Decentralization illusion in DeFi: Evidence from MakerDAO

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Abstract
Decentralized Autonomous Organization (DAO) is very popular in Decentralized Finance (DeFi) applications as it provides a decentralized governance solution through blockchain. We analyze the governance characteristics in the relevant Maker protocol and its stablecoin Dai (DAI) and governance token Maker (MKR). To achieve that, we establish several measurements of centralized governance. Our empirical analysis investigates the effect of centralized governance over a series of factors related to MKR, DAI and Ethereum, such as financial, transaction, exchange, network and twitter sentiment indicators. Our results show that governance centralization influences both Maker protocol and Ethereum blockchain. The main implication of this study is that centralized governance in MakerDAO very much exists, while DeFi investors face a trade-off between efficiency and decentralization. This further contribute in the contemporary debate on whether DeFi can be truly decentralized.

Keywords: Blockchain; decentralized finance; governance; centralization.
1. Introduction

As Bitcoin was proposed in 2008 (Nakamoto, 2008), blockchain has deeply changed financial markets. The main disruption lies in the disintermediation of financial institutions from their centralized role. The absence of centralized third parties, e.g., central banks, in the blockchain universe and circumventing traditional barriers of financial markets’ participation are the major attributes of this market revolution. Decentralization, therefore, is logically regarded as the core value proposition of blockchain (Harvey et al., 2021).

Decentralized Finance (DeFi) is blockchain-based financial applications which are designed to replicate most financial activities, e.g., lending and borrowing, in the traditional markets. Theoretically, governance in DeFi is decentralized since all members are decision makers. In traditional finance, governance is inevitably centralized, which can be the origin of several problems. The most intractable issue is probably agency problem, where the owners and managers of an organization have different interests (Jensen and Meckling, 1976). Managers can pursue their own profits in the expense of the owners’ benefits. Therefore, the most challenging objective of governance is to align the interests between owners and managers (Fama and Jensen, 1983). Within the DeFi context, though, owners and managers are theoretically identical, which creates an opportunity to investigate the premises of this theory once again.

Stemming from this background, the most contemporary debate on DeFi, interestingly, remains whether decentralization is realistic or an illusion (Aramonte et al., 2021). DeFi platforms showcase elements of centralization, usually in the form of ‘governance tokens’ and power concentration to large coin-holders. This phenomenon can lead to collusion among core decision makers during the governance process. It is obvious, then, that governance becomes a very critical dimension of the success of true decentralization in blockchain. Decentralized Autonomous Organization (DAO) is one popular solution to decentralized governance and decision making (Jentzch, 2017). In a DAO, all members are the owners of the organization and they have decision-making power to the development of it. Usually, the suggested changes will be written in the form of an Improvement Proposal, which then is voted through an established poll, where all members can make public their option. DAO members choose their option through governance tokens. Usually, these governance tokens are also tradable cryptocurrencies. The votes are weighted by the amount of governance token held by voters. In other words, governance in DAO is tokenized. Currently, DAO is the most common governance mechanism adopted by DeFi.

The literature of governance in blockchain is voluminous. Usually, when it comes to blockchain, the debate evolves around the trade-off between decentralization and efficiency. Decentralization will result in lower speed of decision-making process, implying that the network becomes inefficiency (Hsieh et al., 2017). Yermack (2017) argued that in practice, blockchain governance is not completely decentralized. In some extreme cases, the final decision is taken by only the core developers. For example, Bitcoin core developers once decided to lower the transaction fees without discussing with community (Gervais et al., 2014). Cong et al. (2021) discuss the issue from the perspective of centralized mining and suggest that centralized pools designed for risk sharing could act as centralization force in the Bitcoin blockchain. Though several papers provide both theoretical models and empirical evidence of governance centralization in blockchain, the literature surprisingly remains silent when it comes to centralization in DeFi.

Positioning the centralized governance debate in the DeFi universe at the forefront of the literature is the main motivation of this paper. We focus on the DeFi platform, Maker protocol, developed and managed by MakerDAO, as a case study. The rational behind this choice is simple. MakerDAO is one of the most influential DAOs. Since 2017, when the DeFi universe expanded exponentially, the Maker protocol has emerged as the leading lending protocol, which conceptually replicates the operation of a bank in cryptocurrency markets. In the Maker protocol, Maker (MKR) is the governance token. In terms
of its value, one token equals to one vote in the proposed polls. Except from this tokenized value, Maker protocol issues the DAI, which is a stablecoin soft-pegged to US Dollar (Maker, 2021). Currently, DAI is one of the most traded stablecoins\(^1\). Although the Maker protocol seems to be a big success of DAO, the way it is governed in practice has not been rigidly examined. To the best of our knowledge, this is the first paper that focuses on providing empirical evidence of centralized governance in DeFi.

To achieve that, we collect information for the Maker protocol governance, including all voters, their choice, and votes in Maker governance polls from 5\(^{th}\) August 2019 to 22\(^{nd}\) October 2021. Our empirical analysis follows two stages. The first stage is to examine governance polls by defining three novel measurements of centralized governance, namely voting participation, centralized voting power, and voting efficiency. In the second stage, we investigate effect of centralized governance to the development of the Maker protocol. To achieve this, we expose MKR and DAI to several Maker-specific factors. These factors can be divided into several categories, including financial, transaction, exchange, network and Twitter sentiment indicators. Such an empirical setup is consistent with similar studies in the field, such as Liu and Tsyvinski (2021). Beside well-investigated factors, e.g., network factors, we also consider transaction demand, which is a theoretical determinant of token price (Cong, Li and Wang, 2021). Intuitively, transaction factors may relate to governance in DeFi. Besides, exchange factors help to illustrate how Ethereum, as an underlying blockchain, interacts with cryptocurrency exchanges, where various cryptocurrencies are traded. Finally, since the Maker protocol is on Ethereum blockchain, governance centralization may also have influence on the blockchain. For that reason, we also investigate the correlation between centralized governance proxies and equivalent Ether (ETH) statistics, which is the underlying cryptocurrency of Ethereum.

The empirical framework brings forward some very interesting findings. By examining governance polls in the Maker protocol, we observe signals of centralized Maker governance. Comparing with the rapidly increasing number of users, voters are centralized in a small group of members, and the most dominant voters are heterogeneous in characteristics in different criteria. The unevenly distributed voting power, as a preliminary signal of governance centralization, leads to our measurements of governance centralization in Maker protocol. By applying factor analysis, we find that effects of centralized governance are complex, and most empirical results are around voting participation and efficiency of decision making. Intuitively, more voters and total votes are signals of larger voting participation, implying more decentralized governance. The second stage results are found consistent with this conjecture. First, voting participation can directly affect financial factors of MKR and DAI. For example, the MKR price increases with more voters and total votes in governance polls. More numbers of voters can result in higher volatility of DAI. This suggests that the stablecoin can be affected from the participation in the polls and that decentralized governance could reduce its reliability. Second, after expanding our work on other indicators, we find centralized governance can lower the adoption of Maker Protocol. When users discard centralized MakerDAO, the long-term growth of Maker protocol will not be optimistic. Our findings may apply to other DAO-governed DeFi platforms as well. Finally, voting efficiency appears to play a significant role towards the boost of the Maker Protocol development, and better efficiency, e.g., shorter time of decision-making process, may bring more users, transactions, and positive discussion. Overall, we find that both the degree of centralized governance and its efficiency, posing a relevant trade-off among DeFi investors.

The remainder of our paper is organized as follows. Section 2 provides a summary of the governance process in MakerDAO. The dataset and the measurements of centralized governance in the Maker protocol are defined in section 3. The main empirical results are presented in section 4, while robustness checks are provided in section 5. Section 6 provides some concluding remarks. Finally, the appendix provides a description of the utilized factors, the ETH related analysis and robustness checks using an instrumental variable.

\(^1\) Transaction statistics of DAI can be obtained on IntoTheBlock. Usually, the daily number of DAI transactions is more than 10 thousand.
2. Governance in the Maker protocol

2.1 Decentralized Autonomous Organization (DAO), MakerDAO and Maker protocol

Decentralized Autonomous Organization (DAO) is a novel mechanism of organizational governance and decision-making. The DAO white paper is first given by Jentzsch (2017). Technically, DAO can be deployed on blockchain, and currently, most DAOs rely on Ethereum, which is a programmable blockchain. Ethereum yellow paper is introduced by Wood (2021), and Ethereum users can write smart contracts in Turing-complete programming language, e.g., Solidity. By writing and executing smart contracts, users can actualize various interactions and functions, e.g., transactions, on Ethereum (Atzei, Bartoletti and Cimoli, 2017). The programmable character enables the implementation of DAO. It is to say, the core of DAO governance is based on standard smart contract code instead of human actors. In DAO, the governance is tokenized. In practice, DAO-based protocols usually have their own governance token, and governance token holders can vote on changes to the protocols.

MakerDAO is created in 2014, and it has grown up to one of the most influential DAOs. The Maker protocol is multi-collateral lending system, and the protocol is governed by MakerDAO teams, including individuals and service providers (Maker, 2021). Based on the functions of Maker protocol, the protocol is usually categorized as a lending protocol (LP), resembling banks in cryptocurrency markets (Gudgeon et al., 2020). Simply, users can lend their tokens to LPs for economic incentives, e.g., interests. On the other hand, users can borrow tokens, and LPs usually require collateralization. The economic mechanism, mathematical models and the roles of LPs are well discussed by Bartoletti, Chiang and Lluch-Lafluente (2020). Maker protocol issues Dai (DAI), and the protocol is de facto a Multi-Collateral Dai (MCD) system. Dai is probably the most notable stablecoin, which is soft-pegged to the US dollar (Maker, 2021). Generally, stablecoins are cryptoassets that aim for price stability (Werner et al., 2021). Usually, stablecoins are pegged to a currency, e.g., US dollar. Multi-Collateral Dai was launched in Nov 2019. In Maker, a user can lock any supportive collateral, e.g., Ether (ETH), and a corresponding amount of Dai will be generated as debt. More details of DAI debt in Maker are given by Qin et al. (2021).

Issued by Maker protocol, Maker (MKR) is known as the governance token. In practice, MKR plays two roles. First, MKR is the governance token of Maker protocol, and MKR holders can vote on changes to the protocol. On the other hand, MKR contributes to the recapitalization of the system. MKR is created or destroyed through the automated auction mechanism of Maker protocol. When the debt of protocol is outstanding, MKR is created and sold for Dai. By contrast, the protocol sells Dai for MKR, and the surplus MKR will be destroyed. At the inception of MakerDAO, 1 million MKR were issued. The protocol sets a threshold of minimum and maximum of MKR, and the total circulated MKR will fluctuate between the thresholds.

2.2 Maker governance structure and voting process

An innovative selling point of the Maker protocol is decentralized governance. In the Maker protocol, governance can be divided into two parts: on-chain governance and off-chain governance. In on-chain governance, there are two types of votes, namely the Governance Polls and Executive Votes. Any MKR holders can vote using the Maker Protocol’s on-chain governance system. Governance polls, which are about non-technical changes, measure the sentiment of MKR holders. Executive votes “execute” technical changes to the protocol. The voting results are documented on blockchain. Off-chain governance is mainly about informal discussion, e.g., discussion on the MakerDAO forum. Both MKR holders and the larger community can express their opinions. Voting power is weighted by the amount of MKR that a voter owns and represents. One MKR equals to one vote. Finally, the option with the largest votes wins. In the Maker protocol, Maker Improvement Proposals (MIPs) are structured and
formalized for a voting event, and key issues and changes to the system are rigidly defined in MIPs. Usually, the Maker Foundation will draft the initial MIPs, and any community members can propose competing MIPs. Then, the final decisions will be made by MKR voters through the current Maker governance process. The above information is illustrated in the following figure.

**[Figure 1]**

MKR holders can be voters and directly choose their options on Maker Governance Portal. On the other hand, they can choose a Vote Delegate to be their representatives (Maker, 2021). As a result, delegates gain voting power from MKR holders, and these MKR holders can indirectly vote. One MKR equals to one vote. The voters can express their preference of MIPs by voting, and they do not have to participate in voting if they do not agree to any MIPs in a poll. The voting results are weighted by the amount of MKR voted for a proposal. Noticeably, Vote Delegates were not introduced in the very beginning. On July 30th 2021, the guidance to Vote Delegates was first introduced in the Maker forum, while on 10th November 2021, there are 16 Delegates and 65989.65 MKR are delegated. Currently, there are three types of voting in Maker governance, i.e., Forum Signal Threads, Governance Polls and Executive Votes. These are summarized on the following table.

**[Table 1]**

Table 1 highlights the functions of the three types of votes. Forum Signal Threads are the least consequential, and the threads are a part of off-chain governance. Governance Polls and Executive Votes occur on-chain, and they can be accessed through the Maker Foundation’s Voting portal. Simply, Governance Polls determine processes outside the technical layer, while Executive Votes are about technical changes to the protocol. Executive Votes use 'Continuous Approval Voting' model to make the system more secure. The voting models means that new proposals need to surpass the voting weight of the last successful proposal (Maker, 2021).

2.3 Governance centralization

Centralization in the governance layer of blockchain has caused attention of academic audience, and the discussion mainly focuses on two problems, namely owner control and improvement protocol (Sai et al., 2021). In Bitcoin, Gervais et al. (2014) argue that the author Satoshi Nakamoto may accumulate significant Bitcoin since Nakamoto participated in activities at the early stage of Bitcoin blockchain. Similar evidence of owner control exists in Ethereum as well (Bai et al, 2020). The large proportion of wealth may result in economic manipulation in blockchain. As for improvement protocol, this problem derives from the process of moderation in blockchain. Usually, blockchain and DeFi adopt improvement proposal system in decision making process. By analyzing the authors and contributors of improvement proposals, Azouvi et al. (2018) found that core developers are the main contributors to the development of Bitcoin and Ethereum. In other words, these core developers have more decision-making power in the decision-making process.

