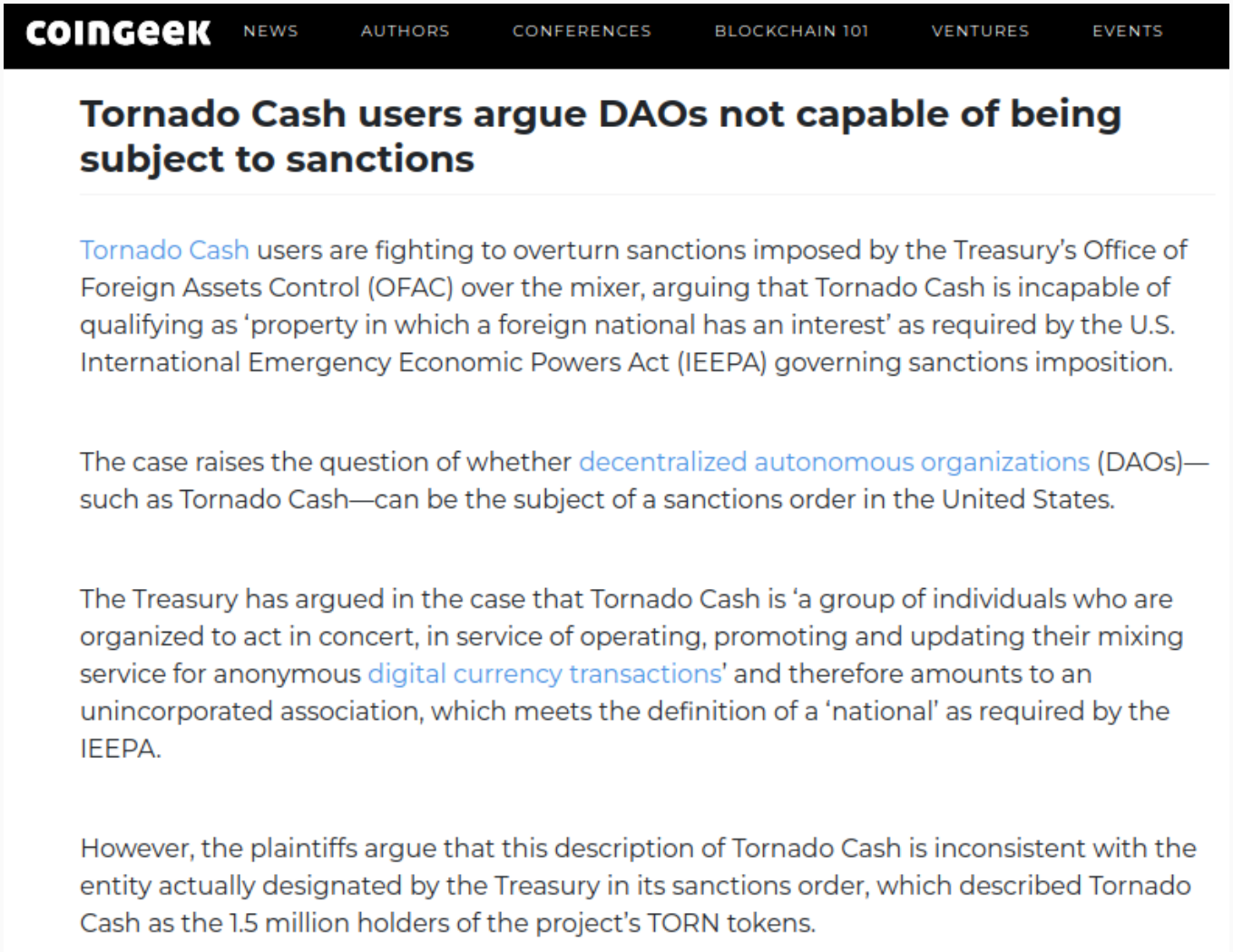
The Governance of Decentralized Autonomous Organizations:

A Study of Contributors' Influence, Networks, and Shifts in Voting Power

Stefan Kitzler, Stefano Balietti, Pietro Saggese, Bernhard Haslhofer and Markus Strohmaier

Sept 21th, 2023

Motivation



coingeek NEWS AUTHORS CONFERENCES BLOCKCHAIN 101 VENTURES EVENTS

Tornado Cash users argue DAOs not capable of being subject to sanctions

Tornado Cash users are fighting to overturn sanctions imposed by the Treasury's Office of Foreign Assets Control (OFAC) over the mixer, arguing that Tornado Cash is incapable of qualifying as 'property in which a foreign national has an interest' as required by the U.S. International Emergency Economic Powers Act (IEEPA) governing sanctions imposition.

The case raises the question of whether decentralized autonomous organizations (DAOs)—such as Tornado Cash—can be the subject of a sanctions order in the United States.

The Treasury has argued in the case that Tornado Cash is 'a group of individuals who are organized to act in concert, in service of operating, promoting and updating their mixing service for anonymous digital currency transactions' and therefore amounts to an unincorporated association, which meets the definition of a 'national' as required by the IEEPA.

