Will Blockchains Disintermediate Platforms? Limits to Decentralization in DAOs *

— PRELIMINARY –

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Abstract

Blockchain technologies are designed to promote decentralization and self-governance in economic and social settings. In the context of platforms, an early claim of some proponents of these technologies was that blockchains would promote disintermediation, replacing intermediaries with decentralized governance, for instance leading to platforms governed by decentralized autonomous organizations (DAOs).

We have seen some elements of that (e.g., in DeFi—Decentralized Finance), but upon closer examination, most of the "decentralized" platforms are actually controlled by a small number of agents, or even a single agent, that effectively act as intermediaries. In this work we study the underlying dynamics and explore the potential for decentralized governance of blockchain-based platforms by modeling a simplified setting with a one-sided platform and comparing control by a centralized intermediary to control by a DAO that makes decisions via majority voting of its governance tokens.

Our analysis suggests that a "democratic" DAO with governance tokens equally distributed among potential users would set a low access price for the platform and maximize network size and total surplus. If tokens can be traded, however, there is a strong tendency for concentration of control, which makes it challenging to maintain decentralized governance. This tendency becomes stronger if at least a certain fraction of small holders is myopic, and would sell their tokens without considering the future impact of their actions. Concentration in the ownership of governance tokens can be limited either by design or by regulation, but implementation and enforcement would be challenging. Intermediaries may be changed by blockchain technologies, but they are not likely to disappear.

Keywords: Blockchain platforms, DAOs, Decentralization

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1 Introduction: Platforms, Blockchains and DAOs

Platforms attract and connect users, enabling value-creating interactions characterized by network effects. In successful platforms, the network effects give market power to the intermediaries—the term we employ for platform operators—who can charge higher prices and extract value in complementary ways, such as from the collection and analysis of valuable usage data. When the Internet transformed the economics of creating value via platforms, some predicted that the dramatic reduction in search and coordination costs and the algorithmic creation of platform value (e.g., via recommendation and matching technologies) would lead to disintermediation—in the sense that the role of centralized intermediaries would be diminished and instead platform control would be decentralized and the value created by platforms would be captured by their users. With few exceptions, however, Internet platforms have been controlled by centralized intermediaries that have enjoyed significant economic returns.[1]

The emergence of blockchain technologies is raising once again the possibility of "true" platform disintermediation; proponents of that view argue that blockchains can provide algorithmic platform services in a fully decentralized way, without the need for an intermediary that captures a significant fraction of the value away from the users. Blockchains offer their users a shared distributed ledger of information, which may be data or executable code, i.e., smart contracts. As long as processes can be encoded in smart contracts, algorithmic execution is guaranteed even when involving separate entities that do not trust each other. Smart contracts prevent reneging and thus can address opportunistic behavior and enforcement costs, subject to the limitations of what actions they can encode.

Platform services on blockchains are commonly provided by dApps, which are applications built with smart contracts. The term stands for "decentralized apps," but dApps can

[1]Notably, 7 of the 10 most valuable companies in mid-2022 control and operate major platforms: Apple, Microsoft, Alphabet, Amazon, Meta, VISA and Tencent.

have various degrees of decentralization in their governance: for instance a centralized intermediary can maintain control over strategic decisions such as pricing and development—as in NFT platform OpenSea, or control can be decentralized, typically by delegating these decisions to a Distributed Autonomous Organization, or DAO—as is the case for the cryptocurrency exchange UniSwap.

Digital Autonomous Organizations (DAOs) are decentralized entities that use blockchain technology and smart contracts to govern themselves autonomously. The rules, decision-making processes, and financial transactions in DAOs are typically encoded in smart contracts, allowing for transparent, trustless, and self-governing operations without a central authority or intermediary. DAO membership and decision rights are typically allocated via "governance" tokens on the blockchain, with the DAO's operations and decisions either encoded in its contracts or determined based on proposals voted on by its members based on their ownership of the governance tokens. The voting process is conducted through the blockchain or associated mechanisms that can communicate the results back to the blockchain and the results of these votes are automatically executed by the DAO's smart contracts.

In this work we study to what extent and under what conditions blockchains can disintermediate platforms by allowing decentralized control that bypasses a centralized intermediary—typically through a DAO—and thus whether blockchain technology will finally deliver the disintermediation some predicted as a result of the Internet. Will blockchain-based platforms emphasize accessibility and set low prices to maximize network size and total surplus, or will they operate similar to a profit-maximizing centralized intermediary that would set a higher "monopoly" price to maximize profits?

2 Model Setting

We model a one-sided monopoly platform that sets the access price for its users. Our model and results apply also to a platform that obtains its revenue from advertising or selling user data. In this setting we compare platform governance by a DAO that makes decisions based on its participants voting via their governance tokens, to control by a centralized profit-maximizing intermediary. While our model is simplified for tractability of our analysis, we explore the applicability of our findings to more general settings.