Beside the two problems described above, DAO, as a new organizational form to automate governance, may bring both opportunities and challenges. Benefiting from blockchain technology, the ownership is more transparent and voting can be more accurate (Yermack, 2017). On the other hand, centralization seems to be still inevitable in DAO. Gu et al. (2021) found that Maker Governance Polls do not attract much participation and MKR held by the dominant voters may theoretically lead to collusion in some poll. Yet, they only use two polls as examples. This is not enough to showcase robustly the existence of centralized governance in MakerDAO. The quest to obtain information from more polls is achieved in this study as the following data collection section shows.
3. Data collection and identification

3.1 Data Collection

In Maker Governance Portal\(^2\), the details of governance polls, e.g., the number of voters and results, are publicly available. To get the voters’ addresses, we query the voting history from MCD Voting Tracker\(^3\). We investigate governance polls from Poll 16 (deployed on 15\(^{th}\) August 2019) to Poll 663 (deployed on 22\(^{nd}\) October 2021). The dates when the polls are deployed are used which correspond to when the transactions are added to Ethereum blockchain. Though the dates might be earlier than the start dates when voters can choose options, the contents of polls are already publicly accessible once the polls are sent to the blockchain. Poll 16 is the first governance poll that MKR holders can participate in. Some polls failed\(^4\), so they are not documented in Maker Governance Portal. Hence, the dataset consists of a total of 638 successful governance polls, and the voters’ public names can be found by searching for their addresses on Etherscan.io and Maker Governance Portal. To study the effects of centralization in Maker governance, we consider two influential crypto assets issued by Maker protocol, namely MKR and DAI. The statistics of these two crypto assets can be obtained on IntoTheBlock.

3.2 Measurements of centralized voting power in Maker governance polls

This section introduces the novel measurements of centralized voting power in Maker governance polls. For each measurement, we first calculate the value at the poll level. Then, daily measurements can be generated. Here, measurements can fall into three categories, i.e., voting participation, centralized voting power, and voting efficiency.

3.2.1 Voting participation

To proxy voting participation, we use two measurements. One is total votes of Maker governance polls on a given date. The other is the number of total voters on a given date. Intuitively, when these two measurements are higher, there are more voters and votes in governance polls.

Assuming that there are \(n\) polls on a date \(d\), we have

\[
\text{Total votes}_d = \sum_{i=1}^{n} \text{Total votes}_{i,d} \quad (1)
\]

and

\[
\text{Voters}_d = \sum_{i=1}^{n} \text{Voters}_{i,d} \quad (2)
\]

3.2.2 Centralized voting power

In order to capture centralized voting power, we utilize two measures. The first is the Gini coefficient which is traditionally used to measure inequality (Dorfman, 1979).

Assuming that there are \(n\) voters in a governance poll, we have

\(^2\)https://vote.makerdao.com/
\(^3\)https://beta.mcdgov.info/
\(^4\)Poll 28, 39, 47, 69, 78, 183, 282, 284, 286, and 500 failed.
\[ Gini = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} |votes_i - votes_j|}{2n^2 \text{votes}} \] (3)

Where \( votes_i \) is the votes of voter \( i \), and \( \text{votes} \) is the average votes in a governance poll.

After computing the gini coefficient for each poll, we can calculate a daily measurement by calculating average.

Assuming that there are \( n \) polls on a date \( d \), we will calculate daily gini coefficient, i.e., \( Gini_d \), via maximum likelihood estimation, and the detailed method is given by Taleb (2015).

The second proxy for centralized voting power is the largest voter’s power in Maker governance polls. This can be approximated by either the Largest voting share or the Largest share win. In that way, we can reflect also on the relative voting power of the largest voter. For each poll, \( \text{Order} \) refers to the voting order of the largest voter. When \( \text{Order} \) is smaller, the largest voter will choose their option earlier.

Assuming that there are \( n \) polls on a date \( d \), we have

\[ \text{Largest voting share}_d = \frac{\sum_{i=1}^{n} \text{Largest voting share}_{i,d}}{n} \] (5)

For each poll, we define a variable to measure whether the largest voter wins.

\[ \text{if win} = \begin{cases} 1, & \text{if the largest voter chooses the same option as the result of a poll} \\ 0, & \text{if the largest voter chooses a different option from the result of a poll} \end{cases} \]

Then, \( \text{Largest voting share} \) and \( \text{if win} \) can be combined to measure the voting power of the largest voters when they win.

Assuming that there are \( n \) polls on a date \( d \), we have

\[ \text{Largest share win}_{i,d} = \text{Largest voting share}_{i,d} \times \text{if win}_{i,d} \] (6)

And

\[ \text{Largest share win}_d = \frac{\sum_{i=1}^{n} \text{Largest share win}_{i,d}}{n} \] (7)

Finally, the voting sequence can actually play a role as this can be documented in several voting systems (see amongst others, Börgers (2010), Brams (2008), and Brams and Fishburn (2002)). Simply, voters have different strategies, and their preference of voting order will vary with their goals. For each poll, we define a variable \( \text{Order} \) to measure the decision speed of the largest voter. Here, the order of the largest voter refers to the order in the whole history. It is to say, the largest voters may change their choice later. Assuming that there are \( n \) records in the voting history of a governance poll, we have

\[ \text{Order} = \frac{\text{voting order of the largest voter}}{n} \] (8)

Assuming that there are \( n \) polls on a date \( d \), we have

\[ \text{Order}_d = \frac{\sum_{i=1}^{n} \text{Order}_{i,d}}{n} \] (9)
When order is smaller, the largest voter chooses an option earlier than other voters. All voters can see the existing choices on the website.

### 3.2.3 Voting Efficiency

The last measurement of centralized governance is the voting efficiency, which proxies the efficiency of decision-making process. Here, for each poll, we calculate the total time that all voters need to make decisions. By summing up, we will get the measurement Speed. When Speed is higher, decision-making process is more efficient.

For voter $i$ in a poll $j$ deployed on date $d$, the voter’s speed is defined as

$$Speed_{i,j,d} = timestamp_{i,j,d} - timestamp_{j,d}$$

Where $timestamp_{i,j,d}$ is the time point when voter $i$ gives their final choice for poll $j$, and $timestamp_{j,d}$ is the timestamp when poll $j$ is deployed on the blockchain.

Assuming that there are $n$ voters in poll $j$, we have

$$Speed_{j,d} = \frac{1}{n} \sum_{i=1}^{n} Speed_{i,j,d}$$

Assuming there are $m$ polls on date $d$, the daily measurement of speed is

$$Speed_{d} = \frac{1}{m} \sum_{j=1}^{m} Speed_{j,d}$$

### 4. Empirical results

This section summarizes the empirical results of this study. The first sub-section presents the descriptive statistics of both polls and voters. Then, the centralization in Maker governance polls is described by the calculations of the measurements of centralized governance defined in the previous sections. The second sub-section summarizes the factor analysis we perform to investigate the effects of centralized governance on the Maker protocol (MKR and DAI).

#### 4.1 First stage: Governance polls in the Maker protocol

The collected information from the 638 governance polls is crucial for understanding centralization in Maker protocol. Table 2 presents the descriptive statistics of these polls.

[Table 2]

| [Table 2] |
| --- |

The votes are calculated in MKR tokens and for each governance poll, breakdown ratio is the proportion of breakdown votes to total votes. Beside the votes and vote share of the largest voter, the order of voting is considered. We also present the daily number of governance polls and voters in figure 2.

[Figures 2]

From the figures we can easily see that within a day, the number of deployed polls is usually less than 25. Usually, no more than 700 voters will express their choices on the same day. For some polls, no more than ten voters will participate in decision making process. The finding implies that not all polls can have large voting participation. Compared to the rapidly growth of Maker users, voters are a small group. Our analysis extracts a total of 1250 unique voters in our dataset. For each voter, the number of polls that they participate in can be surprisingly different. To show case this we present the following
By examining the total votes and the highest votes that a voter has in a single poll, it is implied that the voting power is not equally distributed across voters. This could be an early sign of voting centralization. However, to make this claim clearer, we need to delve deeper in the composition of the voters and their characteristics. To that end, we identify the voters whose identity is publicly available, the top ten voters that participate in most polls, the top ten voters that largest total votes and the top ten voters that have the largest single vote. This information is summarized in the following tables.

These tables present some interesting findings towards identifying centralized governance in the Maker protocol. Table 4 shows that except a16z\(^5\), the known voters are delegates in Maker governance and their identity is publicly available on Maker governance portal. Table 4 gives more details of these known voters in governance polls. The mechanism of voting delegates was introduced in July 2021, therefore, most delegates participated in their poll in August 2021. Noticeably, the total votes and the highest votes in a single poll are different among these known voters. Field Technologies, Inc. is the known voter that has the largest total votes (as of November 1\(^{st}\), 2021). In terms of voters that are participating in most polls, it is obvious that their characteristics are different, while none of them has a public name, i.e., their identity is unknown. Voters with the largest total votes are again heterogeneous in characteristics, while only two from the top ten are found to be delegates (Field Technologies, Inc. and a shadow delegate). When accounting the voters with the largest single votes, we find again a different composition. We identify delegates such as Field Technologies, Inc., Flip Flop Flap Delegate LLC, a shadow delegate and a16z being dominant, while the remaining voters appear with unknown identities. Taking a wholistic look at these findings, we notice that some voters may participate in many polls and have large total votes at the same time, namely voters with the addresses 0x4f...3f30 and 0x6a...ab40. In other cases, some voters might not participate in many polls, but when they do they have significantly large votes in certain polls. For example, a16z only votes for three polls, but their single votes are more than 30,000. These characteristics of the dominant voters suggested that on-chain developments on the protocol are driven by dominant voters and that decentralization does not seem to hold. Voting power appears to be distributed unevenly across different known or unknown small groups of voters, especially when total votes and large votes in a single poll are considered.

In order to further show this, we focus now on the notion of centralized voting power in the Maker polls. We compare the largest vote for each poll with the total votes and we find that the largest voter can account for a significant share of the total votes in most polls. Practically, the largest voter is the pivotal figure in implementing protocol changes, as they tend to account for around one third of the voting share. In terms of the known voters (namely delegates and a16z), the trend is similar. These known voters are identified after the delegate regulation change in Maker protocol (after Poll 600) and their dominant power is evident. However, it is hard to say if they were able to play an important role in previous polls. All this information is illustrated in the following figure.

To support the above, we also illustrate the total votes over the breakdown votes and their respective voters, the breakdown ratio, the voting share of the largest voter and average voting share of the largest voter daily. The results show that winning polls are driven by most votes, largest voters contribute significant votes to the winning options, while largest voters consistently concentrate at least 30% of the average daily voting share. These voting patterns are presented in the online Appendix OA.1. The key message remains that centralized voting power, hence, exists.

Although the above could be though descriptive information extracted from our unique dataset, we take further steps to quantitatively establish centralized governance on the Maker protocol. Firstly, we

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\(^{5}\) It is easy to establish by searching for other voters’ addresses on Etherscan.io that a16z represents the venture capital firm Andreessen Horowitz, which is the most influential venture capital in DeFi markets.
measure the centralized voting power in Maker governance at a poll level and across days by utilizing
the gini coefficient estimations. The results are summarized in the table and figure that follows.

[Table 8] [Figure 4]

At a poll level, we find that the gini coefficient is always more than 50% and exhibits a maximum of
98.05%. Given that the gini coefficient estimation is higher than 0.60 for most of the polls, highly
centralized voting power in the Maker governance is established. We also calculate and illustrate the
daily gini coefficient. The expected daily average gini coefficient should be around zero, if no
centralized voting occurs. However, we observe that there are days that the value is higher than 0.75,
implying again strong centralization of voting power in particular days within our period under study.
We further highlight the evidence of vote centralization by estimating the Lorenz curve of the
cumulative total votes for particular polls. The results support the above findings and are presented also
in the online Appendix.

Finally, the other measurements of governance centralization are established based on the definitions
given in Section 3. Their descriptive statistics are provided in the following table.

[Table 9]

4.2 Second stage: Factor analysis

In this section, we will apply a series of univariate regressions, with MKR and DAI used as dependent
variables and the measurements of centralized governance as independent variables. We consider
financial, transaction, network, exchange, and Twitter sentiment factors. In other words, we estimate
the following regressions:

\[ \text{factor}_{i,t} = \beta_0 + \beta_i \text{central}_t + \varepsilon_t \]  \hspace{1cm} (13)

Where:

- \( i = \{ \text{MKR}, \text{DAI} \} \)
- \( \text{central}_t = \{ \text{Voters}_t, \text{TotalVotes}_t, \text{LargestShare}_t, \text{LargestShareWin}_t, \text{Order}_t, \text{Speed}_t, \text{Gini}_t \} \)

Given \( i \), factors can be defined as a set:

\[ \text{factor}_{i,t} = \{ \text{financial}_{i,j,t}, \text{transaction}_{i,k,t}, \text{network}_{i,l,t}, \text{exchange}_{i,m,t}, \text{Twitter sentiment}_{i,n,t} \} \]

Where \( j = 1, \ldots, 11, k = 1, \ldots, 9, l = 1, \ldots, 4, m = 1, \ldots, 10, \) and \( n = 1, \ldots, 3 \).

