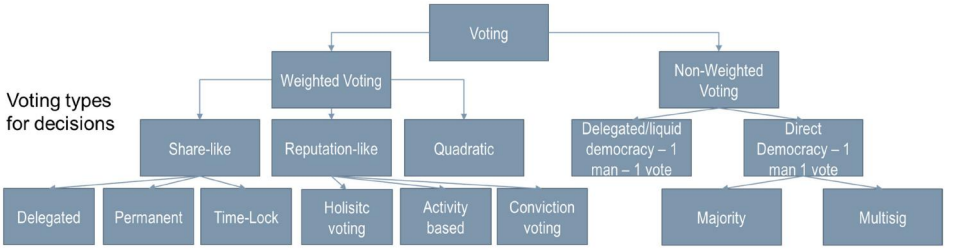

Figure 4. Catgorization DAO voting models.

the Aragon membership structure (Aragon 2022). Each member or account has one vote, which is not transferable. We can distinguish two sub-types of direct democracy: majority rules and multisig voting (where a fixed number of members need to vote in favor to execute the decision).

In weighted voting, the participants do not have to be equal or do not have to assign an equal weight voting to a proposal. We distinguish three main sub-types within the weighted voting category: share-like, reputation-like, and quadratic voting.

For the first type of weighted voting, share-like voting, the voting weight can differ per participant based on the share in the DAO. Shares can be granted by performing activity, can be donated, or can be bought. They are transferable if the owner wants to sell them, without the need for a decision by the DAO. The share-like construction can be found in various purpose-built DAOs and DAOs deployed through platforms like Aragon and DAOHaus (Moloch-based). We can distinguish three subtypes within weighted share-like voting: delegated, permanent, and time-lock voting. Delegated voting with share-like construction works similarly to delegated voting in non-weighted voting constructions. Permanent share-like voting mechanisms are mechanisms where the share weight counts for every single proposal. With time-lock voting mechanisms, the weight of the share is locked into one proposal for the time of that proposal and cannot be allocated to other proposals.

The second type of weighted voting is reputation-like voting. The voting weight is based on the reputation of the participants. This reputation can change over time but is not transferable. The assignment of a new reputation is either algorithmically determined (DAO stack) or by DAO voting. Almost all platforms, Aragon, DAOstack, and Colony, work with or support a form of reputation-based voting. We distinguish three subtypes within reputation-based voting: activity-based reputation, conviction, and holistic voting. In activity-based voting, one will gain a reputation based on their actions performed and/or voting participation. With this voting variant, reputation growth or decline is based on whether a participant votes in line with the outcome of the eventual decision. There are platforms like Colony that let reputation decay over time with inactivity. Conviction voting (Arsenault 2020; Emmett 2019) is a mechanism where an element of time is added to the voting. The eventual voting weight is based on the reputation level multiplied by a multiplier based on the duration that a certain vote was signaled. The longer a certain vote was signaled unchanged, the higher the voting weight gets. This voting mechanism was proposed by 1Hive and Giveth (Emmett 2019), and is put into practice for the first time by Garden platform. In holistic (or progressive) voting mechanisms, as implemented by DAOstack, the

primary majority needed is an absolute majority. But a prediction pool can set the predicted outcome of a vote. If a high enough amount of reputation is staked on the prediction, the needed majority becomes a relative majority, leaving the necessity for a quorum. The holistic system's weighting of voting in both voting and prediction is based on reputation of the participants.

Finally, in the third type of weighted voting, quadratic voting, a participant can spend a fixed amount of vote credit in a voting round consisting of various proposals. Based on the number of votes the participants want to spend on a certain proposal, they pay a quadratic amount of voting credit.

3.1.3. Incentive models

In this subsection, we derive a categorization of incentive models of DAOs. We divide the incentive models as described in the literature and as analyzed in our empirical research into three main groups: direct and indirect participant incentives and no incentive (Figure 5).

The direct incentives in DAOs are divided into two direct subcategories (i.e., reputation, tokens) and linked to one indirect subcategory (staking revenues). Within reputation-based weighted voting, the direct incentive for a participant is gaining an additional (non-tradeable) reputation. This then leads directly to more influence in voting. DAOStack has a direct activity reputation token markup based on voting activity without the need for the DAO to assign additional reputation for the active participant. Aragon and Colony assign reputation through the nomination of other tokenholders. The second direct incentive model is through (tradeable) tokens. Active participation in the governance of the organization entitles a participant to earn additional (tradeable) economic/governance tokens or sometimes airdrop of other tokens (AirdropAdventure 2022). Direct incentives are explicitly described in the Decred and Nexus Mutual DAO.

