

Economic DAO Governance: A Contestable Control Approach

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Abstract

In this article, we propose a new form of DAO governance that uses a sequential auction mechanism to overcome entrenched control issues that have emerged for DAOs by creating a regime of temporary contestable control. The mechanism avoids potential public choice problems inherent in voting approaches but at the same time provides a vehicle that can enhance and secure value than inheres to DAO voting and other DAO non-market governance procedures. It is robust to empty voting and is code feasible. It facilitates the ability of DAOs to meet their normative and operational goals in the face of diverse regulatory approaches. Designed to shift control to the party with the most promising business plan, at the same time it distributes surplus in a way that tends to promote investment by other parties.

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1 Introduction

Decentralized Autonomous Organizations (“DAOs”) are a recent innovation, dating from the April 2016 launch of “The DAO.”¹ DAOs operate largely through the execution of code and have no centralized management. When participant decisions are required, DAOs typically utilize voting by token holders, roughly analogous to shareholder voting in a corporate setting. In most cases, the tokens are publicly traded.

Governance issues for DAOs have received considerable attention of late. Lots of experimentation with governance is taking place as well as a large volume of commentary.² Most of the experimentation has centered around different voting mechanisms, including quorum-based token voting, a “direct democracy” approach in which token holders vote on proposals subject to a quorum requirement, and approaches in which delegation or other forms of representation are possible.³

Token voting potentially clashes with the goal of decentralization because of the danger of two types of entrenchment that threaten to create the equivalent of centralized management. First, *explicit control* is attainable by accumulating a sufficiently large token position. Second, it is often the case that a chronic lack of voter participation puts *implicit control* in the hands of a small set of active token holders who regularly engage in governance voting.⁴ Chronic lack of participation is consistent with rationality in many instances. The passive token holders may be portfolio investors or may have a small enough holding that the costs of being an informed voter greatly exceed the potential benefits in the form of higher token values or otherwise. More generally, the benefits of any effort expended by a token holder to become an informed voter will accrue mostly to other token holders who are in effect free riders.⁵

¹Vigna (2016).

²The Decentralization Research Center (formerly, the DAO Research Collective) website includes a significant and representative collection of commentary and descriptions of experiments under the headings “Governance” and “Decentralization.” DAO Research Collective (2023).

³Nigam et al. (2023)(section on “Voting systems”).

⁴See, e.g., Feichtinger et al. (2023), Sun et al. (2022), and Liu (2023).

⁵Khanna (2022, pp. 239-240) describes this collective action problem in the corporate setting with reference to some of the literature. Reyes et al. (2017, p. 26) appear to be the first to note the presence and importance of the same problem in the DAO setting.

In order to address the danger of entrenchment as well as several other major potential problems for DAOs, we propose a different approach to DAO governance centered on a sequential auction mechanism. The fundamental building block of the mechanism is a *basic auction* that grants the auction winner *temporary, contestable control* of the DAO. Bids in the basic auction consist of a token target price, a surplus claim, and revelation of any toehold position held by the bidder at the time of the bid. Under the mechanism, the target token price part of the bid is effectively a *value claim*, S , by the bidder that with control the bidder can implement a business plan that increases the token value from the prevailing market price, P_0 , at the time of the bid to S . The surplus claim part of the bid is a claim by the bidder of a portion of the total surplus, $(S - P_0)q$, generated if the token target price is attained, where q is the total number of tokens outstanding. The winning bid is the one that leaves the most surplus to the other token holders, that is, the bid that maximizes total surplus minus the bidder's surplus claim.

In section 4 and Appendix A.1, we show that the dominant strategy in the basic auction is for the bidder to choose a business plan that produces the largest possible surplus net of the bidder's cost, C , and to truthfully reveal the token value, V , that the bidder envisions as attainable under that business plan. As a result, with some minor exceptions, the mechanism will choose the socially best project, the one that maximizes $V - C$. In addition, because the winning bid is the one that produces the largest amount of surplus for the existing token holders, the mechanism will tend to maximize the amount of surplus realized by token holders from future innovations, which in turn will tend to maximize the market value of the DAO both at start up and on an on-going basis.

The basic auction moves the DAO from a *default governance state* that typically is a voting regime into a *control period* in which the winning bidder controls the DAO independent of holding the majority or supermajority of tokens require to secure control under the voting regime. This feature allows the other token holders to enjoy a majority or even an overwhelming majority of the economic surplus generated by the winning bidder's project through their token ownership. Token ownership and control are separated during the control period.