We consider a setting with n potential users for a platform with network effects, to whom we may also refer as "users" or "agents." Each user has a type k distributed uniformly on $[0, 1]$ and by joining a platform with ω users ($0 \leq \omega < n$), derives utility $u_k(\omega) = \gamma k^\alpha \omega^\beta$ where $\beta \geq 0$ measures the strength of network effect ($\beta = 0$ implies no network effect), $\alpha \geq 0$ measures the level of preference differentiation among types ($\alpha = 0$ implies no differentiation), and $\gamma > 0$ is a utility scaling parameter.

The platform cannot price discriminate and thus sets access price p for all users. A potential user that does not join the platform derives zero utility while a potential user of type k that joins the platform pays the access price p and derives utility u_k as above. For any such price p, if a potential user of type k prefers to join the platform, then all types $k' > k$ also will prefer to join the platform. Similarly, if a potential user of type k prefers not to join, then all users of type $k' < k$ will not join as well. Thus for every p, there is a threshold user of type κ and corresponding network size $\bar{\omega}$, where $u_\kappa(\bar{\omega}) - p = 0$ and $\bar{\omega} = (1 - \kappa)n$. Thus at any price $p \in [0, \gamma \frac{\alpha^\alpha \beta^\beta}{(\alpha+\beta)^{\alpha+\beta}} n]$, there are two possible equilibria: $\omega = 0$ and $\omega = (1 - \kappa)n$.

The base case in this setting is a profit-maximizing centralized intermediary that sets the price (by indirectly setting κ_m) to satisfy the first-order condition (FoC) $\gamma n^{\beta+1}[\alpha \kappa_m^{\alpha-1}(1 - \kappa_m)^{\beta+1} - \kappa_m^\alpha(\beta + 1)(1 - \kappa_m)^\beta] = 0$, implying $\alpha(1 - \kappa_m) = \kappa_m(\beta + 1)$ and thus $\kappa_m = \frac{\alpha}{\alpha+\beta+1}$. The second-order condition (SoC)for profit maximization gives $\omega_m = \frac{\beta+1}{\alpha+\beta+1}$, $\frac{\partial \kappa_m}{\partial \beta} < 0$, $\frac{\partial \omega_m}{\partial \beta} > 0$ and thus the centralized intermediary sets price $p_m = \gamma n^\beta \frac{\alpha^\alpha (\beta+1)^\beta}{(\alpha+\beta+1)^{\alpha+\beta}}$ and realizes profit $\pi_m = \gamma n^{\beta+1} \frac{\alpha^\alpha (\beta+1)^{\beta+1}}{(\alpha+\beta+1)^{\alpha+\beta+1}}$.

In this setting, the social surplus is maximized by setting $p = 0$ so that all prospective users join the platform. By contrast, a profit-maximizing centralized intermediary would act like a monopolist, setting a relatively high price for platform access that maximizes its profits but limits participation and network size. This would result in lower total social surplus and a corresponding deadweight loss. Note that this inefficiency increases with the degree of differentiation among the user types α and decreases as a fraction of the total surplus with the level of network effects β. When the prospective users are relatively homogeneous, the intermediary has an incentive to increase participation, and that incentive increases when network effects are higher. In the case of fully homogeneous users (when $\alpha = 0$), the intermediary can set a price so that all potential users join the platform while it captures the entire surplus generated; intermediary profits are maximized and consumer surplus vanishes, yet there is no deadweight loss as the total social surplus is maximized. Similarly as network effects increase, participation and consumer surplus increase at the profit-maximizing price set by the intermediary, which also increases the intermediary's profits.

3 DAO-controlled platform

When the platform is controlled by a DAO, there is no centralized intermediary making the pricing decision. Instead, this decision is reached through the DAO's governance mechanism. For our analysis, we assume a simple majority voting mechanism, where there are τ governance tokens distributed among the potential users of the platform.[2] For instance, the price p charged by the platform can be determined by voting on successive price proposals, adopting the first to be supported by a majority. The resulting platform revenue $p\,\omega$ is subsequently distributed as a dividend to the governance tokens, with each token receiving $p\,\omega/\tau$.

[2]This seems to be a common mechanism for DAOs

A potential user that holds t governance tokens and decides not to join the platform at price p would realize net utility equal to the dividend received $t\frac{p\omega}{\tau}$, which is maximized when the price is set to p_m. At that price users of type $k > \kappa_m$ will join the platform, resulting in a network of size $(1 - \kappa_m)n$.