The first indirect incentive to participate in the governance process is through revenues obtained by staking tokens, as found in NAVcoin. By staking tokens, the participant gets the right to participate in governance, but participants do not necessarily need to be active in voting or other activities in order to earn that staking revenue.

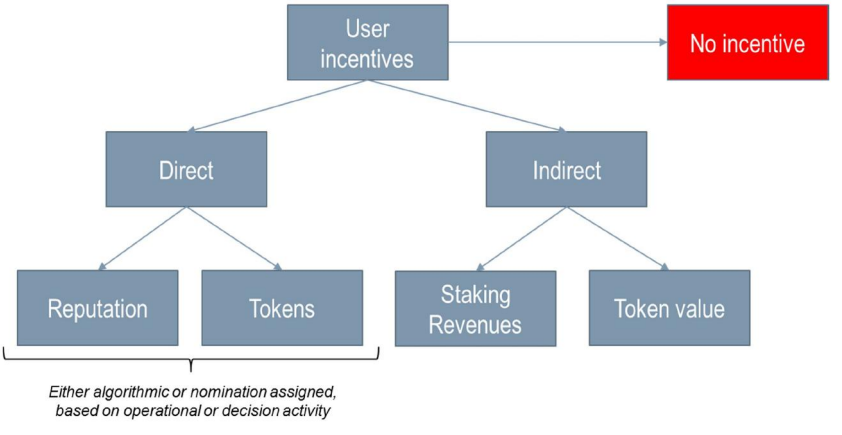

Figure 5. Incentive structure overview.

Even without voting, participants will receive staking revenue (so not necessarily for voting itself). The second indirect incentive to participate in governance analyzed is based on an increase in the value of the (tradeable) tokens. This is observed for Bisq, Dash, and Compound Finance, but this could also be applicable for all share-like models.

The "no incentive" category can be found in membership organizations. Membership organizations have no direct or indirect incentive at all as the token is nontransferable, no reputation or (economic) tokens can be earned, and no staking revenues are granted.

4. Empirical study of governance decision and incentive models (of selected/verified DAOs and their effectiveness)

We analyzed 220 DAOs that show high lifetime activity, in-depth on their decision and incentive models. Within this group of 220 DAOs, as stated earlier, a group of 90 showed no or low activity in the 6 to 18 months between the first and second measurement, while 130 of these 220 DAOs showed high or medium activity. The analysis is meant to find a relationship between the decision models, incentive models, and the accountability of tokenholders and continuation or termination of activity (long-term viability). A detailed overview is shown in Table 1.

4.1. Statistical analysis

After the first comparison analysis shown in Table 1, we statistically analyze the relationship between the governance elements and the long-term viability of DAOs. The effect size of each government element on DAOs' long-term viability was estimated by using partial eta squared (η^2), which is a statistical method to estimate the effect size of different variables in ANOVA or general linear model (GLM) (Cohen 1973; Richardson 2011). The partial eta squared was used here since the independent variables (i.e., government elements) are in categorical or nominal scales while the long-term viability is in ordinal scale (i.e., level of activities) and in ratio scale (i.e., the number of activities). Partial eta squared is computed as:

$$\eta^2 = \frac{SS_{effect}}{SS_{effect} + SS_{error}}$$

where SS_{effect} is the sum of squares for the effect of interest and SS_{error} is the sum of squares for the error term associated with that effect (Cohen 1973). The indication of small, medium and large effects corresponds respectively to values of η^2 of .0099, .0588, and .1379 (Cohen 1973, pp. 278-280).

For the measures of the three government elements, the independent variables used were in categorical or nominal scales:

1. Accountability is measured as voting power distribution denoted as the variable VPD (1 = dictatorship, 2 = semi-dictatorship, 3 = democracy)
2. Decision/voting model is measured in two levels:

Table 1. Comparing the long-term viability of various DAO governance elements.