The detailed description of the above set of factors is presented in detail in the Appendix A.1.

4.2.1 Financial factors

Maker governance polls are directly related to non-technical changes, e.g., adding a new collateral, to
Maker protocol. These changes will add more financial functions or revise the parameters of
transactions on the protocol. Therefore, it is crucial to examine whether MKR and DAI factors, such as
daily prices, returns and volatilities are going to be affected by centralized governance, in the form of
the metrics discussed in section 3. The univariate regression findings for these factors are summarized
in the following table.

[Table 10]
The two panels of the table bring forward some interesting findings for the effects of centralized governance measures for MKR and DAI. We observe that Voters, TotalVotes, and Speed have a significant positive effect in the MKR price, while LargestShare and Gini the opposite. Voters tends to positively affect long-term volatility, while higher Order has a negative effect in short-term and long-term volatility. This conceptually means that, when governance polls attract more voters, the price will be higher. However, decentralized voting power may result in higher volatility. This could be a finding towards the claimed value proposition of MakerDAO, i.e., decentralized governance. However, the higher speed of voters is found to be a significant booster for the MKR price, which is a signal of centralization of power. The quicker the vote, the higher the voting efficiency in terms of implementing change. This is evidence of centralized governance. Here it should be noted that more voters are a symbol of decentralized governance, and the associated volatility increase could be attributed to the fact that voters hold different opinions on the polls and react unpredictable if the polls’ outcomes do or do not meet their expectations. However, the voting order can mitigate this issue for MKR. That is because the largest voters tend to vote after observing other voters’ choice and therefore the uncertainty of a poll’s results is not high. When the uncertainty of a poll that aims to implement change on the protocol is low, then this should be reflected in the short-term and long-term volatility of MKR’s price. We also observe that as the daily gini coefficient has a significant negative effect to the MKR price.

For the case of DAI, we continue to observe significant effects of centralized governance. Voters and TotalVotes lead to a significant decrease of the DAI price. Here, the effect is opposite compared to MKR, which could be attributed to the fact that DAI is the stablecoin counterpart of MKR and it can attract more attention from DAO. Additionally, higher Order also lowers DAI volatility. It is normal again that after observing other voters’ choices, the largest voters are more certain about the winning option, the quicker the Maker community can account for the future changes in the Maker Protocol. As DAI is issued by Maker, DAI’s volatility is expected to decrease as well. All the above show that centralized governance is significantly evident for the financial factors relevant to MKR and DAI. Especially, in the case of MKR all centralized measures appear to affect at least one financial factor significantly. Although the financial characteristics of coins are quite important, the literature has shown that the researcher needs to expand on other indicators integral to the technical structure of coins, tokens and protocols in order to capture their potential fundamental value (Kraaijeveld and De Smedt, 2020; Nadler and Guo, 2020; Liu and Tsyvinski, 2021; Nakagawa and Sakemoto, 2021). For that reason, we next expand in other MKR and DAI related factors that are non-financial in nature to further establish that that centralized governance exists in the Maker protocol.

### 4.2.2 Transaction and exchange factors

Centralized governance should exhibit should manifest also in the activities of MKR and DAI traders. These activities are captured by transaction factors, such as the average balance of the addresses, average transaction size, the number of transactions, transaction volume, the number of large transactions, and large transaction volume. As we did with the financial factors, we present the univariate regression findings for these transaction indicators in the following table.

[Table 11]

The regression findings are again showing the significant effects of centralized governance in the trader activities across MKR and DAI investors. For example, we observe that TotalVotes has a significant positive effect on the average transaction size (both in MKR and USD), volume of large transactions and the number of transactions in MKR. Voters can lead to a higher number of transactions, but Order will lower both the number and volume of transactions. LargestShare and
LargestShareWin exhibit a negative effect on the average transaction size (in USD), while Speed can increase the average transaction size (in USD). A higher Gini leads to an increase of the average balance of addresses (in USD). Finally, the speed of voters has a positive effect on the average transaction value, while the order of voting appears to decrease the volume and number of transactions. In the case of DAI, the results are similar for the case of Voters and TotalVotes. The daily gini coefficient and the order of voting does not seem to play a role. However, Speed appears to be a prominent measure of centralized governance to affect positively all transaction factors in DAI. Unlike MKR, in DAI the LargestShare and LargestShareWin can decrease the average balance of DAI addresses. The main message of these findings is that there is substantial evidence of centralized governance effects in multi-faceted aspects of trading activities and balances of MKR and DAI traders. Conceptually, it appears that more voters and total votes infuse transaction numbers and volume. The prominent significance of Speed is an example of how increased voting efficiency can pool together investors willing to execute more transactions, especially transactions with a larger size.

Given that we established the significant effects of centralized measures in the transaction factors in the previous section, it is essential to examine whether similar effects are established also in exchange-related factors of MKR and DAI. These factors capture the interflows between token holders and exchanges and can illustrate the token holder’s behavior when the Maker protocol is more centralized. These exchange factors include deposit and withdrawal amounts in MKR and DAI wallets across all supported exchanges, net increases/decreases in exchanges’ holdings over time and respective inflow and outflow number of transactions. As in previous sections, univariate regressions are presented in the following table.

The results of the table bring forward the importance of centralized governance in the exchange factors, especially for the case of MKR. In MKR, Voters and TotalVotes can lead to more inflow and outflow transactions, while the outflow volume and total flow are also positively affected by those measures. However, the effect is negative when it comes to net flow (in MKR and USD). Order appears to pose significant negative effect when it comes to volume of inflow and outflow. Conceptually, the interlinks between Maker protocol and exchanges will be more active when there are more voters and total votes, and finally the net flow will be lower. Interestingly, total flow will also be lower when the largest voters choose to express their choice later. A lower total flow implies that there are less transactions on exchanges. In other words, more MKR will be held in users’ accounts. This is reasonable, as more voters and total votes can lead to more withdrawn MKR. Here it should be noted that MKR is the governance token, which means that voters will have to exchange MKR if they need to participate in polls. Similarly, the demand for MKR is expected to be higher if total votes are larger. For the case of DAI, the stablecoin of MakerDAO, the effects are not as significant, except for the case of speed of voting that appears to have a significant effect in the number of outflow transactions and a negative effect for netflow (in DAI and USD). The difference in the centralized effects between MKR and DAI could be attributed to the fact that exchange factors might be driven more from inflows and outflows of MKR tokens used for voting in on-chain governance. However, the findings still promote the key message of this study. That voting power is centralized and it affects the decentralization value proposition of the Maker protocol.

4.2.3 Network and Twitter sentiment factors

Finally, we focus on factors capturing network characteristics and social media sentiment. Firstly, as decentralized governance is the main selling point of Maker protocol, network statistics, such as total addresses, new addresses, active addresses, and their active ratio, may be differentially affected by centralized governance measurements. This is examined by the univariate regressions presented in the following table.
The picture here is quite robust. It is clear that centralized voting is affecting the MKR and DAI network factors consistently. For MKR, Voters, TotalVotes, and Speed exhibit significant positive effects on the total addresses with MKR balance, while LargestShare, LargestShareWin, Gini, and Order have the opposite effect. Increases in Voters and TotalVotes can bring more new addresses and active addresses. Speed can also increase the number of active addresses, while Order leads to less active addresses. Similar findings are observed for the case of DAI except for the gini coefficient and the order of voting. Overall, the results suggest that more users hold MKR and DAI once more voters and votes are identified. Holding MKR and DAI means lower polling participation, which means that centralized voting power is found to significantly drive away users of Maker protocol. This is a strong signal of centralization in the DeFi platform.

In terms of social media sentiment, we focus on Twitter. Currently, Twitter is the main social media platform, where DeFi investors express their opinions. The community can discuss and communicate with each other, while the Maker protocol also has official accounts on Twitter. Focusing on Twitter sentiment factors, we are able to investigate if centralization in governance affects the sentiment tone of users. These results are presented in the following table.

As in previous factors, significant effects are identified for both cases. For MKR, LargestShare and LargestShareWin have a negative effect towards neutral tweets, suggesting that large voting concentration discourages neutral sentiment, which would be the default position for a truly decentralized platform. Voting speed appears to increase the number of positive and neutral speed in MKR. For DAI, Voters, TotalVotes, and Speed can increase the number of positive tweets. Large voting concentration surprisingly does not appear to provide any kind of sentiment attention. Finally, higher Speed leads to increased sentiment around DAI, which is found to be more significant to negative tone than the other two. In other words, voting efficiency, as a form of centralized governance, could lead to more negative tweets than neutral or positive ones. The above effects of centralized measures in social media sentiment are another signal that decentralization in MakerDAO is not ensured. Overall, our two-stage analysis is providing substantial empirical evidence towards centralized governance in MakerDAO, as several significant univariate relationships are established across different classes of factors. However, the next section is providing some further robustness checks towards that end.

5. Robustness checks

5.1 The case of Ethereum

The Maker protocol is an Ethereum-based protocol. For that reason, it makes sense that for robustness we should investigate ETH factors in a similar set-up, as we do with MKR and DAI. For that reason, we replicate all the univariate regressions of section 4 for the equivalent ETH indicators. Here, we present only the summary of the significant relationships identified in the following table.

As in the main empirical results, we observe that measurements of centralized Maker governance also affect significantly several factors across all classes. For example, Voters, TotalVotes, and Speed (LargestShare and LargestShareWin) are positively (negatively) affecting the ETH price. Order has a negative effect to Ether volatility. Extending to non-financial factors, such as transaction and exchange

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6 Given the extent of factors and univariate regressions examined, we also present summary of the relationships in Online Appendix OA.2.
7 For the sake of space, all the regression outputs are presented in the Online Appendix OA.3.
indicators, we see that measurements of voting participation and efficiency have positive effects, but higher degree of centralization in the Maker governance will negatively affect the prosperity of transactions. Results are similar when it comes to network factors. Larger voting participation and higher efficiency can increase the number of total users and active users. More Voters can attract more new users as well. In terms of social media sentiment, LargestShare, LargestShareWin and Order decrease the number of positive and negative tweets. Speed shows a positive effect with Twitter sentiment note, implying that higher efficiency of decision-making in DeFi can attract people’s attention. TotalVotes has a positive effect to the number of positive tweets. This finding could be explained by the potential differences of preferences among the DeFi and Ethereum community. For example, when DeFi governance appears more centralized, positive sentiment can be created because of potential improved efficiency, while negative note could also be generated due to the unilateral decision power potential of some large voters. Overall, the ETH analysis implies that polling activities on DeFi will influence Ethereum, while the relationship between governance centralization in DeFi and the Ethereum community might not be completely negative. Of course, the complicated interactions between DeFi and ETH lead to diversified discussion on social media, implying that investors might have different expectations and vested interests.

5.2 Addressing endogeneity: Off-chain governance as an instrumental variable (MKR)

The empirical results presented in section 4 could face criticism due to potential endogeneity concerns. To alleviate this issue, we use the instrumental variable approach and estimate two-stage least squares (2SLS) regressions. We construct an instrumental variable (IV) using datasets for forum signal threads, that are a part of the off-chain governance in the Maker protocol. Anyone can participate in the discussion and voting in the threads. That means that, unlike the on-chain governance investigated previously, off-chain governance does not require MKR in one’s account. Even people who do not use blockchain can share their opinions and click an option in the thread. For some signal threads, the informal discussion will finally turn to MIP, where voters will choose their options.

The results of signal threads could be thought are related with on-chain governance. On the other hand, as a non-custodial stablecoin, the price of DAI is independent of Maker protocol but depends on exogenous collateral (Klages-Mundt et al., 2020). So, the direct relationship between DAI and off-chain governance is not well understood. Similarly, off-chain governance may not be an endogenous variable to other factors of Maker protocol. Theoretically, Maker governors aim for maximizing their revenue (Klages-Mundt and Minca, 2021). In other words, the factors, e.g., transaction factors, are outcomes of decisions jointly made by voters in Maker governance. For each thread, we document the first post date and the number of voters. In some threads, there will be several voting polls, and we will only count unique voters within a thread. Then, the number of off-chain voters daily can be calculated. This is a valid instrument for our setup as explained in the Appendix A.2. Based on the above we report the first and the second stage regressions in the following tables for the case of MKR.

[Tables 16-20]

Before using an instrument, we first test if our instrument suffers from weak instruments concerns. Except for Column (1) in Panel B and Panel C of Table 17, our instrument can be used in 2SLS regressions. Then, we are curious that if measurements of centralized governance are endogenous to factors for MKR and DAI. To test the endogeneity, we apply Durbin’s test and Wu-Hausman test. Since the null hypothesis is that endogeneity does not exist, usually, we do not observe endogeneity between our measurements and factors for MKR and DAI, meaning that the corresponding OLS regressions in section 4 are reliable. For results where endogeneity is observed (e.g., Column (5), Panel B of Table 16), we compare results of 2SLS regressions and results in section 4, and the findings are consistent. Therefore, the measurements of centralized governance are generally not found endogenous to MKR.

\[\text{For the sake of space, the equivalent 2SLS results for DAI are provided in the Online Appendix OA.4}\]
6. Conclusion

Decentralization is crucial innovation of blockchain, and the rapid growth of DeFi relies on decentralization. Complete decentralization is theoretically impossible (Abadi and Brunnermeier, 2018), and empirical evidence of centralization is detected in different layers of blockchain (Sai et al., 2021). In this paper, we focus on governance in DeFi and particularly on the Maker protocol, which is governed by MakerDAO. Decentralized governance is a crucial domain for DeFi, and Maker protocol is an ideal case since its voting history is transparent and precise (Beck, Müller-Bloch and King, 2020). Furthermore, in emerging DeFi ecosystem, MakerDAO is regarded as the most influential DAO.