However, the plaintiffs argue that this description of Tornado Cash is inconsistent with the entity actually designated by the Treasury in its sanctions order, which described Tornado Cash as the 1.5 million holders of the project's TORN tokens.

Source: https://coingeek.com/tornado-cash-users-argue-daos-not-capable-of-being-subject-to-sanctions/

Objectives

In this study, we **focus on DAO contributors**,
encompassing project *owners*, *administrators*, and *developers*.

Our aim is to empirically examine

their **influence in decision-making** processes (Obj_1),
the **structure of their co-voting network** (Obj_2), and
any sudden **shifts in majorities** just before voting takes place (Obj_3).

Background and Definitions

Decentralized Autonomous Organizations **(DAOs)** are a novel form of governance model that has become popular in the crypto ecosystem since 2020.

DAO voting can be executed *on-chain* or *off-chain*. Typically, governance tokens holding or delegation enable voting rights of users.

Snapshot is an off-chain voting platform but it determines voting rights from on-chain and stores the outcome on the DLT. This method is more scalable, accessible and efficient, at the cost of higher centralization.

Definitions

- User $u \in \mathcal{U}$ exercise voting on DAO *space* $s \in \mathcal{S}$.
- A **proposal** is a proposed change to a space s, with options O^p to select.
- A user **votes** $\mathcal{V}$ on a proposal p.
- A **contribution** $c \in \mathcal{C}$ is a relation of a vested user with a role $T = \{\text{owner}, \text{administrator}, \text{developer}\}$ in a DAO s.

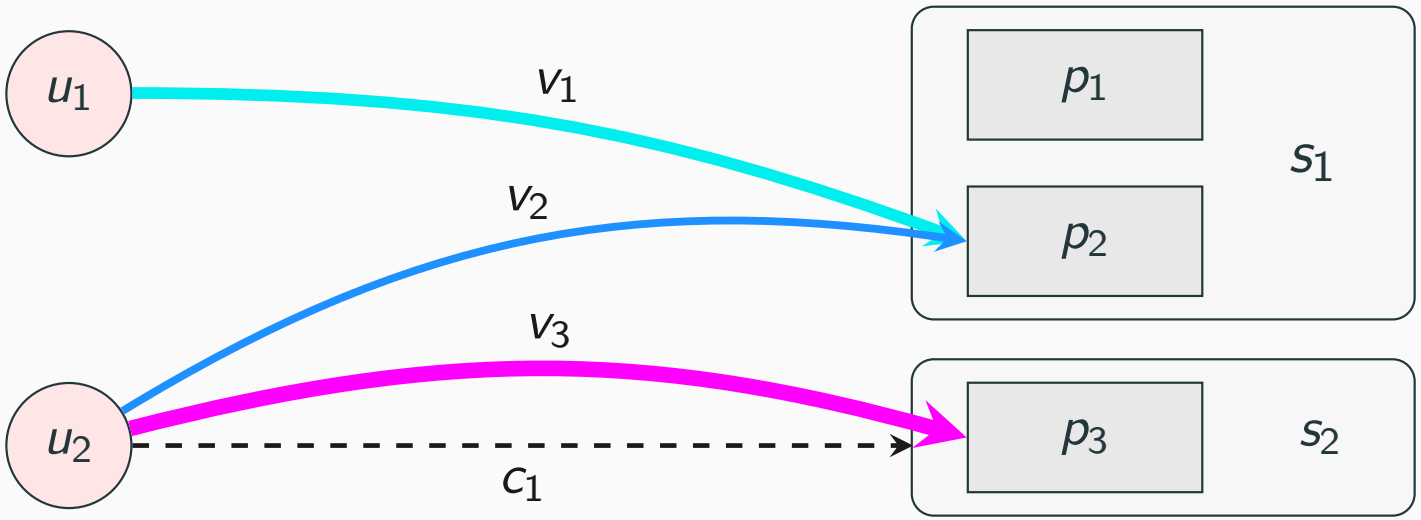


Figure 1: Conceptualization of DAO voting.

Background and Definitions — Vote

A **vote** of user u on a *single-choice* proposal p selects one option $o \in O^p$.

The **voting power** is the weight w assigned to the option o and characterizes the influence of a vote v. It is determined by the strategy function f, e.g. f^{erc20} extracts the holding of a specified governance token at the block height h.

The *outcome* are the ranked options $\hat{O}^p = [\hat{o}_1^p, \hat{o}_2^p, \dots]$ in descending order by aggregated voting power w. The *decision* $\hat{o}_1^p$ is the option having the highest accumulated voting power for the proposal p.