	Categories		Total High LT Activity			Continuation of Activity (High/Medium)			Loss of activity (Low/None)		Δ to total	Δ to cont'd
Voting power	Dictatorship	220	29	13,2%	130	16	12,3%	90	13	14,4%	1,3%	2%
	Semi Dictatorship		20	9,1%		11	8,5%		9	10,0%	0,9%	2%
	Democracy		171	77,7%		103	79,2%		68	75,6%	−2,2%	−4%
Quora Restriction?	Relative Majority	220	46	20,9%	130	33	25,4%	90	13	14,4%	−6,5%	−11%
	Yes		147	66,8%		85	65,4%		62	68,9%	2,1%	4%
	Progressive		26	11,8%		12	9,2%		14	15,6%	3,7%	6%
	Two layer		1	0,5%		0	0,0%		1	1,1%	0,7%	1%
Quora Percentage	0 to 25%	148	90	60,8%	85	50	58,8%	63	40	63,5%	2,7%	5%
	25 + to 50%		12	8,1%		10	11,8%		2	3,2%	−4,9%	−9%
	50 + to 75%		32	21,6%		17	20,0%		15	23,8%	2,2%	4%
	75 + to 100%		9	6,1%		4	4,7%		5	7,9%	1,9%	3%
	Various		5	3,4%		4	4,7%		1	1,6%	−1,8%	−3%
Decision lvl 1	Weighted	220	170	77,3%	130	95	73,1%	90	75	83,3%	6,1%	10%
	Non-weighted		42	19,1%		31	23,8%		11	12,2%	−6,9%	−12%
	Unknow		5	2,3%		2	1,5%		3	3,3%	1,1%	2%
	Mixed		3	1,4%		2	1,5%		1	1,1%	−0,3%	0%
Decision lvl 2	Reputation	220	45	20,5%	130	25	19,2%	90	20	22,2%	1,8%	3%
	Share		125	56,8%		70	53,8%		55	61,1%	4,3%	7%
	Direct Democracy		42	19,1%		31	23,8%		11	12,2%	−6,9%	−12%
	Mixed		3	1,4%		2	1,5%		1	1,1%	−0,3%	0%
	Unknown		5	2,3%		2	1,5%		3	3,3%	1,1%	2%
Incentives	Yes – Tokens	220	2	0,9%	130	2	1,5%	90	0	0,0%	−0,9%	−2%
	Yes – Fee		1	0,5%		1	0,8%		0	0,0%	−0,5%	−1%
	Yes – Automatic Rep		26	11,8%		12	9,2%		14	15,6%	3,7%	6%
	Indirect – Staking Revenu		1	0,5%		1	0,8%		0	0,0%	−0,5%	−1%
	Indirect – Token Value		121	55,0%		66	50,8%		55	61,1%	6,1%	10%
	Indirect – SR and TV		1	0,5%		1	0,8%		0	0,0%	−0,5%	−1%
	No		63	28,6%		45	34,6%		18	20,0%	−8,6%	−15%
	Unknown		5	2,3%		2	1,5%		3	3,3%	1,1%	2%

   a. Voting model level 1 denoted as the variable VL1 (1 = non-weighted; 2 = weighted)
   b. Voting model level 2 denoted as the variable VL2 (1 = reputation; 2= share; 3 = direct democracy). In the sample of 220 DAOs no liquid democracy or quadratic voting models were present. Therefore, these voting models were not included in the analysis.
3. The incentive model is denoted as the variable IM (1 = no, 2 = indirect, 3 = direct)
4. Quorum denoted as the variable QR (1 = progressive; 2 = relative majority; 3 = yes. Yes means there is a fixed quorum in place. In Relative majority there is no minimum quorum required. Progressive is a combination of Yes and Relative as described in section 3.

The dependent variables of DAOs' long-term viability (ordinal scale) are measured in both ordinal and ratio scales:

1. Level of activities (0 = no activity, 1 = low level of activities, 2 = medium level of activities, 3 = high level of activities)
2. The number of activities (measured in ratio or continuous scales).