A potential user of type k that holds t tokens and decides to pay the access price p and join the platform realizes net utility $U_k(\omega, t, p) = \gamma k^\alpha \omega^\beta - p + t\frac{p\omega}{\tau} = \gamma k^\alpha \omega^\beta - p\left[1 - \frac{\omega}{\tau}t\right]$ where $p = \kappa^\alpha(1-\kappa)^\beta n$ and $\omega = (1-\kappa)n$. If $t \leq \frac{\tau}{\omega}$, the user will receive in dividend less than what it pays for access to the platform, and thus prefers to set $p = 0$. If $t > \frac{\tau}{\omega}$, an interior solution may exist where the user would prefer to set an access price $p > 0$, inducing users of type higher than $\tilde{\kappa}$ to join, where $-\beta\left[k^\alpha + \kappa^\alpha(T(1-\kappa)-1)\right] + (1-\kappa)\left[\alpha\kappa^{\alpha-1}(T(1-\kappa)-1) - T\kappa^\alpha\right] = 0$ with $T = nt/\tau$ denoting token ownership normalized for the total number of potential users and outstanding tokens.

The DAO could set $p = 0$, which maximizes total welfare but we show that it may not do so even when tokens are "democratically" distributed; in fact, the higher the profit at price p_m, the less likely the DAO will set $p = 0$.

3.1 Democratic DAO with non-transferable tokens

We first consider a "democratic" DAO where each potential user gets an equal number of t non-transferable governance tokens that are acquired exogenously to our setting—for instance with an initial "token drop" or via previous use of the platform; for simplicity and without loss of generality we set $t = 1$. We refer to this type of DAO as "democratic" as each potential user gets one non-transferable vote. This corresponds to $\tau = n$ and thus $T = 1$ for all potential users. Then $\frac{\tau}{\omega} = \frac{1}{1-\kappa} \implies t \leq \frac{\tau}{\omega}$ if $\kappa > 0$, and thus all users prefer $p = 0$ while non-users prefer $p = p_m$ as platform revenue is extracted from the platform users and distributed to all token holders, whether they join the platform or not.

A potential user of type k prefers to set price p_m and not join the platform (receiving a dividend equal to its share of platform revenue) rather than set price $p = 0$ and join the platform when $\frac{\pi_m}{n} > \gamma k^{\alpha} n^{\beta} \iff \frac{\alpha^{\alpha}(\beta+1)^{\beta+1}}{(\alpha+\beta+1)^{\alpha+\beta+1}} > k^{\alpha}$, with the threshold type being $\tilde{\kappa} = \frac{\alpha}{\alpha+\beta+1}\left(\frac{\beta+1}{\alpha+\beta+1}\right)^{\frac{\beta+1}{\alpha}}$. In this case the $\tilde{\kappa}\, n$ token holders of type less than $\tilde{\kappa}$ would prefer to set the price to p_m, and the remaining $(1-\tilde{\kappa})n$ token holders would prefer to set a price $p = 0$. This leads to the following Corollary:

PROPOSITION 1 *A democratic DAO with non-transferable tokens and majority voting sets price $p = 0$ if $\frac{\alpha}{\alpha+\beta+1}\left(\frac{\beta+1}{\alpha+\beta+1}\right)^{\frac{\beta+1}{\alpha}} < \frac{1}{2}$ and sets price $p = p_m$ if $\frac{\alpha}{\alpha+\beta+1}\left(\frac{\beta+1}{\alpha+\beta+1}\right)^{\frac{\beta+1}{\alpha}} > \frac{1}{2}$.*

This is because if $\tilde{\kappa} < \frac{1}{2}$ then setting $p = 0$ is a Condorcet winner against any other price proposal, and similarly for setting $p = p_m$ if $\tilde{\kappa} > \frac{1}{2}$. Furthermore, in terms of comparative statics, $\partial\tilde{\kappa}/\partial\alpha > 0$ and $\partial\tilde{\kappa}/\partial\beta < 0$, meaning that the type of the marginal user that will prefer to set $p = 0$ rather than $p = p_m$ increases with α and decreases with β.

As user types become more heterogeneous, an increasing fraction of types that derive low or intermediate benefit from joining the platform find it more attractive to adopt a high price and thus obtain some of the surplus of the types that benefit most from the platform, instead of pricing at $p = 0$ and participate in the platform themselves. On the other hand, as network effects become stronger, there is more support for pricing at the socially efficient $p = 0$. For instance, for any $\beta \geq 0$, if $0 < \alpha < \beta + 1$, then $\tilde{\kappa} < 1/2$ and the "democratic" DAO with non-transferable tokens sets price $p = 0$; for sufficiently high α, however, $\tilde{\kappa} > 1/2$; i.e., the DAO sets price $p = p_m$.

Figure 1 illustrates this for $\beta = 0$ and $\alpha = 1$, $\alpha = 2$ and $\alpha = 3.5$. In the first two cases $\tilde{\kappa} = 1/4$ and $\tilde{\kappa} = 2/(3\sqrt{3})$, resulting in a majority of potential users favoring $p = 0$, while in the third case $\tilde{\kappa} = 0.506$ with a (small) majority of potential users favoring $p = p_m$.