The sequential aspect of the mechanism ensures that control arising from a basic auction is temporary. There are several terminating events. If the control party succeeds in reaching the token target price, control ends and the DAO reverts to its default governance state. The control period ends if

there is a supervening auction and the control party fails to win that auction. Control is contestable because the mechanism allows a supervening auction to take place at any time, triggered by any party willing to make an initial bid. Finally, the control period is limited in time and ends when the limit is reached even if the token target price was not realized and there was no supervening auction.

Section 4 details a set of features that create appropriate bidding and project execution incentives for control parties. Control parties that fail to achieve the token target price forfeit a portion or all of a substantial *value deposit* to the other token holders, guaranteeing that those token holders receive the full benefit of the winning bidder's claimed future performance whether or not execution is successful. *Value destruction* by control parties is deterred by potential loss of both the value deposit and an additional *surety deposit*. Value destruction is a serious concern because control may be separated from ownership to an extreme degree. A party with control but very few tokens can take a large financial short position and then tank the DAO. The threat of losing the value deposit also creates appropriate post-auction execution incentives.

The mechanism just described defeats potential entrenchment in the form of explicit or implicit control. Holding a majority or supermajority of tokens no longer secures control of the DAO. The majority holder may lose control to a party with little or no token stake by being outbid in a basic auction, and a basic auction may be initiated at any time by a party willing to submit an initial bid. Similarly, implicit control is insecure. A single challenging party can initiate an auction contest for control even in the presence of the massive indifference of the vast majority of token holders, the indifference that enabled a small group to control the DAO implicitly.

The social value properties of the mechanism emerge definitively only if the token value of the DAO represents the intrinsic value of the DAO itself. As a result, the proposed approach is limited to *economic DAOs*, defined as DAOs with publicly traded governance tokens for which the token value reflects the inherent value of the enterprise.

DAOs vary greatly in purpose and approach. Some DAOs are very similar to commercial businesses providing services such as a trading exchange. These *commercial DAOs* are the most obvious example of economic DAOs. They provide goods and services with the profits accruing to token holders. The market capitalization of a commercial DAO represents its value in terms of the risk-adjusted present value of future returns. But economic

DAOs are a much broader category. All that is necessary is that the market capitalization represents the value of the enterprise to the token holders. A charitable or investment DAO, for example, might gather funds to donate or invest. Such DAOs might have particular objectives, such as promoting environmental or climate change goals. Greater effectiveness at what they do in the view of all *potential* participants, including the specification of the objectives themselves, translates into a higher demand for the tokens along with a higher market capitalization.⁶

An important ideal for a DAO governance mechanism is for most, and ideally all, aspects to be *code feasible*. Code feasible means implementable using available blockchain technology without recourse to external institutions. Code feasibility is a key aspect of decentralization, close to a necessary condition. By decentralization we mean the ability for the token project to operate in the absence of trusted parties.

The desideratum of code feasibility distinguishes the case of DAOs from conventional corporate or public governance structures. Those structures depend primarily on human management rather than code implementations that are automatic and, at present, are also more constrained by various legal requirements and regulations. The mechanism developed here is potentially applicable to the governance of some conventional institutions, in particular, public corporations. We leave full consideration of such applications to future work because they involve their own considerable and distinct complexities as well as a different, more stringent set of legal constraints. On the other hand, theoretical work and experience with governance of conventional institutions is pertinent, and we draw on both in what follows.

The sequential auction mechanism proposed here eliminates the danger of entrenchment inherent in token-voting schemes. It also has some very positive social value aspects: It tends to promote choice and implementation of the best set of business plans while at the same time securing the high-

⁶Exit and entry through the token trading market is easy and nearly costless for publicly-traded DAOs. The associated community is open, not limited to current token holders. As a result, designing a governance system for a publicly traded DAO is very different from designing such a system for communities such as nation states or social clubs that are relatively closed because moving in and out of the community voluntarily is much more costly or even impossible. A range of non-commercial DAOs can be analogized to cities and towns offering different mixtures of local public goods in exchange for a different packages of taxes to residents and potential residents in a hypothetical world characterized by negligible moving costs.

est possible initial and on-going investment value for the DAO by allocating as much surplus as possible to existing token holders. Going further, it is important to consider how the mechanism relates to voting approaches, decentralization, and the associated web3 ideals that emphasize the role that DAOs can play in creating new kinds of democratic communities. Section 2 addresses the interaction of the mechanism with voting approaches, which is possible without first going through a more technical description of the mechanism. That section has an introductory aspect because the interaction with voting is the motivation for the sequential aspects of the mechanism. Section 3 provides a conceptual overview of the mechanism with reference to the pre-existing corporate governance literature. Section 4 together with two Appendices present the full, technical version of the mechanism, including some evaluative aspects that arise naturally as part of the presentation. Section 5 contains further evaluation, including a final subsection discussing decentralization and closely related regulatory considerations. Section 6 concludes with an assessment of the mechanism in light of web3 ideals.