As shown in Table 2 (in ***bold italic***), regarding the level of activities as the dependent variable (measured in ordinal scale), the voting mechanisms on level 1 (VL1) shows a small effect ($\eta^2 = 0.021$) and is significant ($p < 0.05$). Incentives also show a small effect ($\eta^2 = 0.022$) and is slightly less significant ($p < 0.1$). The interaction effect of accountability (voting power distribution) and quorum on the activity level appears to have a small effect ($\eta^2 = 0.019$) and is slightly significant ($p < 0.1$). These findings indicate that more data points (larger sample size) are needed to further test other independent variables' statistical relationships/effects.

Subsequently, as shown in Table 3 (in ***bold italic***), when measuring DAOs' long-term viability in ratio scale (i.e., number of activities as the dependent variable), we found that only accountability (the variable voting power distribution (VPD)) showed

Table 2. Effects of different government elements and their interactions on DAOs' **level** of activities using two-way ANOVA in GLM.

Governance Element	Variables	df	F-value	Sig.	η^2
Accountability	VPD	2	0.989	0.374	0.009
	VPD × VL1	1	1.022	0.313	0.005
	VPD × VL2	1	1.077	0.301	0.005
	VPD × IM	2	2.249	0.262	0.014
	VPD × QR	***1***	***3.813***	***0.052***	***0.019***
Decision/Voting	***VL1***	***1***	***4.555***	***0.034***	***0.021***
	VL1 × IM	2	1.267	0.284	0.012
	VL1 × QR	1	0.255	0.614	0.001
	VL2	2	2.281	0.105	0.021
	VL2 × IM	1	0.927	0.457	0.003
	VL2 × QR	0	.	.	.
Incentive	***IM***	***2***	***2.403***	***0.093***	***0.022***
	IM × QR	2	0.262	0.770	0.003
Quorum	QR	2	1.891	0.154	0.018

Table 3. Effects of different government elements and their interactions on DAOs' **number** of activities using two-way ANOVA in GLM.

Governance Element	Variables	df	F-value	Sig.	η^2
Accountability	***VPD***	***2***	***4.470***	***0.013***	***0.043***
	VPD × VL1	1	0.022	0.884	0.000
	VPD × VL2	1	0.020	0.888	0.000
	VPD × IM	***2***	***3.329***	***0.038***	***0.034***
	VPD × QR	***1***	***3.929***	***0.049***	***0.020***
Decision/Voting	VL1	1	0.000	0.996	0.000
	VL1 × IM	0	.	.	.
	VL1 × QR	1	0.023	0.879	0.000
	VL2	2	2.026	0.135	0.020
	VL2 × IM	0	.	.	.
	VL2 × QR	0	.	.	.
Incentive	IM	2	1.757	0.175	0.017
	IM × QR	1	2.647	0.105	0.014
Quorum	QR	2	0.349	0.706	0.003

(nearly) medium effect ($\eta^2 = 0.043$) and is statistically significant ($p < 0.05$). Additionally, the interaction effects of accountability and incentives ($\eta^2 = 0.034$) and of accountability and quorum ($\eta^2 = 0.020$) show small-to-medium effects and are both statistically significant at $p < 0.05$. There are no statistically meaningful effects on the other two governance elements (decision/voting and quorum).

In the following subsections, we further discuss the three main governance elements: accountability, decisions, and incentives.

4.2. Accountability

Voting power distribution in 13.2% DAOs (29 of the 220 DAOs) are dictatorships (see Table 1), 9.1% of the DAOs analyzed are semi-dictatorships, and 77.7% of the DAOs are classified as democracies. Based on the comparative analysis, no large difference was observed in the group of DAOs that stopped activity compared to DAOs with continued activity based on voting power distribution. But the statistical analysis did show a medium effect that was statically significant. Empirically, it thus seems that accountability (voting power distribution) does affect survivability, whereas democracies seem to have a positive effect on the long-term viability of DAOs.

4.3. Governance decision model and quorum effectiveness

The next element of governance we analyze in our empirical research focuses on the decision-making model and quorum rules of the governance mechanisms. As shown in Figure 4, we split the decision models into two levels: the first level is the division between weighted and non-weighted voting, with the second level detailing the first level.