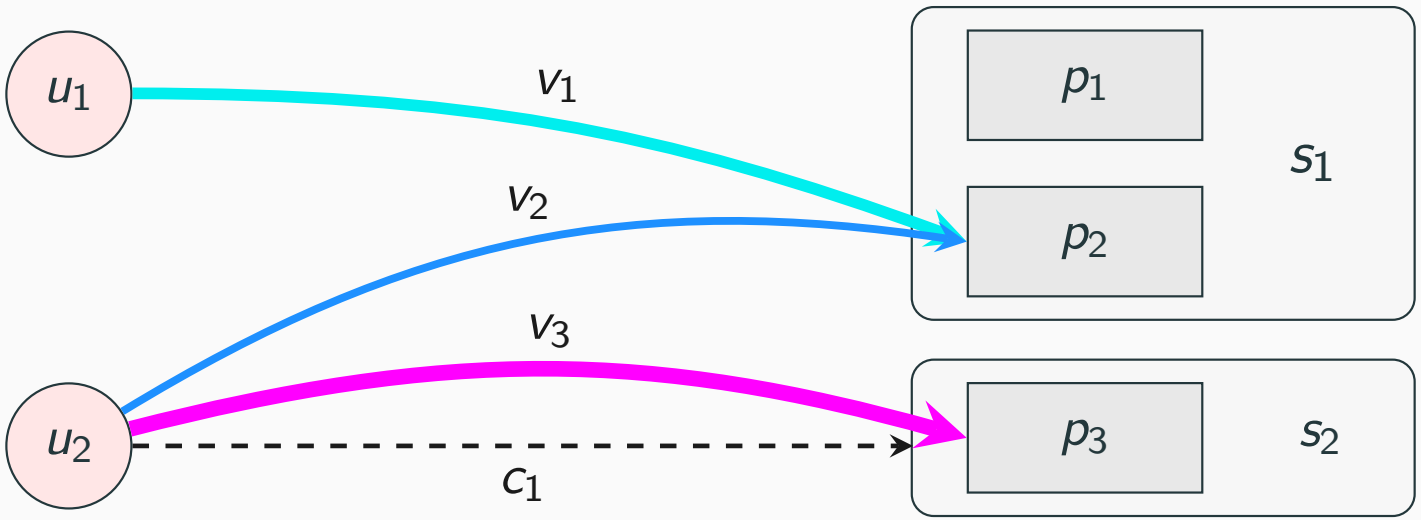


Figure 1: Conceptualization of DAO voting.

Background and Definitions — Vote types

The set of all votes related to proposal p is $V^p \subseteq \mathcal{V}$ can be separated into:

- **Same-space votes** V^P_{SS}: A user can contribute and vote on an improvement proposal for the same space (→).
- **Other-space votes** V^P_{OS}: A user can also contribute to one space and vote on an improvement proposal for another space (→).
  → We denote $V^P_C = V^P_{SS} \cup V^P_{OS}$ as the set of **contributor votes**.
- Else: A user votes without any contribution to a space (→).

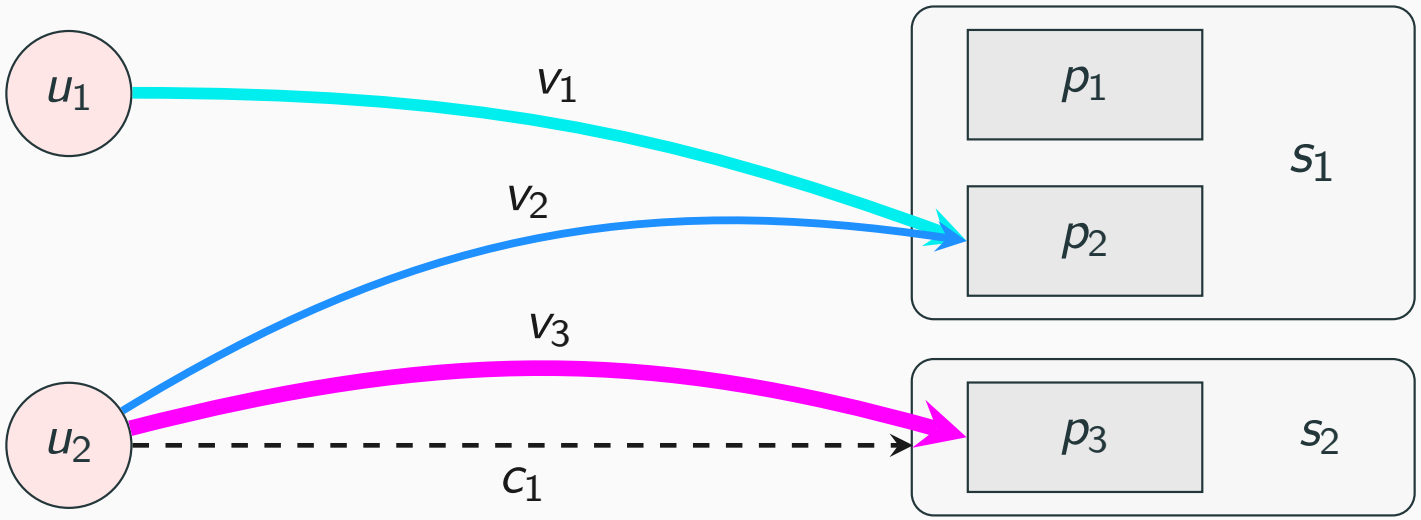


Figure 1: Conceptualization of DAO voting.

Data Sources

We gathered data from the following sources:

- **Snapshot**: encompassing voting data, spanning from Nov 2020 to Dec 2022.
- **Ethereum blockchain** full archive node: to acquire code account creators, cryptoasset balances and Ethereum Name Service (ENS).