2 Interaction of the Mechanism with Voting

The mechanism enables not only a sequence of auctions for control but also possible intervening periods in which governance reverts to a default governance state, typically a voting method of some kind. This approach allows the mechanism to achieve both operational goals and procedural goals in any combination or sequence. As discussed previously, at the operational level, the basic auctions comprising the sequence allow identification of the best business plans for the DAO combined with a tendency to implement them in a way that shifts as much surplus as possible to existing token holders from the control parties who undertake the implementation. When no party is willing to bid for control, intervening periods set in place a default governance state.

Aside from operational efficiency, DAO participants may value particular procedural approaches that embody *process values* in the form of certain community, “democratic,” or participatory norms. Potential control periods allow for a reset of the default governance state when it departs from the desired process values or, more ambitiously, revision of the default governance state itself. In terms of voting methods, the mechanism is available to preserve process values both by providing a guardrail that corrects vot-

ing method failures in an interim fashion before reinstating the method and by facilitating comprehensive reform of the voting method itself if desired by current and potential DAO participants.

Three subsections follow. The first two describe how the mechanism can correct possible voting method failures that may have negative operational or procedural consequences. The third addresses how the mechanism can promote process values.

2.1 Addressing Social Choice Problems

At present DAOs typically operate through a series of votes on proposals. If vote buying or other forms of bargaining with side payments are not possible, then each voting approach, whether directly or through electing representatives, can be conceptualized as a mechanism with nontransferable utility.⁷ As such, a large series of well-known potential “social choice” pathologies arise. A striking and relevant instance is the “McKelvey-Schofield Chaos Theorem” derived by McKelvey (1976) and Schofield (1978). This Theorem states that if the choice space is more than one-dimensional and preferences are Euclidean (decline with distance from an ideal point) or meet some more general conditions defined in Schofield (1978), then: (i) majority voting is unstable in the sense that every alternative is dominated by at least one other alternative; and, most strikingly, (ii) a series of majority votes can lead to *any* alternative in the choice space, even ones that are Pareto dominated. Most DAOs operate through a sequence of majority votes, and it is unlikely that the choice set of possible directions of change reduces to one dimension that fully captures preferences.

Most generally, there is the Gibbard-Satterthwaite Theorem derived by Gibbard (1973) and Satterthwaite (1975) which states that if individual preference orderings are complete and transitive but otherwise unrestricted and there are at least three alternatives, then a direct mechanism is dominant strategy incentive-compatible if and only if it is dictatorial.⁸ In a rough sense what the Theorem means is that with unrestricted preferences, a mechanism

⁷Nontransferable utility implies that players cannot bargain with each other using money or some similar indicator of value to reach a mutually agreeable result. Pareto improving moves, where for instance party A buys off party B to achieve a particular outcome that results in gains for A that outweigh the losses for B are not possible.

⁸Borgers (2015) provides a concise discussion and proof of this Theorem and its significance.

in which each individual votes sincerely, recording their actual preferences, will only work if there is a single individual who decides everything or if there are no more than two alternatives. Once strategic voting enters the picture, results can become unpredictable, difficult to estimate, and possibly very unrepresentative compared to voters' actual preferences.⁹

The mechanism allows a way around these social choice problems. The basic auction creates a determinate outcome, one that awards control to the party that claims it can perform in a way that has the most benefit for the other token holders, a claim that is backed up by a value deposit. Initiating an auction not only creates determinacy, but also is a way to address any inferior operational or procedural outcomes that emerge from the social choice process.

2.2 Addressing Empty Voting

In addition to the social choice difficulties with voting approaches, there is another entirely separate set of potential problems associated with what has been termed “empty voting.” Following the seminal work of Hu and Black (2006), we use the following terminology. *Empty voting* occurs when a party is able to exercise the voting rights of a token without holding the associated economic rights to token value appreciation and any distributions. *Hidden ownership* is the opposite: the party holds the economic rights without the right to vote the token, and, typically, without appearing to be an owner in any corporate or blockchain register.