Regarding the first-level voting (weighted vs. non-weighted), in five of the 220 DAOs analyzed, it is unclear if they are weighted or non-weighted voting systems. Three DAOs have a combination of weighted and non-weighted. We find a significant difference in the active DAOs compared to the inactive DAOs. Weighted decision model DAOs have a higher representation in the loss of activity group (83%)

than the continued activity group (73%). Non-weighted voting model DAOs in the loss of activity group represent 12%. This is much lower than in the continuation of activity group, which is 24% for non-weighted voting DAOs. This suggests that non-weighted voting contributes positively to the long-term viability of DAOs. Based on the statistical analysis, this relationship is shown as well as a small effect and is significant at $p < 0.05$ (Table 2).

When zooming in one level deeper in decision models, within the weighted voting group, the difference in loss or continuation of activity can predominantly be explained by the share-like voting group. The share-like group represents 61% of the loss of activity group, while in the continuation group, the share-like group represents 54%. This suggests that in weighted voting, share-like models contribute negatively to the long-term viability of DAOs. Although the statistical analysis shows a non-significant effect, there is a possibility that there is an effect, but more data points are needed.

Besides the decision models, we also analyze the effect of the usage of a quorum in the decision-making process on the effect of continued activity. Based on the comparative analysis, we find that if no quorum is used, but only a relative majority is needed for decision-making, this positively affects the continuation of activity. The percentage of the relative majority in the non-activity group is 14% against 25% in the continued activity group. The progressive quorum group (holistic voting) turns out to have a slightly higher rate of non-continuity (16%) versus 9% in the continued activity group.

Within the group of DAOs where a quorum is required, we further analyze whether the quorum percentages influence the continuation of activity. We find a clear difference, especially in the group where a quorum of 25+ to 50% is required. This percentage is 3% in the non-activity group, which is much lower than the 12% in the continued activity group, suggesting that a quorum between 25+% and 50% positively contributed to the long-term viability of DAOs. But according to the statistical analysis, only a small, non-significant effect could be observed, so more data is needed to check this relationship.

Our analysis shows a difference in long-term viability based on Level 1 and Level 2 decision models, but not on quorum. Hence, there is no clear explanation yet at this point regarding the differences in long-term viability based on decision models. A potential cause for the higher percentage of non-weighted or direct democracy decision mechanisms could be that these mechanisms come more naturally due to the decentralized character or the business objectives of DAOs; which is another interesting area worth investigating in further research.

4.4. Governance incentive

We finally look at the incentive element in the DAOs. We find a clear difference in the percentages of non-activity and continued activity in the group of DAOs that do *not* have an explicit incentive system. The percentage of DAOs with no incentive mechanism in the non-activity group is 20%, whereas this group in the continued activity group represents 35%. Incentives by reputation, or indirect token value show

a larger percentage in the non-activity group than in the continued activity groups. Although small and significant with $p < 0.1$ instead of $p < 0.05$, this effect is also confirmed in our statistical analysis (Table 2). This suggests that no type of incentive positively influences DAOs' long-term viability. This observation might be perceived as surprising, but it could be explained in line with the observations regarding governance decision models. As DAOs are first set up in decentralized communities that might focus more on the commons or altruistic business objectives, incentivizing might not be so important to the communities that use DAOs. Therefore, we recommend further research to analyze the purpose or business objective, in combination with various governance elements of the DAO.

5. Discussion: an emerging DAO governance theory for the long-term viability of DAOs

Research on DAO governance so far is mainly limited to describing governance models and elements or single case studies. The little empirical research predominantly focuses on aggregated elements (like voting percentages and value of all DAOs from specific platforms), or their tokens and differences between platforms, or focuses primarily on a single use case (Appel and Grennan 2023; Faqir-Rhazoui, Arroyo, and Hassan 2021; Sims 2021). In this paper, we empirically examined how various governance elements can actually influence a DAO's long-term viability over many different DAOs and DAO platforms instead of primarily observing and summarizing the past behavior of a single use case.

A previous study by Rikken, Janssen, and Kwee (2023) shows that the number of tokenholders (as a basic element of accountability) significantly influences the survivability of a DAO, where the crucial threshold lies around 20 tokenholders. Although no specific explanation was given on the possible reason for this relationship, we suspect that this can be explained by having a broader active community that keeps activities going and thus influences the long-term viability of a DAO in a positive way. In future research, it would be interesting to study the combination of the number of tokenholders and voting power distribution.