We identify voters' **contributions** to DAOs by joining linking addresses:

- (Sub-)Domain **owner** address from DAOs' ENS (+ *The Graph*) references,
- **Administrators'** addresses from Snapshot,
- The creators, or **developers**, of code accounts (CA) from the blockchain transaction for all space-related CA from Snapshot.

Data Sources

We combine the Snapshot voting data and the identify contributions. Then, we clean, verify, and validate our dataset with Ethereum references:

	Raw	Cleaned (Sections 4 & 5)	Validated (Section 6)
Spaces $\mathcal{S}$	12,294	872	357
Voters $\mathcal{U}$	1,603,994	986,557	119,413
Contributions $\mathcal{C}$	11,949	7478	3927
Proposals $\mathcal{P}$	76,851	35,124	8116
Votes $\mathcal{V}$	8,365,707	5,240,622	438,668
Contributor votes $\mathcal{V}_{\mathcal{C}}$	316,900	191,507	22,878

Table 1: Dataset summary.

Influence of contributors on DAO governance (Obj_1)

We analyze the influence of contributors by defining two metrics:

contributor involvement and *contributor self-decisions*

First, *contributor involvement* as the average share of contributors' voting power in a given space:

Given a proposal p, we consider **contributor votes** $V_C^P \subseteq V_p$ **independent** of their selected **option** o.

1. Normalize weights for each proposal $\tilde{w}_i$
2. Relative voting power of contributors per proposal $\tilde{w}_C^p = \sum_{v_i \in V_C^p} \tilde{w}_i$
3. *Contributor involvement* as relative voting power of contributors per space

$$\bar{w}_C^s = |P|^{-1} \sum_{p \in P} \tilde{w}_C^p \tag{1}$$

Influence of contributors on DAO governance (Obj_1)

Contributor involvement

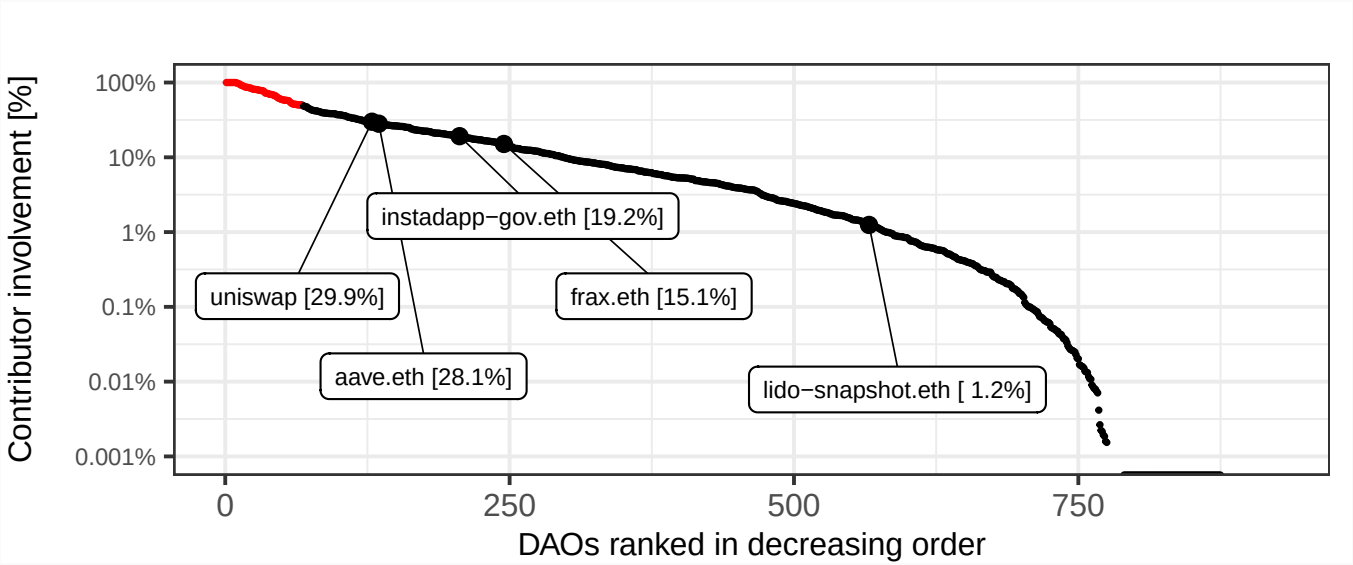


Figure 2: Contributor involvement across DAO spaces.

- Contributors' voting power is relatively low for most DAOs, and the median value is 4.26% (std 21.22).
- For 66 (7.54%) DAOs, it is higher than 50% (●), i.e. on average, contributors have a majority in these DAOs.
- Some high-TVL dApps are highlighted (●).

Influence of contributors on DAO governance (Obj_1)

Second, *Contributor self-decisions* as the average share of proposals in a space decided by *self-votes*, i.e. decisive votes of same-space contributors:

Given a proposal p, we consider **decisive self-votes** $V_D^p = V_{\hat{o}1}^p \cap V_{SS}^p$, i.e., only **same-space votes** V_{SS}^P, which selected the **winning choice** $\hat{o}_1^p$.