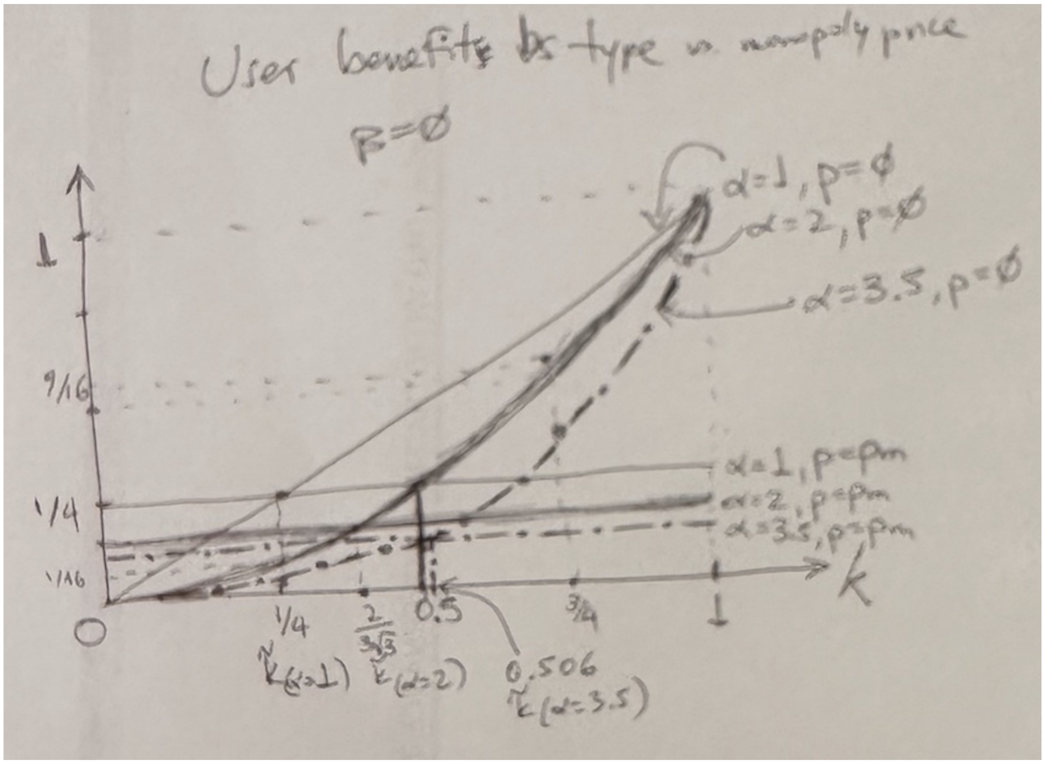

Figure 1. Price setting for $\beta = 0$ and user differentiation $\alpha = 1$, $\alpha = 2$ and $\alpha = 3.5$

What we see in this case is that in the "baseline" outcome a majority of the potential users votes for a zero price, which results in all users joining the platform and a socially efficient outcome. However, if the holders of the governance tokens are very different in terms of their benefit from the platform, then a majority can vote to set the price at the level that would be set by a monopolist; this would result in a smaller network—in fact the potential users voting in favor of the monopoly price do not join the platform as they would not be willing to pay that price.

A "democratic" DAO with voting power equally distributed among all potential users would thus frequently set low prices to maximize the platform's network size and benefits, which could minimize or eliminate deadweight loss and maximize the total social surplus. This efficient outcome, however, is predicated on relatively homogeneous potential benefits from participating in the platform, and egalitarian distribution of the governance tokens.

Departing from either of these conditions can result in the platform setting higher prices, and at the extreme when token ownership becomes very concentrated, its behavior could be close to that of a centralized monopolist.

3.2 DAO with uneven token holdings

We now consider pricing and participation decisions for the case that governance tokens are distributed unevenly by the platform developer (thus favoring certain potential users), or are auctioned off, or may have been distributed equally to potential users may have been subsequently traded and thus may have been transferred from their initial owner—these cases are characterized by a token allocation where token holders have uneven holdings before the price setting and participation decisions are made. In this section we consider the token holdings as given and examine the DAO's pricing decision. In section 4 we study equilibria where trading takes place in anticipation of the subsequent pricing decision by the DAO.

For a user who holds t tokens, define $T = n\frac{t}{\tau}$, i.e., the "normalized" token holdings compared to the tokens that would be held by each user if token holdings were equal for all users. The net payoff received by that user of type k with T normalized holdings when the marginal user is κ, with corresponding network size $\omega = 1 - \kappa$, is

$$U_k(\kappa, T) = \gamma k^\alpha (1-\kappa)^\beta n^\beta - \gamma \kappa^\alpha (1-\kappa)^\beta n^\beta [1 - (1-\kappa)T] =$$
$$\gamma\, n^\beta (1-\kappa)^\beta \left[k^\alpha - \kappa^\alpha (1 - (1-\kappa)T)\right].$$

This is the payoff derived from joining the platform (which depends on the network size $\omega = 1 - \kappa$) and the dividend received corresponding to the T level of token ownership, net of the price paid to join the platform. Setting the platform price p determines the marginal user type κ, and thus the pricing decision can be thought of as setting the marginal user type that will join the platform.