Our empirical findings based on the statistical analyses of governance elements coupled with the findings by Rikken, Janssen, and Kwee (2023) result in a preliminary DAO governance theory. The theory shows possible influencing factors on the long-term viability of DAOs (Figure 6). Bacharach (1989) argues that a theory is a statement of relationships between one or more variables or constructs in an empirical environment. In line with this, the observed units or variables in our theory are the governance elements and the long-term viability, whereas the boundary of the theory is on-chain governance DAOs on permissionless blockchain protocols. Besides the three governance elements investigated in this paper (the grey and yellow boxes in Figure 6), our analyses suggests that other factors (orange box in Figure 6) might influence the long-term viability of DAOs. Moreover, these factors can also be interrelated.

An important element that has not yet been considered in the literature, but was found to be relevant in our research, is a DAO's goal or business purpose (e.g., an

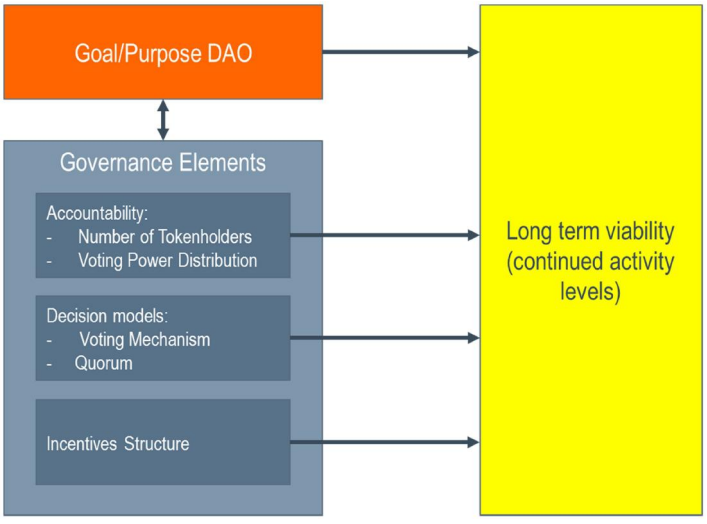

Figure 6. Preliminary theory for the long-term viability of DAOs.

investment DAO or a philanthropic DAO). Based on our preliminary observations, we consider that the goal can directly influence the long-term viability as some goals of the organization or project might not be suitable for DAO-based governance (Yang 2022). We also speculate that the business objective might have an influence on several factors of our theoretical model as a moderating variable on DAOs' long-term viability (Figure 6). Therefore, we propose that future research should investigate the connection between the goal or business purpose, governance elements, and the long-term viability of DAOs. This would require more in-depth data gathering as the goals or business purposes of DAOs have not yet been captured.

Since our in-depth empirical analysis is restricted to 220 DAOs, we recommend expanding the DAO dataset. This can be used to verify our initial findings with the growing number of DAOs and maturing of DAOs and their governance models. The exponentially growing number of DAOs drives this recommendation.

To further expand this preliminary theory, another element that can be considered in future research is to include the effect of the choice of blockchain infrastructure that a DAO is deployed on. This can be the effect of the choice between a permissioned and permissionless infrastructure or the type of permissionless infrastructure. The choice of permissionless infrastructure (e.g., Ethereum, Polygon, Gnosis Chain, EOS, etc.) can have various important governance influencing factors. For instance, transaction speed or transaction pricings that differ per infrastructure may influence the cost of efficiency of governance.

Furthermore, other governance elements could potentially influence the long-term viability of DAOs that are not part of this research. These elements, like "emergency brake" mechanisms, such as rage quit, should be further researched theoretically and empirically to better understand these mechanisms and analyze their relationship with the long-term viability of DAOs. These additional influential elements can be further extended/added into and refined in our preliminary theory of the long-term viability of DAOs.

Table 4. Possible influencing factors usage DAOs.