By examining Maker governance polls, we find that voters are centralized in a small group, and voting power is unequally distributed among these voters. In most voting activities, the largest voters could account for a significant proportion of votes. Previously, Azouvi, Mallar and Meikeljohn (2018) and Gervais et al. (2014) argue that a few key developers have unilateral decision-making power in blockchain governance. This problem might derive from the requirement of programming skills. Our results expand the discussion to DeFi. Any MKR holder can easily participate in governance by clicking an option on the website, which would indicate that governance would be more decentralized. Interestingly, our results show that governance in Maker protocol is highly centralized.

Measurements of centralized governance are established in three categories, namely voting participation, centralized voting power, and efficiency of decision-making process. By investigating the relationships between Maker-specific factors, we find that larger voting participation and better efficiency usually have positive influence on the Maker protocol. For example, transaction volume will be higher, and more users will be attracted. On the other hand, the high degree of centralized governance will refrain the protocol growth. For example, when voting power is highly centralized, the number of total users and new users will decrease. Therefore, investors may give up DeFi that are highly centralized in terms of governance. In the case of DAI, the effects of larger voting participation may not be ideal. For example, more voters will cause higher volatility of DAI. Given that DAI is a stablecoin, high volatility reduces it reliability. Ethereum shows interlinks with centralized governance in DeFi as well. This is interesting as most mainstream DeFi protocols are based on Ethereum blockchain. For example, larger voting participation has positive effects on ETH price. This is another contribution, as most previous studies focus on the interlinks in DeFi (Tolmach et al., 2021; von Wachter, Jensen and Ross, 2021) or the token systems on Ethereum (Fröwis, Fuchs and Böhme, 2019; Chen et al., 2020), while our findings suggest that DeFi can influence its underlying blockchain. Currently, the best governance structure for stablecoins is an open question. If governance is extremely centralized, several agents can easily manipulate the stablecoin systems (Klages-Muldt et al., 2020). This paper implies that centralized governance to some extent may contribute to the stability of stablecoins. Overall, DeFi protocol benefits from decentralization and efficiency, and the findings are consistent with the arguments of Abadi and Brunnermeier (2018) and Hsieh, Vergne and Wang (2017). With our findings, we make a compelling case in favor of the argument that decentralization in DeFi platforms is an illusion and that the trade-off between efficiency and decentralization is the rather true value proposition offered to investors in DeFi applications.

However, our findings appear conceptually and empirically robust, they should be interpreted with their limitations in mind. First, the identity of dominant voters is unknown. Anonymity is another character of blockchain and DeFi, and we may not know voters’ identity until they are willing to announce (Qin et al., 2021). Second, we do not illustrate the accumulation of significant voting power. After checking these dominant voters’ transaction history, we find that most of them do not have many transactions of MKR. Few of them have transactions of other cryptocurrencies. In blockchain, any agent
can have endless addresses, i.e., accounts. Therefore, these voters may have specific accounts for participating in Maker governance. Finally, we do not know whether the authors of MIPs are dominant voters. If a dominant voter proposes changes to the Maker protocol, the aim of such MIPs might be tied to the own vested interests. With their large voting power, this could lead to further centralization of power and potential collusion during the development of Maker protocol. Currently, writing MIPs requires both programming skills and understanding of technical structure of DeFi. Assuming that not many voters have such competence, at least key developers can guide voters by proposing specific MIPs, implying the centralized power of core developers exists in DeFi. For this, the developers should explain their proposals with more details, and the aims of codes, along with possible outcomes, should be described in a more understandable way. Besides, though there is no clear solution now, for better public inspection, Maker protocol could provide the MIP authors’ addresses, thereby users will be able to detect suspicious activities of developers.

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Appendix

A.1 Description of utilized factors

The following tables summarize the factors used in our univariate regressions.

[Tables A.1 – A.5]

A.2 Off-chain governance as an instrumental variable

Table A.6 presents the correlation between off-chain voters and measurements of centralized governance in Maker protocol and the respective descriptive statistics.

[Table A.6]
Figures

Figure 1. Governance in Maker Protocol

Panel A: The structure of governance in Maker Protocol

Governance of the Maker protocol

On-chain governance

Governance polls

Executive Votes

Off-chain governance

Discussion in the forum

The public governance calls

Note: Panel A shows the governance structure of Maker Protocol. It is divided into two parts, the on-chain governance and off-chain governance. Panel B illustrates the voting process of Maker governance polls. MKR holders can participate in polls as voters, or they can choose delegates as their representatives.

Figure 2. The number of polls and voters in Maker governance (Aug 5, 2019 – Oct 22, 2021)

Panel A: The number of Maker governance polls daily (Aug 5, 2019 - Oct 22, 2021)

Panel B: The number of voters that participated in Maker governance polls daily (Aug 5, 2019 - Oct 22, 2021)

Note: This figure presents daily number of polls and voters in Maker governance. Panel A shows the daily number of Maker
governance polls, while Panel B presents the number of voters daily in Maker governance polls.

Figure 3. Total votes, votes of the largest voter and votes of the known voters in Maker governance polls (Poll #16 – Poll #663)

Note: Panel A presents total votes and votes of largest voters in Maker governance polls (Poll #16 – Poll #663). In most polls, the largest voter can take account for a significant proportion of voting power. Panel B shows the votes from the known voters in Maker governance polls (Poll #16 – Poll #663). The known voters include voting delegates and a16z and show strong voting power after Poll #600.
Figure 4. Gini coefficient

Note: This figure shows gini coefficient in Maker governance. Panel A reports gini coefficient at the poll level (Poll #16 – Poll #663). Panel B reports gini coefficient daily in Maker governance polls (Aug 5, 2019 – Oct 22, 2021).
Table 1. Types of votes in Maker protocol

| Type of votes | Functions |
|---------------|-----------|
| Forum signal threats | (1) Determine consensus that something needs to be done in response to a perceived issue, (2) determine consensus for a concrete action to be taken in response to a perceived issue. |
| Governance polls | (1) Determine governance and DAO processes outside the technical layer of the Maker Protocol, (2) form consensus on important community goals and targets, (3) measure sentiment on potential Executive Vote proposals, (4) ratify governance proposals originating from the MakerDAO forum signals, (5) determine which values certain system parameters should be set to before those values are then confirmed in an executive vote, (6) ratify risk parameters for new collateral types as presented by Risk Teams. |
| Executive votes | (1) Add or remove collateral types, add or remove Vault types, adjust global system parameters, adjust Vault-specific parameters, (2) replace modular smart contracts. |

Note: This table describes three types of votes in Maker protocol. Forum signal threats are a part of off-chain governance, and all community can participate in the discussion on the Maker forum. Governance polls and executive votes are on-chain.

Table 2. Descriptive statistics of Maker governance polls

| Type of votes | Involved polls | Total votes | Breakdown votes | Breakdown ratio | Breakdown votes of the largest voter | Vote share of the largest voter |
|---------------|---------------|-------------|-----------------|-----------------|--------------------------------------|----------------------------------|
| Mean          | 36096.52      | 24.39       | 31529.94       | 88.78%          | 18.03                               | 16941.61                         | 52.66%                          |
| Median        | 33097.15      | 23.00       | 28625.80       | 98.24%          | 16.00                               | 17063.93                         | 48.35%                          |
| Maximum       | 131555.35     | 146         | 108694.07      | 100.00%         | 142                                 | 39403.85                         | 98.51%                          |
| Minimum       | 259.74        | 5           | 232.80         | 13.04%          | 1                                    | 203.27                           | 20.28%                          |
| Std           | 22383.18      | 12.76       | 19998.47       | 16.67%          | 11.63                               | 8452.45                          | 18.02%                          |

Note: This table reports the descriptive statistics of Maker governance polls.

Table 3. Descriptive statistics of voters of Maker governance polls

| Involved polls | Total votes | First poll | The highest votes |
|----------------|-------------|------------|-------------------|
| Mean           | 12.55       | 18422.58   | 278.66            | 665.39            |
| Median         | 2.00        | 1.42       | 248.00            | 1.00              |
| Maximum        | 514         | 4170786.51 | 660               | 39403.85          |
| Minimum        | 1           | 0.00       | 16                | 0.00              |
| Std            | 42.46       | 164269.26  | 194.65            | 3372.75           |

Note: This table reports the descriptive statistics of voters of Maker governance polls.

Table 4. Known voters in Maker governance polls

| Address | Identity | Involved Polls | Total votes | First poll | The highest votes | Since |
|---------|----------|----------------|-------------|------------|-------------------|-------|
| 0x5e793ce0e6027323ac150f0d45c2344d28b6b019 | a16z | 3 | 96480.00 | 631 | 32160.00 | 2019-11-08 |
| 0x845b3be1e4f41a361d7d11b8a239b9f1991e95 | Feedback Loops LLC | 44 | 53892.24 | 610 | 10102.26 | 2021-08-02 |
| 0xad2fda5f6ce305d2ced380f0dafa791b6a267f2f81 | Field Technologies, Inc. | 52 | 1165679.40 | 610 | 28511.07 | 2021-08-02 |
| 0xaf8aa6846539033ea0c3ca49c7373e370e039b | Flip Flop Flap Delegate LLC | 53 | 454657.27 | 610 | 23903.23 | 2021-08-10 |
| 0x22d5294a2d49294bdf1d9dbb6beda36ec104ad9b3 | MakerMan | 46 | 37071.23 | 610 | 5061.75 | 2021-08-13 |
| 0x45127ce92b58c3a89e89f63535073da9ca2f1f15f | monet_supply | 45 | 45633.81 | 610 | 5139.34 | 2021-08-09 |
| 0x144fde2000ca405452ca1c0e21c0b53561a98e6 | Shadow Delegate | 63 | 12022.10 | 598 | 239.50 | 2021-07-21 |
| 0x00daee2c2a6a3f6e660b32e8765edcfa9347a1 | Shadow Delegate | 45 | 936786.68 | 610 | 22044.84 | 2021-08-01 |
| 0x2c3b917ceca4510300146c4b9b78e6b23d862c4ed | Shadow Delegate | 33 | 660000.00 | 609 | 2000.00 | 2021-08-02 |
| 0xe6e3401397427eb0b491ec27c7ba06817c7f6db | Shadow Delegate | 28 | 149405.00 | 615 | 5976.20 | 2021-08-26 |
| 0x68b216e9c4a67b9850c0028f1f2724c93c5e5a61 | Shadow Delegate | 5 | 23605.00 | 649 | 4721.00 | 2021-08-20 |
| 0xb21e535b349e4e0f520318aeca589e174b0126b | Shadow Delegate | 57 | 1898.27 | 607 | 50.27 | 2021-07-28 |

Note: This table reports the known voters of Maker governance polls. For each voter, the number of involved polls, total votes, and the highest votes in a single poll are presented. Votes are calculated in MKR tokens. The table highlights the first poll that a voter participated in, and the corresponding date is shown in the column ‘Since’.

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### Table 5. Ten voters that participate in most Maker governance polls

| Address | Involved Polls | Total votes | First poll | The highest votes | Since |
|---------|----------------|-------------|------------|------------------|-------|
| 0xfdd650e5838fb21ead6d479c743d0d9c3a833f | 514 | 4493.6 | 16 | 9.41 | 2019-05-07 |
| 0x883b94bbd31902c79ab2c2da8f9d439e94232319 | 479 | 83336.47 | 18 | 238.50 | 2019-04-11 |
| 0x4f2161c7eb1dc40d6f6eb24db81bf4a6eb0c3f30 | 479 | 1907163.70 | 17 | 8002.4 | 2019-08-11 |
| 0xd353bbf690df8d2bcd6798df40b31ae564ec2 | 426 | 1441.31 | 18 | 7.04 | 2019-08-13 |
| 0xe602d16a52b022a81e44e70292261b66f17 | 412 | 8699.84 | 51 | 51.14 | 2019-11-19 |
| 0x7a74fb56d64b99b5e9f69b5a3d28327da8087aa0 | 359 | 32796.53 | 26 | 339.79 | 2019-05-14 |
| 0xd818b3d62751b09cfd0a9e4a416d132612f81 | 311 | 15515.95 | 305 | 116.45 | 2020-09-27 |
| 0x6a30094573a9b8095e700ebbe1c41ebab40 | 294 | 844500.00 | 17 | 3000.00 | 2019-07-26 |
| 0x4eabbb099c3d6eb38cb03693ed667fe020f405 | 277 | 51739.05 | 17 | 8002.4 | 2019-08-22 |
| 0xe602d16a52b022a81e44e70292261b66f17 | 269 | 13452.21 | 18 | 61.75 | 2019-08-05 |

Note: This table reports the ten voters that participate in most Maker governance polls. Identity is not presented as a column, as none are found with public names. For each voter, the number of involved polls, total votes, and the highest votes in a single poll are presented. Votes are calculated in MKR tokens. The table highlights the first poll that a voter participated in, and the corresponding date is shown in the column ‘Since’.