A monopolist operating but not using the platform would maximize platform revenue by setting the marginal user type to κ_m, corresponding to the revenue maximizing monopoly price p_m. A potential user holding $t > 0$ tokens that does not join the platform will also prefer to maximize revenue, choosing the same marginal user κ_m as the monopolist. By contrast, in choosing κ (and thus p), each user of the platform would be trading off the platform revenue, and thus the share of revenue received as a dividend, against the increasing utility from a larger network size and the lower price paid to join the platform. Thus each user of type k holding t tokens (or, equivalently, T normalized tokens) would have a preferred marginal user type that we denote as $\hat{\kappa}(k,t)$, or $\hat{\kappa}(k,T)$ or simply $\hat{\kappa}$. In general, $\hat{\kappa} \leq \kappa_m$ for platform users, and $\hat{\kappa} = \kappa_m$ for token holding non-users.

For low values of token ownership (including but not limited to all $T \leq 1$), $U_k(\kappa, T)$ decreases in κ, and platform users would choose $\hat{\kappa} = 0$, corresponding to the price $p = 0$ that maximizes network size. However as the number of tokens owned by a user increases, $U_k(\kappa, T)$ can increase in κ, even leading to $\hat{\kappa} > 0$. The share of revenue received as a dividend will outweigh the positive price that has to be paid to join the platform and the reduction in network utility because of the reduced network size.

In the rest of this section we focus on the simpler case with $\gamma = \alpha = 1$; then $U_k(\kappa, T) = n^\beta(1-\kappa)^\beta[k - \kappa + \kappa(1-\kappa)T]$. For user of type k holding t tokens the most preferred value for the threshold user is $\hat{\kappa}(k,t) = \frac{\beta(T-1)+3T-1-\sqrt{(T+1)^2(\beta+1)^2-2(1-k)\beta(\beta+2)}}{2T(\beta+2)}$

Some comparative statics for this case:

- $\frac{\partial \hat{\kappa}(k,T)}{\partial k} < 0$ follows directy
- $\frac{\partial \hat{\kappa}(k,T)}{\partial T} = (1 + b - ((1+b)^2 t(1+t))/Sqrt[2b(2+b)(-1+k) + (1+b)^2(1+t)^2] + Sqrt[2b(2+b)(-1+k) + (1+b)^2(1+t)^2])/(2(2+b)t^2) > 0$ because $(b+1)^2(t+1)^2 - (b+1)^2 t(t+1) = (b+1)^2(t+1) > 0$
- $\frac{\partial^2 \hat{\kappa}(k,T)}{\partial T^2} < 0$ for the same reason
- $\frac{\partial U_k(\hat{\kappa}(k,T),T)}{\partial T} > 0$ by optimality argument

– consider $T' > T$

– $U_k(\hat{\kappa}(k,T'),T') \geq U_k(\hat{\kappa}(k,T),T') = U_k(\hat{\kappa}(k,T),T) + (T'-T)\underbrace{n^{\beta}\hat{\kappa}(k,T)(1-\hat{\kappa}(k,T))^{\beta+1}}_{\text{unit dividend at } \hat{\kappa}(k,T)} >$

$U_k(\hat{\kappa}(k,T),T)$

- $\frac{\partial^2 U_k(\hat{\kappa}(k,T),T)}{\partial T^2} > 0$

Figure 2 illustrates that for a DAO with uneven token holdings $\hat{\kappa}$ increases with T, and decreases with k and β.

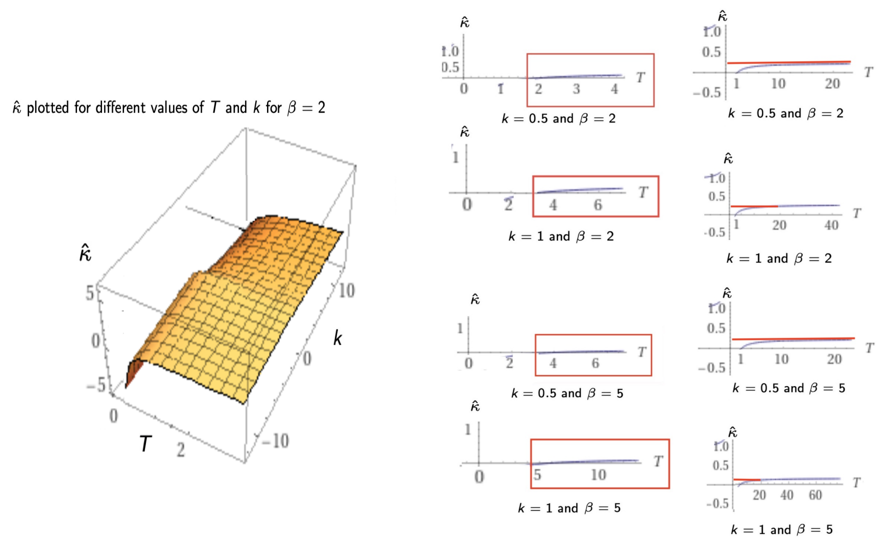

Figure 2. DAO with uneven token holdings, $\hat{\kappa}$ vs. T, k, β

PROPOSITION 2 *In this case platform users' preferences are single-peaked around $\kappa = \hat{\kappa}(k,T)$ when $T \geq 1$ and $\beta \geq -1$. That is, for $\kappa < \hat{\kappa}(k,T)$, $U_k(\kappa,T)$ is increasing in κ, and for $\kappa > \hat{\kappa}(k,T)$, $U_k(\kappa,T)$ is decreasing in κ.*

Proof in the Appendix.