Factor (variables)	Description of Long-term viability influencing factors (observed units/variables)	Statistical Link to Long-term viability – Nominal - Ordinal
Goal or Business Purpose	The goal or purpose of the DAO can influence its long-term viability. Certain goals for DAOs could be more suitable for DAOs than others.	To be studied
Accountability	Combination of Voting Power Distribution and Number of tokenholders.	See Voting Power Distribution and Number of tokenholders below.
Voting Power Distribution	Does the voting require a democratic collation of multiple tokenholders or is there a semi-dictatorship or a dictatorship?	Medium effect – Not significant. Additional data needed
Number of tokenholders	The number of tokenholders influences the long-term viability/activity of a DAO, where a high number of tokenholders seems to lead to a higher activity level.	Strongly related – Significant (Rikken, Janssen, and Kwee 2023)
Voting mechanism	Various voting mechanisms can lead to different decision-making processes, which can influence the long-term viability/activity.	Small effect – Significant on the highest level, not significant on the lower level – more data needed.
Quorum	The minimum amount of voting percentage needed for a decision to pass.	Small effect – Not significant
Governance incentives	Incentives to participate in the governance mechanism of that particular DAO.	Small effect – significant at $p < 0.1$ instead of $p < 0.05$
Infrastructure	The chosen infrastructure or the governance elements of this infrastructure can influence the long-term viability as a result of the entanglement of application and infrastructure.	To be studied

Finally, the DAOs analyzed are all on-chain governance DAOs. However, there is a steep rise in off-chain, less autonomous governance projects that refer to themselves as DAOs through platforms like Snapshot. We recommend including this type of off-chain DAOs as a separate category in further research to analyze if they behave similarly to on-chain DAOs.

In summary, Table 4 shows the identified factors that could influence the long-term viability of a DAO. Various of these elements are analyzed in this paper. Based on the comparative and statistical analysis, we show that all elements can have an effect on long-term viability, although various relations need additional data as the effect is not statistically significant in all cases. As such, the preliminary theory shown in Figure 6 has not been entirely evaluated yet, and we recommend future research to test this further in more detail.

6. Conclusions

DAOs provide a new form of governance, and there is limited knowledge about how DAOs should be designed to be viable in the long-term. Providing insights into the effect of governance elements' impact on the long-term viability of DAOs helps policy-makers and decision-makers in choosing the right setup of these elements when they want to use DAOs to achieve higher levels of transparency, inclusiveness, and accountability. Based on our in-depth analysis of 220 out of 6,000+ DAOs, we find that a number of governance elements can influence the long-term viability of DAOs. More specifically, the empirical analysis reveals the following relationships:

1. Power distribution, dictatorship, semi-dictatorship, or democracy, have a (nearly) medium effect on the long-term viability of DAOs (Table 3). Democracies contribute positively to long-term viability being statistically significant. This suggests that policy-makers should embed democratic governance in a DAO to create a more long-term viable DAO;
2. Non-weighted voting systems (1 account – 1 vote) significantly and positively contribute to the long-term viability of DAOs (Table 2). The findings suggest that policy-makers should ensure that each citizen and other stakeholders have an equal share and are heard;
3. When detailing the voting mechanisms even further, although there seems to be a relation on a cursory examination, this is not significant but should be researched with more data;
4. The usage of quorums has no significant influence on the long-term viability. We recommend researching this further using more data;
5. Finally, the lack of incentive structure for participation contributes positively to long-term viability (Table 2). However, the significance is less strong than level 1 voting mechanisms. This suggests that policy-makers should not provide explicit (financial or reputation) incentives for citizens to contribute to DAOs. Intrinsic motivation and interest in the issues at hand might be more important.

Some of the conclusions based on our data are counterintuitive, like the influence of incentive structures on the long-term viability of DAOs. A possible explanation is that the early-stage DAOs are formed around more altruistic communities (more closely related to the original blockchain community). As such, the results might not be generalizable to all types of citizens. We have not so far found any conclusive empirical evidence, nor have we found any supporting literature on this. Hence, we recommend investigating this in future research. Overall, these hypothesized relationships form a preliminary theory on the influence of DAOs' governance elements on long-term viability (Figure 6). Based on empirical research and the preliminary theory, these findings can help policy-makers and businesses make better decisions in the governance design phase when they want to use a DAO structure to improve trust, transparency, accountability, and potentially increase citizen participation in public administration.

There is a need to collect more data in future research to further test our preliminary theory (as displayed in Figure 6) empirically. In particular, when analyzing the relationship between governance elements and the long-term viability of DAOs, we recommend including a DAO's goal or business objective and the choice of blockchain infrastructure upon which the DAO is deployed. Also, differences between user types might be made, as other users might have different preferences and incentives.

Note

1. Verified means DAOs are selected based on filters in Figure 2. Here we exclude experimental/test DAOs.

Disclosure statement

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