### Table 6. Ten voters that have the largest total votes in Maker governance polls

| Address | Identity | Involved Polls | Total votes | First poll | The highest votes | Since |
|---------|----------|----------------|-------------|------------|------------------|-------|
| 0x7d6149ad9a573a6e2ca6eb873f4897c1b766841b4 | Field Technologies, Inc. | 224 | 4170786.51 | 116 | 20540.06 | 2020-03-24 |
| 0x1ead7050c94c8a10f0871dab28b01b3eb13d38 | 86 | 2019684.05 | 399 | 28479.83 | 2021-01-06 |
| 0x4f2161c7eb1dc40d6f0eb24db81bf4a6eb0c3f30 | 479 | 1907163.70 | 17 | 8002.40 | 2019-08-11 |
| 0xf29a733ce3827765797e111ce7f8709f1ad93 | 133 | 1357946.88 | 168 | 10526.72 | 2020-06-03 |
| 0xad2d5a56f00c35052ced380df8791bea26e7f281 | 52 | 1165679.40 | 610 | 28511.07 | 2021-08-02 |
| 0xc1ba1b5939c16e7c7a1678df610ea263ec5 | 68 | 999993.71 | 16 | 16763.92 | 2019-05-15 |
| 0x0dace2c2a6a3f660b2e38b7ecs56cd9fa934e1 | Shadow Delegate | 45 | 936786.68 | 610 | 25044.84 | 2021-08-01 |
| 0xac39d02c6d60c2851a8441950ac601f8910002 | 86 | 905297.92 | 399 | 10526.72 | 2021-01-13 |
| 0x6a30094573a9b8095e700ebbe1c41ebab40 | 294 | 844500.00 | 17 | 3000.00 | 2019-07-26 |
| 0x612d3fa50b8388e1b5ab1ceddbb091331ab689d | 145 | 725110.20 | 155 | 5000.76 | 2020-05-14 |

Note: This table reports the ten voters that have the largest total votes in Maker governance polls. For each voter, the number of involved polls, total votes, and the highest votes in a single poll are presented. Votes are calculated in MKR tokens. The table highlights the first poll that a voter participated in, and the corresponding date is shown in the column ‘Since’.
Table 7. Ten voters that have the largest single votes in Maker governance polls

| Address                        | Identity          | Involved Polls | Total votes | First poll | The highest votes | Since       |
|--------------------------------|-------------------|----------------|-------------|------------|-------------------|-------------|
| 0x8778b64f999a8ed59045d8d6    |                   | 17             | 669865.45   | 57         | 39403.85          | 2019-02-22 |
| 7998a77ab51e258                |                   |                |             |            |                   |             |
| 0x26732399f47e00739d2b4b0451  | acc3f93f73ca14    | 5              | 197019.25   | 288        | 39403.85          | 2020-09-11 |
| 0xd48d3462c5e5d568c88ec33      | 66241ed8b46bd1    | 3              | 108224.28   | 132        | 36074.76          | 2018-08-29 |
| 0x56a176ace516b0f8525b292ba    |                   | 20             | 423092.99   | 145        | 33001.90          | 2020-02-22 |
| 697a16d5e8a7eb                 |                   |                |             |            |                   |             |
| 0x85e793e0c0d27323ac150f6d4    | a16z              | 3              | 96480.00    | 631        | 32160.00          | 2019-11-08 |
| 5c2344d28b6019                 |                   |                |             |            |                   |             |
| 0xad2fd65f6ce305d2ced380fdaf7  | Field Technologies, Inc. | 52            | 1165679.40  | 610        | 28511.07          | 2021-08-02 |
| 91b6a26c7f281                  |                   |                |             |            |                   |             |
| 0x1ead7d050c94c8a1f08071ddeb2  |                   | 86             | 2019684.05  | 399        | 28479.83          | 2021-01-06 |
| 8b01b3eb1b3d38                 |                   |                |             |            |                   |             |
| 0x00daec2c2aa3f66b0e38b7e56dctx9347a1 | Shadow Delegate | 45            | 936786.68   | 610        | 25044.84          | 2021-08-01 |
| 0xaf8aa6846539033ca70f73c0939b | Flip Flop Flap Delegate LLC | 53            | 454657.27   | 610        | 23903.23          | 2021-08-10 |
| 0xa497573e2481d44381b510ede    |                   | 4              | 95432.00    | 127        | 23858.00          | 2020-04-08 |
| 15bcd06be901457                |                   |                |             |            |                   |             |

Note: This table reports the ten voters that have the largest single votes in Maker governance polls. For each voter, the number of involved polls, total votes, and the highest votes in a single poll are presented. Votes are calculated in MKR tokens. The table highlights the first poll that a voter participated in, and the corresponding date is shown in the column ‘Since’.

Table 8. Gini coefficient in Maker governance polls

| Poll-level | Mean  | Median | Maximum | Minimum | Std    |
|------------|-------|--------|---------|---------|--------|
| Mean       | 84.38%| 85.54% | 98.05%  | 57.56%  | 0.06   |
| Median     | 18.57%| 0.00%  | 0.00%   | 0.00%   | 0.35   |

Note: This table reports gini coefficient in Maker governance polls. In the first column, we calculate the gini coefficient for each poll. In the second column, we first integrate a voter’s votes within a day, then we compute the daily gini coefficient via a maximum likelihood estimation.

Table 9. Measurements of governance centralization in Maker

| Voters | TotalVotes | LargestShare | LargestShareWin | Order | Speed |
|--------|------------|--------------|-----------------|-------|-------|
| Mean   | 123.53     | 0.54         | 0.50            | 0.41  | 239757.02 |
| Median | 68.00      | 0.51         | 0.47            | 0.39  | 168643.15 |
| Maximum| 756.00     | 0.96         | 0.96            | 0.91  | 930561.95 |
| Minimum| 7.00       | 0.27         | 0.00            | 0.00  | 14953.29 |
| Std    | 141.27     | 0.16         | 0.18            | 0.20  | 156971.99 |

Note: This table reports measurement of governance centralization in Maker governance polls. We first calculate these measurements for each poll. Then, we sum up to the get the number of voters, total votes and votes from the largest voters daily. The other four measurements are the average of the values in polls that start on the same day. For example, the column LargestShare equals to the average share of the largest voter in polls started on the same day.
Table 10. Financial factors (MKR, DAI)

|       | Voters | TotalVotes | LargestShare | LargestShareWin | Gini  | Order | Speed |
|-------|--------|------------|--------------|-----------------|-------|-------|-------|
| **MKR** | | | | | | | |
| Price | 1278.06*** | 1090.56* | -768.44* | -560.52 | -497.13* | -621.94 | 1648.15*** |
| r | -0.02 | -0.03 | 0.02 | 0.03 | 0.02 | 0.03 | -0.03 |
| (0.64) | (-1.30) | (1.25) | (1.06) | (1.43) | (1.21) | (1.24) | |
| v2 | 0.00 | 0.02 | -0.01 | 0.00 | 0.00 | -0.01 | 0.02 |
| (0.08) | (0.82) | (-0.43) | (-0.10) | (-0.38) | (-0.27) | (0.96) | |
| v3 | 0.01 | 0.03 | 0.00 | 0.01 | 0.00 | -0.03** | -0.01 |
| (0.64) | (1.25) | (-0.14) | (0.61) | (-0.07) | (2.14) | (-0.33) | |
| v4 | 0.01 | 0.02 | 0.00 | 0.02 | 0.00 | -0.02 | -0.02 |
| (0.35) | (1.03) | (0.02) | (1.06) | (0.00) | (1.42) | (-0.89) | |
| v5 | 0.02 | 0.03 | 0.00 | 0.02 | -0.01 | -0.02 | -0.02 |
| (0.94) | (1.33) | (0.18) | (0.91) | (-0.59) | (-1.05) | (-1.03) | |
| v6 | 0.01 | 0.02 | 0.00 | 0.02 | 0.00 | -0.02 | -0.03 |
| (0.86) | (1.20) | (0.32) | (0.98) | (-0.06) | (-1.11) | (-1.53) | |
| v7 | 0.02 | 0.03 | 0.01 | 0.02 | 0.00 | -0.03* | -0.03 |
| (1.13) | (1.32) | (0.59) | (1.27) | (-0.42) | (-1.68) | (-1.52) | |
| v14 | 0.02 | 0.02 | 0.01 | 0.03* | 0.00 | -0.03** | -0.02 |
| (1.56) | (1.09) | (1.21) | (1.76) | (-0.47) | (2.14) | (-1.30) | |
| v30 | 0.02 | 0.01 | 0.01 | 0.02 | -0.01 | -0.03** | -0.01 |
| (1.58) | (0.42) | (1.35) | (1.53) | (-1.06) | (2.41) | (-1.06) | |
| v60 | 0.02* | 0.00 | 0.01 | 0.01 | 0.00 | -0.02** | -0.01 |
| (1.77) | (-0.03) | (0.86) | (1.18) | (-0.85) | (-2.35) | (-1.07) | |

|       | Voters | TotalVotes | LargestShare | LargestShareWin | Gini  | Order | Speed |
|-------|--------|------------|--------------|-----------------|-------|-------|-------|
| **DAI** | | | | | | | |
| Price | -0.02** | -0.02*** | 0.01 | 0.01 | 0.01 | 0.01 | -0.01 |
| (2.20) | (-2.73) | (1.05) | (0.70) | (1.13) | (1.23) | (1.49) | |
| r | -0.01 | -0.01 | 0.00 | -0.01 | 0.01 | 0.00 | 0.00 |
| (0.50) | (-1.17) | (0.44) | (-0.51) | (1.48) | (0.07) | (-0.24) | |
| v2 | -0.01 | -0.01 | 0.00 | 0.00 | 0.01 | -0.01 | -0.01 |
| (0.93) | (-1.13) | (-0.31) | (0.12) | (1.15) | (-0.98) | (-1.31) | |
| v3 | -0.01 | -0.01 | 0.00 | 0.01 | 0.01 | -0.01 | -0.02 |
| (1.11) | (-1.34) | (0.05) | (0.73) | (1.00) | (-0.88) | (-1.53) | |
| v4 | -0.01 | -0.01 | 0.00 | 0.01 | 0.00 | -0.01 | -0.02 |
| (0.71) | (-1.13) | (-0.03) | (0.68) | (0.67) | (-1.39) | (-1.59) | |
| v5 | -0.01 | -0.01 | 0.00 | 0.01 | 0.00 | -0.01 | -0.01 |
| (0.69) | (-1.10) | (-0.16) | (0.61) | (0.47) | (-1.41) | (-1.31) | |
| v6 | 0.00 | -0.01 | 0.00 | 0.01 | 0.00 | -0.01 | -0.01 |
| (0.20) | (-0.77) | (-0.02) | (0.84) | (0.85) | (-1.37) | (-0.72) | |
| v7 | 0.00 | -0.01 | 0.00 | 0.01 | 0.00 | -0.01 | -0.01 |
| (0.45) | (-0.87) | (-0.02) | (0.85) | (0.72) | (-1.37) | (-0.72) | |
| v14 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | -0.01* | 0.00 |
| (0.31) | (-0.47) | (-0.17) | (0.67) | (0.59) | (-1.90) | (-0.28) | |
| v30 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | -0.01* | 0.01 |
| (1.61) | (0.31) | (-0.82) | (0.24) | (-0.13) | (-1.79) | (0.81) | |
| v60 | 0.01** | 0.01 | -0.01 | 0.00 | 0.00 | -0.01** | 0.01 |
| (2.41) | (1.37) | (-1.37) | (-0.30) | (-0.64) | (-2.39) | (0.91) | |

Note: This table reports the univariate regression coefficients and standard t- statistics in the parentheses for the case of the financial factors of MKR (Panel A) and DAI (Panel B). *, **, and *** denote significance levels at the 10%, 5%, and 1% levels respectively. The definitions of the factors are given in Table A.1.
Table 11. Transaction factors (MKR, DAI)

|                  | Voters | TotalVotes | LargestShare | LargestShareWin | Gini | Order | Speed |
|------------------|--------|------------|--------------|-----------------|------|-------|-------|
| **MKR**          |        |            |              |                 |      |       |       |
| AvgBleUsd        | -0.06  | 0.00       | -0.07        | -0.06           | 0.08*| 0.07  | 0.14  |
|                  | (-0.48)| (0.03)     | (-1.11)      | (-0.72)         | (1.86)| (1.05)| (0.74)|
| AvgSizeMkr       | 0.05   | 0.15*      | 0.02         | 0.03            | -0.03| -0.02 | -0.04 |
|                  | (0.44) | (1.69)     | (0.36)       | (0.40)          | (-0.92)| (-0.27)| (-0.25)|
| AvgSizeUsd       | 0.11   | 0.23***    | -0.08*       | -0.10*          | -0.02| -0.02 | 0.24**|
|                  | (1.40) | (3.66)     | (-1.92)      | (-1.92)         | (-0.77)| (-0.47)| (2.09)|
| LargeVolMkr      | 0.12   | 0.21*      | 0.01         | 0.02            | -0.04| -0.07 | -0.06 |
|                  | (0.82) | (1.70)     | (0.14)       | (0.17)          | (-0.76)| (-0.87)| (-0.27)|
| LargeVolUsd      | 0.10   | 0.16**     | -0.05        | -0.06           | -0.02| -0.03 | 0.13  |
|                  | (1.13) | (2.16)     | (-1.19)      | (-1.07)         | (-0.70)| (-0.64)| (1.00)|
| LargeCnt         | 0.09   | 0.15       | -0.03        | -0.04           | -0.02| -0.03 | 0.13  |
|                  | (0.80) | (1.56)     | (-0.57)      | (-0.56)         | (-0.53)| (-0.54)| (0.79)|
| VolMkr           | 0.00   | 0.00       | 0.00         | 0.00            | 0.00 | 0.00  | 0.00  |
|                  | (0.45) | (0.93)     | (-0.54)      | (-0.15)         | (0.22)| (-1.31)| (0.13)|
| VolUsd           | 0.01   | 0.01       | 0.00         | 0.01            | 0.00 | 0.00  | -0.04**|
|                  | (0.79) | (0.43)     | (0.01)       | (0.63)          | (0.47)| (-2.37)| (0.57)|
| TxnCnt           | 0.10***| 0.10**     | -0.03        | -0.01           | -0.01| -0.09**| 0.01  |
|                  | (2.58) | (2.20)     | (-0.94)      | (-0.25)         | (-0.60)| (-2.46)| (0.15)|