Given this single-peakness, the result of the voting dynamics in the case of uneven governance token ownership is that the platform price is set by the pivotal user (in terms of getting the token ownership over the required majority threshold to set the access price) when users are ordered based on their preferred access price for the platform. More formally, if the n users are ordered in ascending order of preferred price p_{DAO}, so that if $j > i$ then the preferred price $p_{DAOj} > p_{DAOi}$, the pivotal user is i^* where $\sum_{j=i^*}^{n} t_j \geq t^* > \sum_{j=i^*+1}^{n} t_j$, where t^* is the required majority of tokens that must vote in favor of a price setting proposal in order for that proposal to be adopted by the DAO. In that case the DAO will set p_{DAOi} as its price.

4 DAO with tradable tokens

We now consider the case that governance tokens are tradable after their initial allocation (which for instance could be the result of a "token drop," an auction or a distribution to potential platform users) and every potential user of the platform can buy or sell tokens.

Users announce the number of tokens they will purchase at a given price. For instance, user j announces that will purchase up to x_j tokens at price y_j, and if $x' > x$ tokens are offered, user j randomly purchases x_j from the x' offered for sale. If multiple users offer to purchase tokens, then an order book can be constructed, and all possible trades will be executed at the price that demand matches supply.

We start by analyzing a setting without network effects ($\beta = 0$) with n users; for simplicity and without loss of generality we assume that there are also n governance tokens and that n is odd, so that a majority requires $(n + 1)/2$ governance tokens.[3] At first we assume the users are patient and have perfect foresight. Specifically, we consider the equilibria in the following 3-stage game:

1. The initial (pre-trade) allocation of n tokens is realized (e.g., via a"token drop").

2. Trading takes place resulting in user i holding t_i tokens ($0 \leq t_i \leq n; \sum_i t_i = n$).

3. The DAO sets price p and corresponding payoffs are realized.

[3] In terms of our previous notation, we assume that $\tau = n$.

If the DAO sets the price to p, the payoff of a user with t tokens is

$$\underbrace{u_k(\omega)}_{\text{usage utility}} - \underbrace{p}_{\text{price paid}} + \underbrace{\frac{t}{\tau} n\, p(1-p)}_{\text{dividend received}}$$

4.1 Price setting by the DAO

Given a certain post-trading allocation of token holdings, in stage 3 of the above game each user has a preferred price based on the number of tokens t they hold and whether or not they would want to participate in the platform (and thus pay) that price.

Lemma 1 *The preferred price of a potential user is either p_m if they do not participate in the platform, 0 if they participate and $t \leq 1$, and $p_m - \frac{1}{2t}$ if they participate and $t > 1$.*

This lemma directly follows from the FoCs. It may also have been proven in Section 3.

The lemma implies that indexing the *participating* platform users by ascending token holdings, they would also be indexed in ascending preferred access prices, and thus the pivotal user would set the price.

A user is willing to trade (buy or sell) one or more tokens if this will result in a higher post-trade payoff (including the price received in the case of a sale or the cost of acquiring in the case of a purchase).

4.2 No trading under democratic token allocation

PROPOSITION 3 *If $t_i \leq 1$ for all i, then the only equilibrium is a no-trade equilibrium with $p^*_{DAO} = 0$.*

Proof: In Appendix.

This proposition implies that if no user has more than one token (which implies that each user has one token as there are n users and n tokens), then there will be no trading of governance tokens, and as shown in Section 3, the DAO will set price $p_{DAO} = 0$. No user would find it profitable to purchase another user's governance token at a price that would compensate the selling user for the reduction in its surplus from having to pay a price $p_{DAO} > 0$; the result is setting the socially optimal price $p_{DAO} = 0$ that avoids any deadweight loss.

4.3 Maximum post-trade holdings

PROPOSITION 4 *For any initial token distribution, there is no equilibrium with any user holding more than* $\frac{n+1}{2}$ *tokens.*

Proof: In Appendix.

This proposition implies that holding more tokens than the minimal majority is unprofitable; any additional tokens acquired will cost more than their prospective dividend. Furthermore, divesting any tokens in excess of the minimal majority will be profitable as these tokens can be sold for more than the expected dividend.