- Relative voting power for decisive self-votes $\tilde{w}_D^p = \sum_{v_i \in V_D^p} \tilde{w}_i$
- Fraction of proposals per space that fulfill two criteria:

$$\delta^s := |P|^{-1} \sum_{p \in P} [\,(\tilde{w}_D^p > \tilde{w}_{CV}^p) \wedge (\tilde{w}_D^p > \tilde{w}_{\hat{o}2}^p)\,], \tag{2}$$

$$\tilde{w}_{CV}^p = \sum_{v_i \in V_{CV}^p} \tilde{w}_i,$$
$$\tilde{w}_{\hat{o}2}^p = \sum_{v_i \in V_{\hat{o}2}^p} \tilde{w}_i.$$

Influence of contributors on DAO governance (Obj_1)

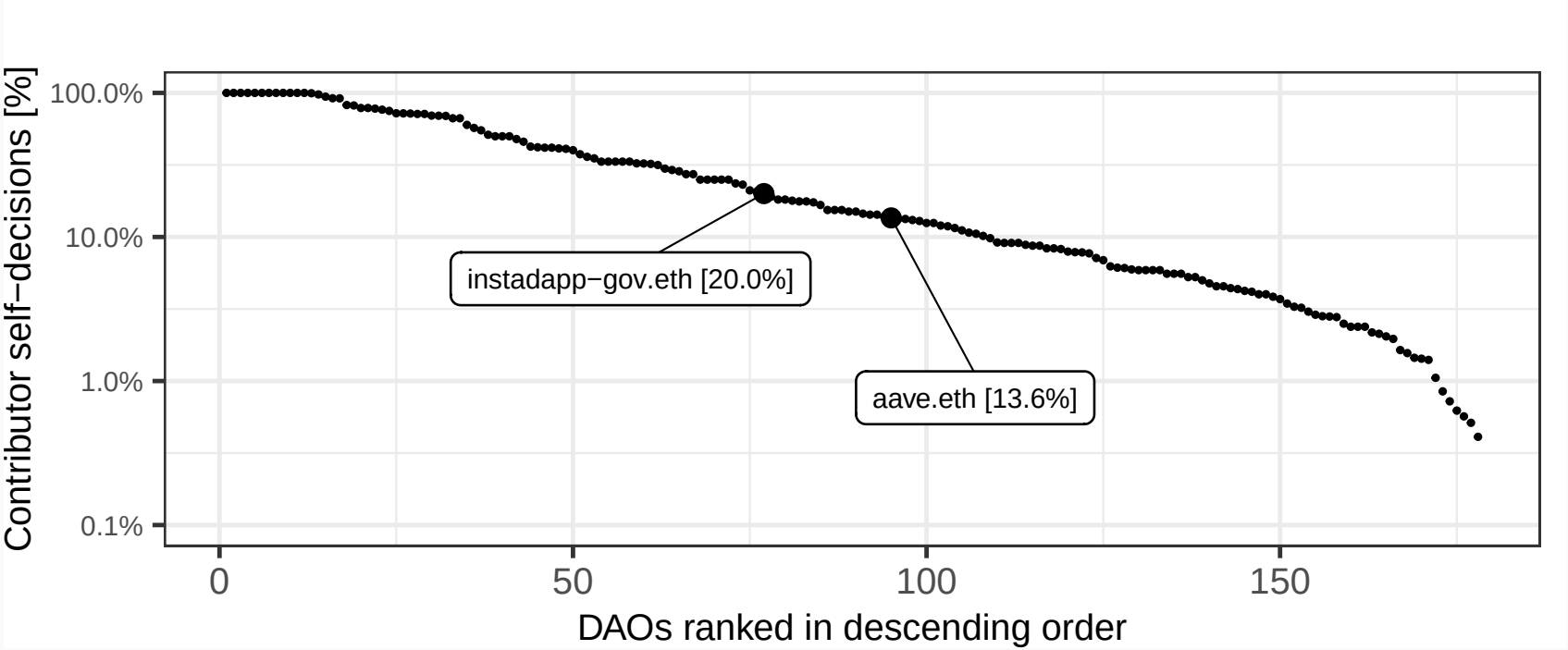


Figure 3: Contributor self-decisions across DAO spaces. DAOs are ranked by contributor self-decisions δ^s.

- In 178 (20.41%) DAO spaces, contributors of the same DAO decided on at least one proposal on their own.
- In total 2100 out of 35 124 proposals were decided by self-votes.

Co-voting networks (Obj_2)

To study users' contributions across DAOs, we conduct a network analysis.

Co-voting networks: user nodes are connected with weighted links that represent the number of proposals they voted on together.

We construct four networks and distinguish by:

- **proposals** of all DAOs or only Top-100 DAOs by TVL
- **votes** of all options or only for winning (i.e., decision)

Network	G_{AA}	G_{AW}	G_{TA}	G_{TW}
Daos	All	All	Top-100	Top-100
Votes	All	Winning	All	Winning
Num Nodes	104,863	75,879	20,401	14,494
Num Edges	739,813,062	107,374,710	19,917,792	6,045,065
Avg. Degree	14,110.09	2830.16	1952.63	834.15

Table 2: Network statistics of four co-voting networks.