|                  | Voters | TotalVotes | LargestShare | LargestShareWin | Gini | Order | Speed |
|------------------|--------|------------|--------------|-----------------|------|-------|-------|
| **DAI**          |        |            |              |                 |      |       |       |
| AvgBleUsd        | 0.13   | 0.21       | -0.32***     | -0.29**         | -0.01| -0.16 | 0.38***|
|                  | (0.98) | (1.44)     | (-2.88)      | (-2.11)         | (-0.10)| (-1.30)| (2.78)|
| AvgSizeDai       | 0.02   | 0.02       | -0.01        | -0.01           | 0.00 | 0.00  | 0.04***|
|                  | (1.60) | (1.52)     | (-1.23)      | (-1.08)         | (0.59)| (0.20)| (2.97)|
| AvgSizeUsd       | 0.02   | 0.02       | -0.01        | -0.01           | 0.00 | 0.00  | 0.04***|
|                  | (1.58) | (1.49)     | (-1.24)      | (-1.09)         | (0.62)| (0.23)| (2.92)|
| LargeVolDai      | 0.02*  | 0.02*      | -0.01        | -0.01           | 0.01 | -0.01 | 0.04***|
|                  | (1.70) | (1.67)     | (-0.75)      | (-0.59)         | (0.80)| (-0.46)| (2.65)|
| LargeVolUsd      | 0.02*  | 0.02*      | -0.01        | -0.01           | 0.01 | -0.01 | 0.04***|
|                  | (1.70) | (1.67)     | (-0.75)      | (-0.59)         | (0.80)| (-0.46)| (2.65)|
| LargeCnt         | 0.07   | 0.10*      | -0.06        | -0.04           | 0.01 | -0.07 | 0.14***|
|                  | (1.35) | (1.70)     | (-1.23)      | (-0.76)         | (0.32)| (-1.42)| (2.55)|
| VolDai           | 0.02*  | 0.03*      | -0.01        | -0.01           | 0.01 | -0.01 | 0.04***|
|                  | (1.68) | (1.68)     | (-0.78)      | (-0.58)         | (0.82)| (0.57)| (2.60)|
| VolUsd           | 0.02*  | 0.03*      | -0.01        | -0.01           | 0.01 | -0.01 | 0.04***|
|                  | (1.68) | (1.68)     | (-0.81)      | (-0.61)         | (0.83)| (-0.54)| (2.64)|
| TxnCnt           | 0.09   | 0.14**     | -0.06        | -0.06           | 0.01 | -0.07 | 0.17***|
|                  | (1.47) | (2.22)     | (-1.15)      | (-0.92)         | (0.34)| (-1.32)| (2.68)|

Note: This table reports the univariate regression coefficients and standard t- statistics in the parentheses for the case of the transaction factors of MKR (Panel A) and DAI (Panel B). *, **, and *** denote significance levels at the 10%, 5%, and 1% levels respectively. The definitions of the factors are given in Table A.2.
### Table 12. Exchange factors (MKR, DAI)

|                  | Voters | TotalVotes | LargestShare | LargestShareWin | Gini | Order | Speed |
|------------------|--------|------------|--------------|-----------------|------|-------|-------|
| **Panel A: MKR** |        |            |              |                 |      |       |       |
| InCnt            | 0.11***| 0.14***    | -0.01        | 0.01            | -0.04| -0.06 | 0.07  |
|                  | (2.53) | (2.89)     | (-0.25)      | (0.18)          | (-1.59)|(-1.60)| (1.44)|
| InVolMkr         | 0.01   | 0.03       | 0.03         | 0.00            | 0.00 | -0.03 | 0.03  |
|                  | (0.66) | (1.24)     | (0.18)       | (0.41)          | (-0.28)|(-1.64)| (1.29)|
| InVolUsd         | 0.01   | 0.01       | 0.00         | 0.00            | 0.00 | -0.02*| 0.01  |
|                  | (1.39) | (0.88)     | (0.17)       | (0.72)          | (-0.40)|(-2.10)| (0.98)|
| OutCnt           | 0.07*  | 0.10**     | 0.01         | 0.02            | -0.02| -0.07*| 0.05  |
|                  | (1.68) | (2.08)     | (0.20)       | (0.38)          | (-1.10)|(-1.85)| (0.97)|
| OutVolMkr        | 0.11** | 0.14**     | 0.01         | 0.02            | 0.00 | -0.09*| 0.18***|
|                  | (1.95) | (2.28)     | (0.12)       | (0.37)          | (-0.09)|(-1.78)| (3.03)|
| OutVolUsd        | 0.08***| 0.06*      | -0.01        | 0.01            | 0.00 | -0.06***| 0.09***|
|                  | (2.67) | (1.83)     | (-0.23)      | (0.37)          | (0.03)|(-2.54)| (2.95)|
| NetMkr           | -0.04***| -0.04**    | 0.00         | 0.00            | 0.00 | 0.01  | -0.06***|
|                  | (-2.52)| (-2.10)    | (-0.08)      | (0.01)          | (-0.31)| (0.54)| (-3.43)|
| NetUsd           | -0.01***| -0.01*     | 0.00         | 0.00            | 0.00 | 0.01  | -0.03***|
|                  | (-2.53)| (-1.85)    | (-0.05)      | (0.41)          | (-0.64)| (1.27)| (-3.67)|
| TotalMkr         | 0.05   | 0.07*      | 0.00         | 0.00            | 0.00 | 0.00  | -0.05*|
|                  | (1.39) | (1.86)     | (0.16)       | (0.40)          | (-0.18)|(-1.78)| (2.27)|
| TotalUsd         | 0.03** | 0.02       | 0.00         | 0.00            | 0.00 | -0.03**| 0.03**|
|                  | (2.18) | (1.45)     | (-0.05)      | (0.56)          | (-0.17)|(-2.46)| (2.13)|
| **Panel B: DAI** |        |            |              |                 |      |       |       |
| InCnt            | -0.01  | 0.00       | 0.04         | 0.01            | 0.00 | 0.01  | 0.00  |
|                  | (-0.13)| (0.08)     | (1.03)       | (0.20)          | (0.01)| (0.20)| (0.09)|
| InVolDai         | 0.02   | 0.06       | -0.01        | -0.04           | 0.04 | 0.05  | 0.07  |
|                  | (0.24) | (0.77)     | (-0.10)      | (-0.55)         | (0.93)| (0.84)| (0.93)|
| InVolUsd         | 0.02   | 0.06       | -0.01        | -0.04           | 0.04 | 0.06  | 0.07  |
|                  | (0.23) | (0.76)     | (-0.10)      | (-0.55)         | (0.94)| (0.87)| (0.94)|
| OutCnt           | 0.01   | 0.08       | 0.01         | -0.11           | 0.02 | 0.11  | **0.18**|
|                  | (0.10) | (0.90)     | (0.21)       | (-1.32)         | (0.40)| (1.62)| (2.25)|
| OutVolDai        | 0.01   | 0.04       | -0.02        | -0.04           | 0.03 | 0.05  | 0.11  |
|                  | (0.22) | (0.57)     | (-0.32)      | (-0.52)         | (0.88)| (0.80)| (1.52)|
| OutVolUsd        | 0.01   | 0.04       | -0.02        | -0.04           | 0.03 | 0.05  | 0.11  |
|                  | (0.21) | (0.57)     | (-0.31)      | (-0.52)         | (0.89)| (0.82)| (1.53)|
| NetDai           | 0.00   | 0.02       | 0.02         | -0.01           | 0.00 | 0.01  | -0.06**|
|                  | (0.11) | (0.82)     | (0.79)       | (-0.19)         | (0.30)| (0.26)| (-2.09)|
| NetUsd           | 0.00   | 0.02       | 0.02         | -0.01           | 0.00 | 0.01  | -0.06**|
|                  | (0.11) | (0.81)     | (0.80)       | (-0.19)         | (0.30)| (0.26)| (-2.09)|
| TotalDai         | 0.02   | 0.05       | -0.01        | -0.04           | 0.04 | 0.05  | 0.09  |
|                  | (0.23) | (0.68)     | (-0.21)      | (-0.54)         | (0.92)| (0.83)| (1.23)|
| TotalUsd         | 0.01   | 0.05       | -0.01        | -0.04           | 0.04 | 0.05  | 0.09  |
|                  | (0.22) | (0.67)     | (-0.21)      | (-0.54)         | (0.92)| (0.85)| (1.24)|

Note: This table reports the univariate regression coefficients and standard t- statistics in the parentheses for the case of the exchange factors of MKR (Panel A) and DAI (Panel B). *, **, and *** denote significance levels at the 10%, 5%, and 1% levels respectively. The definitions of the factors are given in Table A.3.
|            | Voters | TotalVotes | LargestShare | LargestShareWin | Gini   | Order | Speed |
|------------|--------|------------|--------------|-----------------|--------|-------|-------|
| Active     | 0.21***| 0.2***     | -0.06        | -0.05           | -0.04  |
|            | (4.03) | (3.43)     | (-1.25)      | (-0.95)         | (-1.46)| (-2.55)| (2.21)|
| ActiveRatio| 0.02   | -0.01      | 0.02         | 0.00            | 0.04   |
|            | (0.29) | (-0.12)    | (0.35)       | (0.03)          | (1.44) |

### PANEL B: DAI

|            | Voters | TotalVotes | LargestShare | LargestShareWin | Gini   | Order | Speed |
|------------|--------|------------|--------------|-----------------|--------|-------|-------|
| Active     | 0.23***| 0.27***    | -0.06        | -0.09           | -0.04  |
|            | (2.78) | (2.95)     | (-0.83)      | (-0.92)         | (-0.77)| (-0.93)| (3.39)|
| ActiveRatio| -0.07  | -0.09*     | -0.02        | 0.00            | 0.07***|
|            | (-1.38)| (-1.75)    | (-0.41)      | (-0.06)         | (2.56) |

Note: This table reports the univariate regression coefficients and standard t-statistics in the parentheses for the case of the network factors of MKR (Panel A) and DAI (Panel B). *, **, and *** denote significance levels at the 10%, 5%, and 1% levels respectively. The definitions of the factors are given in Table A.4.
Table 15: Ether factors and centralized governance measures (summary)

| Measurements          | Financial factors | Transaction Factors | Exchange Factors | Network Factors | Twitter Sentiment Factors |
|-----------------------|-------------------|---------------------|------------------|----------------|--------------------------|
| Voters                | Price ↑           | AvgBlcUsd ↑         | InCnt ↑          | TotalWithBlc ↑ | Positive ↑               |
|                       | V30, v60 ↑       | VolEth ↑ VolUsd ↑   | OutVolUsd ↑      | New ↑ Active ↑ |                         |
|                       |                   | TxnCnt ↑            | OutVolUsd ↑ Net ↓| TotalUsd ↑     | Active Ratio ↑           |
| TotalVotes            | Price ↑          | AvgBlcUsd ↑         | InCnt ↑          | TotalWithBlc ↑ | Positive ↑               |
|                       | V2 ↑             | AvgSizeUsd ↑        | OutVolUsd ↑      | TotalWithBlc ↓ |                         |
|                       |                   | LargeVolUsd ↑       | NetEth ↓         | Neutral ↓      |                         |
|                       |                   | LargeCnt ↑          | TotalUsd ↑       | Negative ↓     |                         |
|                       |                   | Vol ↑ TxnCnt ↑      |                  |                |                         |
| Largest Share         | Price ↓          | AvgBlcUsd ↓         | OutCnt ↓         | TotalWithBlc ↓ | Positive ↓               |
|                       |                   | AvgSizeUsd ↓        |                  | TotalWithBlc ↓ | Neutral ↓               |
|                       |                   | LargeVolUsd ↓       |                  | Neutral ↓     | Negative ↓              |
|                       |                   | LargeCnt ↓          |                  |                |                         |
| Largest ShareWin      | Price ↓          | AvgBlcUsd ↓         | OutCnt ↓         | TotalWithBlc ↓ | Positive ↓               |
|                       |                   | TxnCnt ↓            |                  | TotalWithBlc ↓ | Neutral ↓               |
|                       |                   | AvgSizeUsd ↓        |                  | Neutral ↓     | Negative ↓              |
|                       |                   | LargeVolUsd ↓       |                  |                |                         |
|                       |                   | LargeCnt ↓          |                  |                |                         |
| Order                 | V4, v7, v14, v30, | Vol ↓              | InCnt ↓          | TotalWithBlc ↓ | Positive ↓               |
|                       | v60 ↓            |                     | OutVolUsd ↓      | TotalWithBlc ↓ | Neutral ↓               |
|                       |                   |                     | TotalUsd ↓       | Neutral ↓     | Negative ↓              |
| Speed                 | Price ↑          | AvgBlcUsd ↑         | InCnt ↑          | TotalWithBlc ↓ | Positive ↑               |
|                       |                   | TxnCnt ↑            | OutCnt ↑         | TotalWithBlc ↓ | Neutral ↑               |
|                       |                   | AvgSizeUsd ↑        | OutVolUsd ↑      | TotalWithBlc ↓ | Negative ↑              |
|                       |                   | LargeVolUsd ↑       | TotalUsd ↑       |              |                         |
|                       |                   | LargeCnt ↑ Vol ↑    |                  |                |                         |
| Gini                  | r ↑              | NetEth ↑            | TotalWithBlc ↓   |                |                         |