COROLLARY 1 *The highest price that can be set by the DAO is* $\tilde{p}_m \equiv \frac{1}{2} - \frac{1}{n+1}$.

Proof: This corollary follows directly from that fact that the price a pivotal user would set is increasing in the number of governance tokens that the user holds, and the above proposition shows that number will not exceed $\frac{n+1}{2}$, corresponding to a platform price of $\frac{1}{2} - \frac{1}{n+1}$.

While $\tilde{p}_m < p_m$, where p_m is the price that would be set by a monopolist, $\tilde{p}_m$ approaches p_m as n increases.

4.4 Trading with uneven token holdings

We now explore trading when initial token holdings are uneven, and the concentration outcomes implied by the resulting equilibria.

Lemma 2 *If some user i holds $t_i \geq 2$, then there exists an equilibrium with $p^*_{DAO} = \tilde{p}_m$.*

Proof in the Appendix.

Lemma 2 shows that it only takes one user to acquire two tokens for an equilibrium to exist where the DAO prices close to the monopoly price. This equilibrium follows from the fact that once a user acquires $t \geq 2$ tokens, then their preferred price switches from $p_{DAO} = 0$ to $p_{DAO} = \frac{1}{2} - \frac{1}{2t}$; at this point there is an equilibrium where that user acquires $\frac{n+1}{2} - t$ additional tokens to get a controlling majority and therefore sets $p^*_{DAO} = \tilde{p}_m$.

This shows that it only takes a small departure from the democratic distribution of tokens to open the possibility for departures from the democratic equilibrium with $p_{DAO} = 0$. A larger departure can exclude that equilibrium as a possible outcome. Consider an initial distribution of token holdings where at least some user has more than one token, i.e., there exists a user i s.t. $t_i \geq 2$. In that case let t_{min} and t_{max} denote the minimum and maximum holdings of users with more than one token, i.e., $t_{min} \equiv \min\{t_i \,|\, t_i \geq 2\}$ and $t_{max} \equiv \max t_i$. Also let T_W denote the total holdings of these users, i.e., $T_W = \sum\limits_{i|t_i \geq 2} t_i$. The following proposition holds:

PROPOSITION 5 *If there exists user i s.t. $t_i \geq 2$ and $t_{max}\frac{t_{min}+1}{t_{min}-1} + T_W > \frac{n+3}{2}$, then*

(a) there is <u>no</u> equilibrium with $p^*_{DAO} = 0$;

(b) there always exists an equilibrium with $p^*_{DAO} = \tilde{p_m}$

(c) there exists at least one other equilibrium where depending on the distribution of the tokens $p^*_{DAO} \in [\frac{1}{4}, \tilde{p_m}]$

Recall that $\tilde{p_m} \equiv \frac{1}{2} - \frac{1}{n+1}$ is the highest price that will be set by the DAO, when there is a user with controlling majority of $\frac{n+1}{2}$ tokens.

If we use ϱ to denote the price at which tokens are traded, in equilibrium (b) above $\varrho = p^*_{DAO}(1-p^*_{DAO})$. Sellers are compensated for the prospective dividend that would be received by the tokens they sell; they prefer the zero access price but and they are willing to sell only because they expect enough other sellers to sell for a user to acquire a controlling majority and set $p^*_{DAO} = \tilde{p_m}$.

In equilibrium (c), $\varrho = p^*_{DAO}$ which is higher than the expected dividend; that is necessary to compensate sellers for the expected price increase they will have to bear. The user purchasing the tokens is willing to pay higher than the expected dividend in order to become pivotal and set their preferred price; the resulting price increase and increased dividend on its existing token holdings compensates for the loss in the purchase of the additional tokens.

COROLLARY 2 *If for some i, $t_i \geq \frac{n+3}{4}$, then $t_{max}\frac{t_{min}+1}{t_{min}-1} + T_W > \frac{n+3}{2}$ and Proposition 5 applies.*

PROPOSITION 6 *If there exists i s.t. $t_i \geq 2$ but $t_{max}\frac{t_{min}+}{t_{min}-1} + T_W < \frac{n+3}{2}$, then there exist two equilibria:*

(a) there exist an equilibrium with $p^*_{DAO} = 0$ and no trading, and

(b) there exists an equilibrium with $p^*_{DAO} = \tilde{p_m}$ and tokens are traded at $\varrho = p^*_{DAO}(1 - p^*_{DAO})$.

4.5 Trading with myopic small token holders

The results above depend on users' perfect foresight for the future value of their token and the future prices they will face under different scenaria of concentration in token holdings. This drives the reluctance of small holders to sell their tokens and the sharp cutoffs in token acquisition by larger users as soon as a certain concentration threshold is achieved. However this doesn't agree with empirical evidence, either in the case of DAOs or other similar situations (e.g., the sale of the assets of the Soviet state). Small holders are often myopic in the sense that they only consider the current value of their holdings and fail to fully account for their future appreciation.