Co-voting networks (Obj_2)

Network description

- *small-world* features identified, i.e., several hubs conveying information rapidly across connected communities.
- *k-coreness* is significantly higher across contributors.
- *centrality* of contributor nodes score higher.

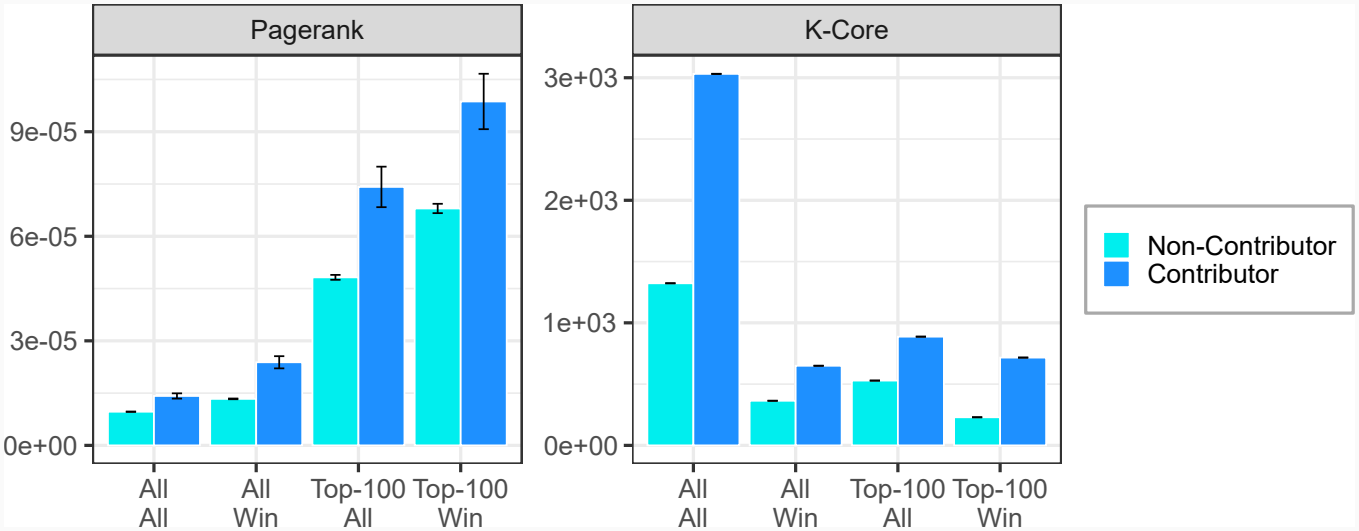


Figure 4: Pagerank and k-core statistics in the four co-voting networks.

Co-voting networks (Obj_2)