Note: This table reports the relationships between measurements of decentralized governance and the factors of ETH as identified in the previous tables. For example, first column and first raw reports Price ↑, which means that the increase of Voters leads to a significant increase in Price of ETH.
Table 16: 2-SLS IV regressions (financial factors – MKR)

Panel A: Estimate Voters using an instrument

|            | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| Off-chain  | 0.17** |     |     |     |     |     |     |     |     |      |      |      |
|            | (4.90) |     |     |     |     |     |     |     |     |      |      |      |
| Voters     | 3996.00 | -0.21 | 0.15 | 0.22 | 0.15 | 0.11 | 0.06 | 0.12 | 0.08 | 0.06 | 0.05 |      |
|            | (1.13) | (-1.62) | (1.39) | (1.55) | (1.30) | (1.03) | (0.61) | (0.85) | (0.73) | (0.78) | (0.81) |      |
| Durbin’s test | 0.77 | 1.90 | 1.71 | 3.80 | 2.47 | 0.91 | 0.23 | 1.00 | 0.53 | 0.36 | 0.33 |      |
| p-value    | 0.38 | 0.17 | 0.19 | 0.05 | 0.12 | 0.34 | 0.63 | 0.32 | 0.47 | 0.55 | 0.57 |      |
| Wu-Hausman test | 0.75 | 1.89 | 1.70 | 3.82 | 2.46 | 0.90 | 0.22 | 0.98 | 0.52 | 0.35 | 0.32 |      |
| p-value    | 0.89 | 0.17 | 0.20 | 0.05 | 0.12 | 0.35 | 0.64 | 0.32 | 0.47 | 0.56 | 0.57 |      |
| Adj. R-sq  | -0.16 | -0.51 | -0.47 | -1.01 | -0.67 | -0.24 | -0.06 | -0.26 | -0.13 | -0.08 | -0.07 |      |
| N          | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 |

Panel B: Estimate TotalVotes using an instrument

|            | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| Off-chain  | 0.24** |     |     |     |     |     |     |     |     |      |      |      |
|            | (5.45) |     |     |     |     |     |     |     |     |      |      |      |
| Total Votes | 2854.4 | -0.15* | 0.11 | 0.16* | 0.11 | 0.08 | 0.04 | 0.09 | 0.06 | 0.04 | 0.04 |      |
|            | (1.09) | (-1.75) | (1.52) | (1.85) | (1.53) | (1.14) | (0.64) | (0.89) | (0.74) | (0.78) | (0.77) |      |
| Durbin’s test | 0.65 | 1.37 | 1.27 | 3.12 | 1.93 | 0.60 | 0.09 | 0.73 | 0.50 | 0.59 | 0.81 |      |
| p-value    | 0.42 | 0.24 | 0.26 | 0.08 | 0.17 | 0.44 | 0.76 | 0.39 | 0.48 | 0.44 | 0.37 |      |
| Wu-Hausman test | 0.64 | 1.35 | 1.25 | 3.12 | 1.91 | 0.59 | 0.09 | 0.72 | 0.49 | 0.58 | 0.79 |      |
| p-value    | 0.43 | 0.25 | 0.27 | 0.08 | 0.17 | 0.44 | 0.76 | 0.40 | 0.48 | 0.45 | 0.38 |      |
| Adj. R-sq  | -0.05 | -0.13 | -0.13 | -0.31 | -0.20 | -0.05 | -0.01 | -0.07 | -0.05 | -0.07 | -0.09 |      |
| N          | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 |

Panel C: Estimate Speed using an instrument

|            | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| Off-chain  | 0.16** |     |     |     |     |     |     |     |     |      |      |      |
|            | (4.18) |     |     |     |     |     |     |     |     |      |      |      |
| Speed      | 4309.60 | -0.22* | 0.16 | 0.23 | 0.16 | 0.12 | 0.07 | 0.13 | 0.09 | 0.07 | 0.06 |      |
|            | (1.21) | (-1.66) | (1.24) | (1.19) | (1.03) | (0.88) | (0.55) | (0.77) | (0.68) | (0.75) | (0.79) |      |
| Durbin’s test | 0.64 | 1.64 | 1.88 | 4.48 | 3.23 | 1.69 | 0.81 | 2.16 | 1.50 | 1.11 | 1.13 |      |
| p-value    | 0.42 | 0.20 | 0.17 | 0.03 | 0.07 | 0.19 | 0.37 | 0.14 | 0.22 | 0.29 | 0.29 |      |
| Wu-Hausman test | 0.63 | 1.62 | 1.87 | 4.54 | 3.23 | 1.67 | 0.80 | 2.14 | 1.48 | 1.09 | 1.12 |      |
| p-value    | 0.43 | 0.21 | 0.17 | 0.04 | 0.07 | 0.20 | 0.37 | 0.15 | 0.23 | 0.30 | 0.29 |      |
| Adj. R-sq  | -0.10 | -0.41 | -0.49 | -1.15 | -0.82 | -0.43 | -0.19 | -0.53 | -0.37 | -0.28 | -0.29 |      |
| N          | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 |

Note: This table reports results of the 2-SLS IV regressions. Panel A, Column (1) reports the results of the following first stage regression: \( Voter_2 = \beta_0 + \beta_1\text{off} - \text{chain}_t + \varepsilon_t \), where \( \text{off} \) - \( \text{chain} \) is an instrumental variable. Columns (2) - (12) report the results of second stage: \( factor_2 = \beta_0 + \beta_2 Voter_2 + \varepsilon_t \). Panel B, Column (1) reports the results of the following first stage regression: \( TotalVotes_2 = \beta_0 + \beta_1\text{off} - \text{chain}_t + \varepsilon_t \), where \( \text{off} \) - \( \text{chain} \) is an instrumental variable. Columns (2) - (12) report the results of second stage: \( factor_2 = \beta_0 + \beta_2 TotalVotes_2 + \varepsilon_t \). Panel C, Column (1) reports the results of the following first stage regression: \( Speed_2 = \beta_0 + \beta_1\text{off} - \text{chain}_t + \varepsilon_t \), where \( \text{off} \) - \( \text{chain} \) is an instrumental variable. Columns (2) - (12) report the results of second stage: \( factor_2 = \beta_0 + \beta_2 Speed_2 + \varepsilon_t \). In Column (1), partial F-statistics are reported in parentheses. In Columns (2) - (12), t-statistics are reported in parentheses. *, **, and *** denote significance levels at the 10%, 5%, and 1%.

Table 17: 2-SLS IV regressions (transaction factors – MKR)

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### Panel A: Estimate Voters using an instrument

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Off-chain | 0.17* | | | | | | | | | |
| (2.86) | | | | | | | | | | |
| Voters | -1.11 | 0.16 | 0.21 | 0.90 | 0.25 | 0.22 | 0.02 | 0.14 | 0.61** | |
| (1.35) | (0.38) | (0.59) | (1.05) | (0.68) | (0.47) | (0.94) | (1.43) | (2.43) | | |
| Durbin’s test | 2.59 | 0.05 | 0.06 | 1.10 | 0.11 | 0.006 | 0.51 | 0.15 | 0.49 | |
| p-value | 0.11 | 0.82 | 0.80 | 0.29 | 0.74 | 0.80 | 0.48 | 0.21 | 0.03 | |
| Wu-Haussman test | 2.57 | 0.05 | 0.06 | 1.07 | 0.10 | 0.06 | 0.50 | 0.15 | 0.50 | |
| p-value | 0.11 | 0.82 | 0.81 | 0.31 | 0.75 | 0.81 | 0.48 | 0.21 | 0.03 | |
| Adj. R-sq | -1.02 | -0.03 | -0.01 | -0.43 | -0.04 | -0.03 | -0.14 | -0.42 | -1.21 | |
| N | 67 | 67 | 67 | 67 | 67 | 67 | 127 | 127 | 127 | |

### Panel B: Estimate TotalVotes using an instrument

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Off-chain | 0.24 | | | | | | | | | |
| (2.46) | | | | | | | | | | |
| Total Votes | -0.79 | 0.12 | 0.15 | 0.64 | 0.18 | 0.16 | 0.01 | 0.10 | 0.44*** | |
| (1.27) | (0.40) | (0.66) | (1.16) | (0.74) | (0.49) | (1.01) | (1.43) | (2.53) | | |
| Durbin’s test | 2.96 | 0.01 | 0.10 | 0.69 | 0.00 | 0.00 | 0.30 | 1.70 | 4.39 | |
| p-value | 0.09 | 0.93 | 0.76 | 0.41 | 0.96 | 0.97 | 0.58 | 0.19 | 0.04 | |
| Wu-Haussman test | 2.96 | 0.01 | 0.09 | 0.67 | 0.00 | 0.00 | 0.29 | 1.68 | 4.44 | |
| p-value | 0.09 | 0.93 | 0.76 | 0.42 | 0.96 | 0.97 | 0.59 | 0.20 | 0.04 | |
| Adj. R-sq | -0.81 | 0.03 | 0.14 | -0.15 | 0.05 | 0.02 | -0.03 | -0.18 | -0.40 | |
| N | 67 | 67 | 67 | 67 | 67 | 67 | 127 | 127 | 127 | |

### Panel C: Estimate Speed using an instrument

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Off-chain | 0.03 | | | | | | | | | |
| (0.26) | | | | | | | | | | |
| Speed | -2.52 | 1.12 | 1.43 | 6.09 | -1.68 | 1.51 | 0.02 | 0.15 | 0.66* | |
| (-0.52) | (0.33) | (0.46) | (0.53) | (0.47) | (0.38) | (0.85) | (1.38) | (1.78) | | |
| Durbin’s test | 2.92 | 0.10 | 0.19 | 1.43 | 0.25 | 0.13 | 0.59 | 1.67 | 6.65 | |
| p-value | 0.09 | 0.75 | 0.66 | 0.23 | 0.62 | 0.71 | 0.44 | 0.20 | 0.01 | |
| Wu-Haussman test | 2.92 | 0.10 | 0.18 | 1.40 | 0.24 | 0.13 | 0.58 | 1.65 | 6.85 | |
| p-value | 0.09 | 0.75 | 0.67 | 0.24 | 0.63 | 0.72 | 0.45 | 0.20 | 0.01 | |
| Adj. R-sq | -24.40 | -0.88 | -1.47 | -12.06 | -2.07 | -1.13 | -0.16 | -0.43 | -1.71 | |
| N | 67 | 67 | 67 | 67 | 67 | 67 | 127 | 127 | 127 | |

Note: This table reports results of the 2-SLS IV regressions. Panel A, Column (1) reports the results of the following first stage regression: \( \text{Voter}_{st} = \beta_0 + \beta_1 \text{off} - \text{chain}_t + \varepsilon_s \). Columns (2) – (11) report the results of second stage: \( \text{factor}_t = \beta_0 + \beta_1 \text{Voter}_{st} + \varepsilon_t \). Panel B, Column (1) reports the results of the following first stage regression: \( \text{TotalVotes}_{st} = \beta_0 + \beta_1 \text{Voter}_{st} + \varepsilon_t \), where \( \text{off} - \text{chain} \text{ is an instrumental variable}. \) Columns (2) – (11) report the results of second stage: \( \text{factor}_t = \beta_0 + \beta_1 \text{TotalVotes}_{st} + \varepsilon_t \). Panel C, Column (1) reports the results of the following first stage regression: \( \text{Speed}_{t} = \beta_0 + \beta_1 \text{off} - \text{chain}_t + \varepsilon_t \), where \( \text{off} - \text{chain} \text{ is an instrumental variable}. \) Columns (2) – (11) report the results of second stage: \( \text{factor}_t = \beta_0 + \beta_1 \text{Speed}_t + \varepsilon_t \). In Column (1), partial F-statistics are reported in parentheses. In Columns (2) - (11), t-statistics are reported in parentheses. *, **, and *** denote significance levels at the 10%, 5%, and 1%. **
Table 18: 2-SLS IV regressions (Exchange factors – MKR)

### Panel A: Estimate Voters using an instrument

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|-------|
| Off-chain | 0.17** | (4.90) | Voters | 0.61** | (2.17) | 0.07 | 0.04 | 0.15 | 0.45* | 0.24* | -0.16* | -0.05 | 0.20 | 0.10 |
| Durbin’s test | 3.90 | 0.16 | 0.30 | 0.10 | 1.20 | 1.02 | 1.86 | 0.85 | 0.63 | 0.70 |
| p-value | 0.05 | 0.69 | 0.58 | 0.75 | 0.27 | 0.31 | 0.17 | 0.36 | 0.43 | 0.40 |
| Wu-Hausman test | 3.92 | 0.16 | 0.29 | 0.10 | 1.19 | 1.00 | 1.85 | 0.83 | 0.62 | 0.69 |
| p-value | 0.05 | 0.69 | 0.59 | 0.75 | 0.28 | 0.32 | 0.18 | 0.36 | 0.43 | 0.41 |
| Adj. R-sq | -0.95 | -0.05 | -0.07 | -0.01 | -0.29 | -0.21 | -0.43 | -0.17 | -0.16 | -0.15 |
| N | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 |