We now explore the case where small holders ($\leq f$ tokens) are myopic in the sense they will sell their tokens if they are offered a price higher than the dividend that would be received based on the price the DAO would set under the *current* token holdings. We continue to assume that large holders ($> f$ tokens) have perfect foresight.

In this case any holders that somehow acquire $> f$ tokens will become "whales," acquire the tokens of the smaller holders, and eventually vote to set the monopoly price. The propositions below show that even if only holders of one token are myopic ($f = 1$) or even *a single* holder of one token is myopic, equilibria with concentrated holdings and high prices become possible.

PROPOSITION 7 (Democratic equilibrium is knife-edge) *If $t_i \leq 1$ for all i, and at least one user is myopic, then there exists an equilibrium with $p^*_{DAO} = \tilde{p_m}$.*

This follows directly from the fact that the myopic user will sell their token for any price > 0; this will result in a user having 2 tokens, and the rest follows from Lemma 2.

If the number of myopic agents is higher than a certain threshold, the equilibrium with $p_{DAO} = 0$ can be eliminated. This threshold will be no greater than $\frac{n+3}{4}$, leading to the following proposition:

PROPOSITION 8 *If at least M agents are myopic, with $M \leq \frac{n+3}{4}$, then there does not exist an equilibrium with $p_{DAO} = 0$.*

This Proposition guarantees that if at least $\frac{n+3}{4}$ users are myopic, then at equilibrium the access price will set at $p_{DAO} > 0$, and in fact $p_{DAO} \geq \frac{1}{4}$. Equilibria with other prices in $[\frac{1}{4}, \tilde{p_m}]$ are also possible.

Myopic token holders that sell at low prices may incentivize larger token holders to increase their holdings beyond the minimum controlling majority.

5 Discussion

DAOs represent a new decentralized organizational form made practical by blockchain technologies and especially smart contracts. They provide a new way of organizing economic activity that is both decentralized and autonomous.They have the potential to reduce transaction costs and improve efficiency by eliminating intermediaries and allowing direct "democratic" decision making. In the context of platforms, DAOs in theory can enable decentralized intermediaries that represent the collective interest of the platform users, making decisions that favor increased user participation and maximize social surplus rather than intermediary profits.

Our analysis suggests that that while this may be feasible in the case of "democratic" DAOs, in practice there are forces favoring concentration of the governance in the hands of a few agents that will act in ways similar to a traditional centralized intermediary. Thus blockchains, distributed ledgers and smart contracts may enable decentralized *operation* of platforms, but instead of decentralized governance of these platforms that would lead to disintermediation, the result is likely to be control by *a new class of intermediaries.*

Specifically we find that democratic DAOs with governance truly distributed among platform users, do result in economically efficient outcomes that maximize user participation and social surplus. Even when the allocation of the governance tokens is not fully egalitarian, the socially efficient outcomes are robust as long as as long as these tokens cannot be transferred or traded, and thus the preferences of the "pivotal" user that determines the platform's policies do not change substantially. Equilibria with outcomes similar to what would be expected from a profit maximizing intermediary only emerge if there are significant imbalances in the distribution of governance tokens, with a single or a small number of users acquiring a controlling majority.

When tokens can be traded, however, there is a qualitative change in the nature of feasible equilibria. While a fully democratic distribution of tokens still results in the socially efficient outcome that maximizes participation and social surplus, this is no longer a robust equilibrium. Even small departures from the egalitarian distribution of governance tokens enable outcomes close to what would be expected under a profit maximizing centralized intermediary. In these outcomes a user can acquire enough tokens to obtain a controlling majority, although there would be no incentive to keep accumulating tokens beyond that point. Larger departures from the egalitarian distribution of tokens will eliminate the socially efficient outcome with maximal user participation.

The "democratic" equilibrium is also not robust to having myopic users, i.e., users that only value their tokens based on their current dividends rather than their future potential. Even a small number of myopic users can result in even more concentrated holdings.

A key characteristic of our setting is the participation of users in the value creation of the platform. Our analysis thus only applies to DAOs where holders of the governance tokens are also potential users of the platform. Given the tendency for concentrated outcomes that depart from the decentralized ideal, if true decentralization is desired it would need to be incorporated in the design of the platform. For instance, the platform designers can incorporate features to prevent concentration of its governance, such as ensuring an egalitarian initial token distribution, or limiting governance token transferability. Alternatively, limits in concentration of ownership could be imposed via regulatory supervision. Both of these alternatives would be challenging to implement and monitor in the context of a DAO.

The main concern following from our analysis is that the governance of DAOs can easily become concentrated in the hands of a few entities, effectively resulting in the emergence of new intermediaries. This concentration of power could be the result of several factors, including the distribution of initial tokens or voting power, the ability of certain entities to grow their holdings via trading, and the ability of large token holders to disproportionately influence the DAO's decision-making. Paraphrasing Mark Twain, predictions of the death of intermediaries because of blockchains will most likely prove an exaggeration.