Network communities

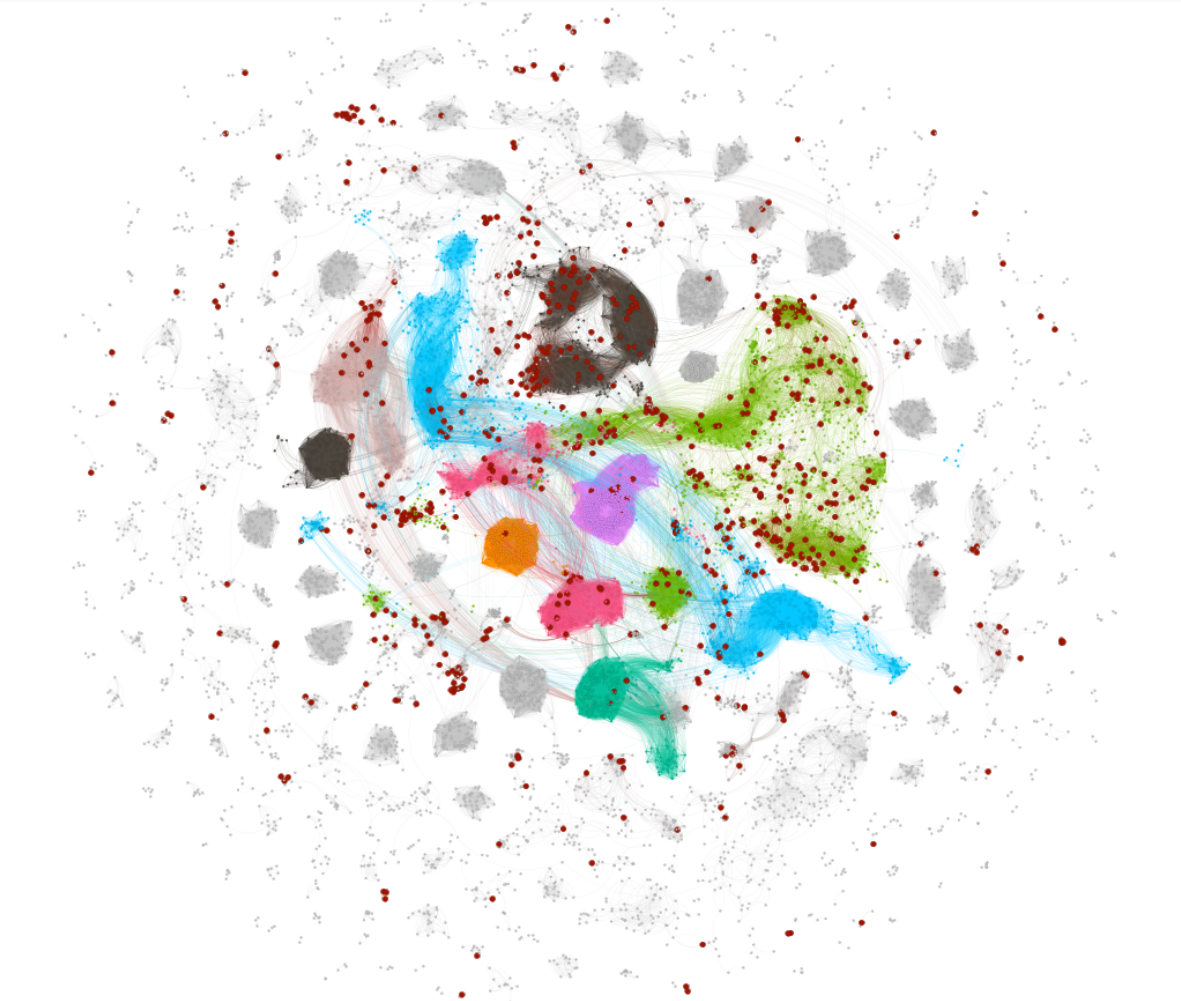


Figure 5: The co-voting network of the Top-100 DAOs by TVL (winning votes only).

Co-voting network (Obj_2)

Network communities

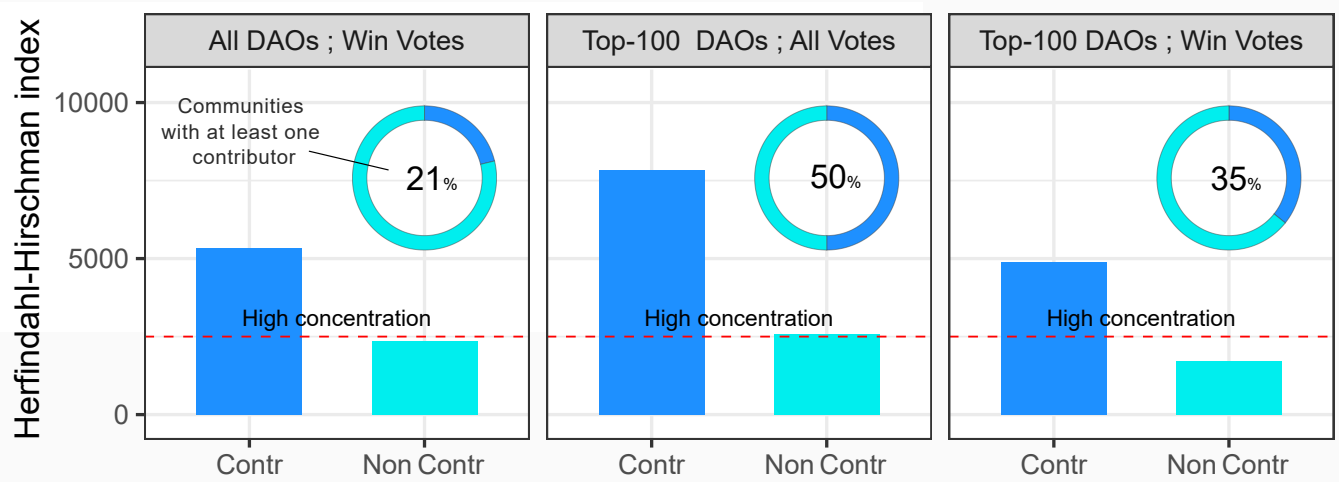


Figure 6: Concentration of contributors across network communities. The bar plots show the Herfindahl-Hirschman concentration index for the distribution of contributors (■) and non-contributors (■) to communities assigned by the Louvain community detection algorithm. The inset donut plots show the share of communities with at least one contributor; in all networks, contributors are concentrated in a few of them.

Pre-voting power shifts ($\mathbf{Obj}_3$)

Governance tokens are cryptoassets and, consequently, can be purchased and sold. Therefore, we hypothesize that changes in the ownership distribution shortly before the poll could indicate **attempts to acquire additional power** in order to influence the decision of a proposal.