### Panel B: Estimate TotalVotes using an instrument

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|-------|
| Off-chain | 0.24** | (5.45) | TotalVotes | 0.43*** | (2.75) | 0.05 | 0.03 | 0.11 | 0.32* | 0.17 | -0.11 | -0.04 | 0.14 | 0.07 |
| Durbin’s test | 2.81 | 0.03 | 0.31 | 0.00 | 0.70 | 0.95 | 1.54 | 0.73 | 0.30 | 0.67 |
| p-value | 0.09 | 0.85 | 0.58 | 0.96 | 0.40 | 0.33 | 0.21 | 0.39 | 0.59 | 0.41 |
| Wu-Hausman test | 2.81 | 0.03 | 0.30 | 0.00 | 0.69 | 0.93 | 1.52 | 0.72 | 0.29 | 0.66 |
| p-value | 0.10 | 0.86 | 0.58 | 0.96 | 0.41 | 0.34 | 0.22 | 0.40 | 0.59 | 0.42 |
| Adj. R-sq | -0.21 | 0.00 | -0.03 | 0.03 | -0.04 | -0.08 | -0.13 | -0.05 | -0.01 | -0.06 |
| N | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 |

### Panel C: Estimate Speed using an instrument

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|-------|
| Off-chain | 0.16** | (4.18) | Speed | 0.65 | (1.59) | 0.07 | 0.04 | 0.16 | 0.49* | 0.26* | -0.17* | -0.06 | 0.21 | 0.10 |
| Durbin’s test | 4.49 | 0.09 | 0.38 | 0.19 | 0.86 | 0.92 | 1.52 | 0.55 | 0.42 | 0.70 |
| p-value | 0.03 | 0.77 | 0.54 | 0.66 | 0.35 | 0.34 | 0.22 | 0.46 | 0.52 | 0.40 |
| Wu-Hausman test | 4.54 | 0.08 | 0.37 | 0.19 | 0.85 | 0.91 | 1.51 | 0.54 | 0.41 | 0.69 |
| p-value | 0.04 | 0.77 | 0.55 | 0.67 | 0.36 | 0.34 | 0.22 | 0.46 | 0.52 | 0.41 |
| Adj. R-sq | -1.12 | -0.02 | -0.10 | -0.05 | -0.15 | -0.16 | -0.28 | -0.04 | -0.07 | -0.15 |
| N | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 | 127 |

Note: This table reports results of the 2-SLS IV regressions. Panel A, Column (1) reports the results of the following first stage regression: \( \text{Voters}_{it} = \beta_0 + \beta_1 \text{Off} - \text{chain}_{it} + \epsilon_i \), where \( \text{Off} - \text{chain} \) is an instrumental variable. Columns (2) – (11) report the results of second stage: \( \text{factort}_i = \beta_0 + \beta_1 \text{Voters}_{it} + \epsilon_i \). Panel B, Column (1) reports the results of the following first stage regression: \( \text{TotalVotes}_{st} = \beta_0 + \beta_1 \text{Off} - \text{chain}_{st} + \epsilon_t \), where \( \text{Off} - \text{chain} \) is an instrumental variable. Columns (2) – (11) report the results of second stage: \( \text{factor}_s = \beta_0 + \beta_1 \text{TotalVotes}_{st} + \epsilon_t \). Panel C, Column (1) reports the results of the following first stage regression: \( \text{Speed}_{st} = \beta_0 + \beta_1 \text{Off} - \text{chain}_{st} + \epsilon_t \), where \( \text{Off} - \text{chain} \) is an instrumental variable. Columns (2) – (11) report the results of second stage: \( \text{factor}_s = \beta_0 + \beta_1 \text{Speed}_{st} + \epsilon_t \). In Column (1), partial F-statistics are reported in parentheses. In Columns (2) - (11), t-statistics are reported in parentheses. *, **, and *** denote significance levels at the 10%, 5%, and 1% levels based on the standard t-statistics.
Table 19: 2-SLS IV regressions (network factors – MKR)

| Panel A: Estimate Voters using an instrument |
|---------------------------------------------|
| (1) TotalWithBlc (2) New (3) Active (4) ActiveRatio |
| Off-chain 0.17** (4.90) |
| Voters 2.98** (1.93) 1.15*** (2.58) 1.03*** (2.69) 0.09 (0.29) |
| Durbin’s test 5.39 8.79 7.76 0.05 |
| p-value 0.02 0.00 0.01 0.83 |
| Wu-Hausman test 5.50 9.22 8.07 0.05 |
| p-value 0.02 0.00 0.01 0.83 |
| Adj. R sq -1.27 -1.97 -1.72 -0.02 |
| N 127 127 127 127 |

| Panel B: Estimate TotalVotes using an instrument |
|---------------------------------------------|
| (1) TotalWithBlc (2) New (3) Active (4) ActiveRatio |
| Off-chain 0.24** (5.45) |
| TotalVotes 2.13* (1.86) 0.82*** (2.61) 0.74*** (2.69) 0.06 (0.29) |
| Durbin’s test 4.15 6.88 6.49 0.10 |
| p-value 0.04 0.01 0.01 0.76 |
| Wu-Hausman test 4.18 7.10 6.68 0.09 |
| p-value 0.04 0.01 0.01 0.76 |
| Adj. R sq -0.32 -0.52 -0.53 -0.02 |
| N 127 127 127 127 |

| Panel C: Estimate Speed using an instrument |
|---------------------------------------------|
| (1) TotalWithBlc (2) New (3) Active (4) ActiveRatio |
| Off-chain 0.16** (4.18) |
| Speed 3.21** (2.02) 1.24** (1.93) 1.11** (2.02) 0.09 (0.28) |
| Durbin’s test 5.11 10.28 8.72 0.11 |
| p-value 0.02 0.00 0.00 0.74 |
| Wu-Hausman test 5.20 10.92 9.14 0.11 |
| p-value 0.02 0.00 0.00 0.74 |
| Adj. R sq -1.10 -2.57 -2.12 -0.04 |
| N 127 127 127 127 |

Note: This table reports results of the 2-SLS IV regressions. Panel A, Column (1) reports the results of the following first stage regression: \( \text{Voters}_t = \beta_0 + \beta_1 \text{off-chain}_t + \epsilon_t \), where \( \text{off-chain} \) is an instrumental variable. Columns (2) – (5) report the results of second stage: \( \text{factor}_t = \beta_0 + \beta_1 \text{Voters}_t + \epsilon_t \). Panel B, Column (1) reports the results of the following first stage regression: \( \text{TotalVotes}_t = \beta_0 + \beta_1 \text{off-chain}_t + \epsilon_t \), where \( \text{off-chain} \) is an instrumental variable. Columns (2) – (5) report the results of second stage: \( \text{factor}_t = \beta_0 + \beta_1 \text{TotalVotes}_t + \epsilon_t \). Panel C, Column (1) reports the results of the following first stage regression: \( \text{Speed}_t = \beta_0 + \beta_1 \text{off-chain}_t + \epsilon_t \), where \( \text{off-chain} \) is an instrumental variable. Columns (2) – (5) report the results of second stage: \( \text{factor}_t = \beta_0 + \beta_1 \text{Speed}_t + \epsilon_t \). In Column (1), partial F-statistics are reported in parentheses. *, **, and *** denote significance levels at the 10%, 5%, and 1%.
### Table 20: 2-SLS IV regressions (Twitter sentiment factors – MKR)

#### Panel A: Estimate Voters using an instrument

|         | (1)  | (2)     | (3)     | (4)     |
|---------|------|---------|---------|---------|
| Off-chain | 0.17** | (4.90) |         |         |
| Voters  | 0.48 | 0.10    | 0.02    |         |
|         | (1.07) | (0.52) | (0.08) |         |
| Durbin’s test | 1.81 | 0.16 | 0.00 |         |
| p-value | 0.18 | 0.69    | 0.95    |         |
| Wu-Hausman test | 1.79 | 0.15 | 0.00 |         |
| p-value | 0.18 | 0.70 | 0.95 |         |
| Adj. R-sq | -0.48 | -0.05 | -0.01 |         |
| N     | 127  | 127     | 127     |         |

#### Panel B: Estimate TotalVotes using an instrument

|         | (1)  | (2)     | (3)     | (4)     |
|---------|------|---------|---------|---------|
| Off-chain | 0.24** | (5.45) |         |         |
| TotalVotes  | 0.35 | 0.07    | 0.01    |         |
|         | (1.06) | (0.51) | (0.08) |         |
| Durbin’s test | 1.83 | 0.09 | 0.01 |         |
| p-value | 0.18 | 0.77    | 0.92    |         |
| Wu-Hausman test | 1.82 | 0.08 | 0.01 |         |
| p-value | 0.18 | 0.77 | 0.92 |         |
| Adj. R-sq | -0.19 | -0.01 | -0.01 |         |
| N     | 127  | 127     | 127     |         |

#### Panel C: Estimate Speed using an instrument

|         | (1)  | (2)     | (3)     | (4)     |
|---------|------|---------|---------|---------|
| Off-chain | 0.16** | (4.18) |         |         |
| Speed  | 0.52 | 0.10    | 0.02    |         |
|         | (1.27) | (0.58) | (0.08) |         |
| Durbin’s test | 1.13 | 0.00 | 0.00 |         |
| p-value | 0.99 | 0.99    | 1.00    |         |
| Wu-Hausman test | 1.11 | 0.00 | 0.00 |         |
| p-value | 0.29 | 0.98 | 1.00 |         |
| Adj. R-sq | -0.23 | 0.05 | -0.01 |         |
| N     | 127  | 127     | 127     |         |

Note: This table reports results of the 2-SLS IV regressions. Panel A, Column (1) reports the results of the following first stage regression: $\text{Voters}_t = \beta_0 + \beta_1 \text{off} - \text{chain}_t + \epsilon_t$, where $\text{off} - \text{chain}$ is an instrumental variable. Columns (2) – (4) report the results of second stage: $\text{factor}_t = \beta_0 + \beta_1 \text{Voters}_t + \epsilon_t$. Panel B, Column (1) reports the results of the following first stage regression: $\text{TotalVotes}_t = \beta_0 + \beta_1 \text{off} - \text{chain}_t + \epsilon_t$, where $\text{off} - \text{chain}$ is an instrumental variable. Columns (2) – (4) report the results of second stage: $\text{factor}_t = \beta_0 + \beta_1 \text{TotalVotes}_t + \epsilon_t$. Panel C, Column (1) reports the results of the following first stage regression: $\text{Speed}_t = \beta_0 + \beta_1 \text{off} - \text{chain}_t + \epsilon_t$, where $\text{off} - \text{chain}$ is an instrumental variable. Columns (2) – (4) report the results of second stage: $\text{factor}_t = \beta_0 + \beta_1 \text{Speed}_t + \epsilon_t$. In Column (1), partial F-statistics are reported in parentheses. In Columns (2) - (4), t-statistics are reported in parentheses. *, **, and *** denote significance levels at the 10%, 5%, and 1% levels based on the standard t-statistics.

### Table A.1: Financial factors

| Description | Price by day (USD) |
|-------------|--------------------|
| Price       | Price by day (USD) |
| r           | Daily return       |
| v2          | 2-day volatility   |
| v3          | 3-day volatility   |
| v4          | 4-day volatility   |
| v5          | 5-day volatility   |
| v6          | 6-day volatility   |
| v7          | 7-day volatility   |
| v14         | 14-day volatility  |
| v30         | 30-day volatility  |
| v60         | 60-day volatility  |
Table A.2: Transaction factors for MKR and DAI

| Description                                      |
|--------------------------------------------------|
| AvgBlcUsd                                        |
| AvgSizeDai                                       |
| AvgSizeMkr                                       |
| AvgSizeUsd                                       |
| LargeVolDai                                      |
| LargeVolMkr                                      |
| LargeVolUsd                                      |
| LargeCnt                                         |
| VolDai                                           |
| VolMkr                                           |
| VolUsd                                           |
| TxnCnt                                           |

Table A.3: Exchange factors for MKR and DAI

| Description                                      |
|--------------------------------------------------|
| InCnt                                            |
| InVolDai                                         |
| InVolMkr                                         |
| InVolUsd                                         |
| OutCnt                                           |
| OutVolDai                                       |
| OutVolMkr                                       |
| OutVolUsd                                       |
| NetDai                                          |
| NetMkr                                          |
| NetUsd                                          |
| TotalDai                                        |
| TotalMkr                                        |
| TotalUsd                                        |

Table A.4: Network factors

| Description                                      |
|--------------------------------------------------|
| TotalWithBlc                                     |
| New                                             |
| Active                                          |
| ActiveRatio                                     |

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Table A.5: Twitter sentiment factors

| Description                  |
|------------------------------|
| Positive                     | The number of Tweets that the texts used in the Tweets related to a given token have a positive connotation. |
| Neutral                      | The number of Tweets that the texts used in the Tweets related to a given token have a neutral connotation. |
| Negative                     | The number of Tweets that the texts used in the Tweets related to a given token have a negative connotation. |

Table A.6: Correlations and descriptive statistics of the instrumental variable

| Correlations                  | Voters  | TotalVotes | Largest Share | Largest ShareWin | Gini   | Order | Speed |
|-------------------------------|---------|------------|---------------|------------------|--------|-------|-------|
| Off-chain voters              | 3.72*   | 9.70***    | 0.02          | 0.17             | 1.96   | 1.72  | 3.87**|
|                               | (0.06)  | (0.00)     | (0.90)        | (0.68)           | (0.16) | (0.19) | (0.05)|

| Descriptive Statistics        | Mean    | Median    | Maximum      | Minimum      | Std    |
|-------------------------------|---------|-----------|--------------|--------------|--------|
| Off-chain voters              | 55.80   | 36.00     | 393          | 0            | 72.17  |

Note: This table presents correlation between the number of off-chain voters and measurements of centralized governance in Maker. P-values are presented in parentheses. *, **, and *** denote significance levels at the 10%, 5%, and 1% levels. Voters, TotalVotes and Speed have significant correlations with the daily off-chain voters.