Given a proposal p, for each voter u_i we re-compute the voting power $w_i(h_{\tau-t})$ at the block $h_{\tau-t}$ before the proposal h_τ. We compare the hypothetical $\hat{O}^p(h_\tau - t) = [\hat{o}_1^p(h_\tau - t), \dots]$ to the previous ranked outcome $\hat{O}^p(h_{\tau-t-1})$ and determine *majority shifts* if $\hat{o}_1^p(h_{\tau-t}) \neq \hat{o}_1^p(h_{\tau-t-1})$

Pre-voting power shifts (Obj_3)

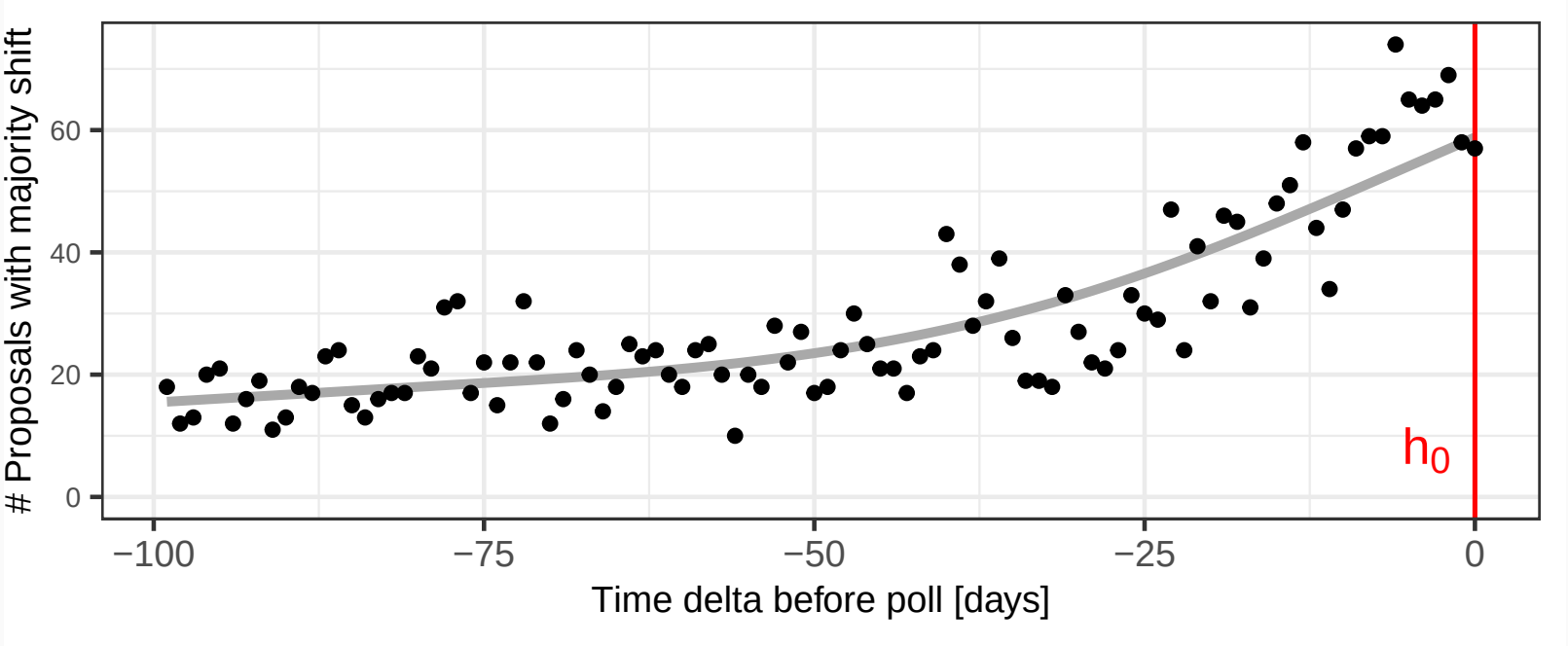


Figure 7: Majority shifts occur in temporal proximity of polls.

- In total, we found majority shifts for 1202 (14.81%) proposals in 229 DAOs in the 100 days before the poll.
- We observe a constant or slightly increasing trend in farther dates from -100 to -50 days, and a clearly increasing trend the closer time gets to the vote date.

Summary of contributions

- We compiled a dataset comprising 986 557 voters across 872 DAOs with 7478 recognized contributions.
- We introduce metrics to measure the *involvement of contributors* and *contributor self-decisions* in DAO voting:
  Contributors have, on average, voting power majorities in 66 (7.54%) DAOs and executed **decisive self-votes in 178 (20.41%) DAOs**
- We analyze the co-voting structures of users through a network approach. Our findings indicate that **contributors** are more likely to be **found towards the center** of the DAO governance ecosystem. Furthermore, contributors are **highly concentrated in a few communities** formed by co-voting patterns.
- We observed *majority shifts* in governance token ownership in 1202 (14.81%) out of 8116 proposals in the days preceding the votes.

Conclusions and Future Work

- We acknowledge that we only identify a pattern of *majority shifts* and further research is required to better investigate this phenomenon.
- We focused on off-chain voting and on one platform alone (Snapshot). Extending the study to other governance platforms and to on-chain DLT voting would be a straightforward improvement.

Contributors' high presence in the decision-making have several implications:

- Evidence for inner power circles has potential impact on smaller stakeholders with limited possibilities to participate in the governance.
- It challenges the notion of decentralization, which is relevant for regulatory discussions because it raises the questions of accountability of vested users.

Presenters:

Stefan Kitzler

kitzler@csh.ac.at

Presented Work:

Kitzler, S., Balietti, S., Saggese, P., Haslhofer B. & Strohmaier M. (2023). The Governance of Decentralized Autonomous Organizations: A Study of Contributors' Influence, Networks, and Shifts in Voting Power.

Pre-print online soon!