Empty votes can easily be created at little or no cost by a variety of means. A party can borrow tokens and then vote them, leaving the economic ownership to the lender. A party can engage in an equity swap, offloading

⁹The discussion by Tabarrok and Spector (1999) about how strategic voting might have affected the U.S. Presidential election of 1860 under various voting regimes is a good example.

the economic rights and retaining the votes.¹⁰ There are many methods that employ derivatives.¹¹

Empty voting exists in conventional markets and has been documented by Hu and Black (2006) as well as in a substantial literature following them. There also are identifiable instances of empty voting in cryptocurrency markets along with an awareness of the possible use of empty voting among participants in those markets.¹² Commentators, including Hu and Black (2006), consistently point out that empty voting can have positive as well as negative effects. Brav and Mathews (2011), for instance, model whether empty voting is likely to have a net positive or negative effect on corporate governance.

Whatever the balance between the positive and negative effects, empty voting creates an element of arbitrariness because prevailing may be a matter of more effectively accumulating empty votes rather than the result of a being able to create more value or virtue.¹³

In the context of a battle for control, the mechanism developed here makes empty voting irrelevant, avoiding any possible accompanying arbitrariness. Any party can initiate an auction, and to win control, a party must submit the best bid, one that promises an outcome that delivers the largest possible surplus to the other token holders, with a guarantee in the form a value

¹⁰For example, the party starts with some tokens then swaps the economic return from the tokens for the economic returns of, say, a Treasury bond of equal value. The party still holds the tokens and can vote them, but the economic interest is in the hands of the swap counterparty.

¹¹For example, the party holding a token can write a call, buy a put, and borrow from a counterparty. The short call removes the token upside, the long put eliminates the downside, and the party can lend out the cash to pay the interest on the amount borrowed. The party is left with no economic position at all, but the party still formally owns the token and can vote it. The cost of entering this position will be nominal except possibly for some fees, which will be low if there are active markets or if potentially competing over-the-counter counterparties are readily available.

¹²Buterin (2021) discusses “vote buying” and presents a theoretical example of empty voting that consists of the equivalent of an equity swap. Copeland (2020) describes an actual example from the takeover of Steem in 2020 by Justin Sun.

¹³As Hu and Black (2006, p. 907) state in the corporate context, potential use of empty voting lead to a situation in which:

Voting outcomes might be decided by hidden warfare among company insiders and major investors, each employing financial technology to acquire votes. Adroitness in such financial technology may increasingly supplant the role of merit in determining the control of corporations.

deposit. It does not matter how many conventional token votes the party or its competitors have, empty or otherwise.

Empty voting can facilitate value destruction. A party can take a large empty voting position, combine that position with a net negative economic interest in the token such as a collection of put options, and then vote for proposals that reduce token value.¹⁴ In the most extreme case, the party could promote governance decisions that totally destroy the value of the token and the DAO project. The mechanism proposed here creates potential protection against such value destruction strategies since it offers a profitable auction route that renders empty voting ineffective.

The mechanism itself implicitly relies on empty voting because it permits a party winning control to prevail in all votes during the ensuing control period despite falling short of holding the required majority of tokens. As a consequence, potential value destruction by the control party is a concern. As discussed in the Introduction and described in detail in section 4, the mechanism contains measures to deter value destruction by a control party regardless of how it arises. Value destruction triggers a potential loss of deposits that outweighs any potential benefits and that compensates existing token holders for any resulting drop in token value.

Designing the mechanism involves considering possible deleterious use of hidden ownership as well as empty voting. In particular, section 4.1.4 describes the need for accurate toehold reporting accompanying auction bids. Hidden ownership is one way to conceal part or all of the bidder’s token position, and the mechanism must defeat use of such a device even if it is hard or impossible to detect as such.

It is important for any DAO governance approach or mechanism to be *EV-robust* in the sense of being effectively resistant both to deleterious uses of empty voting or hidden ownership and to any tendency for the decision mechanism to be compromised or blurred as a result of either manipulation.¹⁵

¹⁴There may be other motives to destroy the token such as being a marketplace competitor. Hu and Hamermesh (2023) discuss a general class of “related non-host assets” situations where an investor might use empty votes to damage the value of one entity in order to enhance the value of another entity in which the investor holds a substantial equity stake.

¹⁵The term “EV-robust” uses the initials “EV” to stand in for “empty voting.” Whenever hidden ownership is created, it is necessarily the case that there will be an offsetting empty voting position. Thus, “EV-robust” can refer to the entire set of strategies hidden ownership as well as empty voting itself.

This task is complicated by the fact that empty voting and hidden ownership are easy to conceal, particularly because the elements that result in the empty voting or hidden ownership positions may have a legitimate hedging or other purpose. The mechanism will not be EV-robust unless it is impervious to concealed empty voting or hidden ownership.

2.3 Promoting Process Values

Although voting approaches have serious potential flaws, voting mechanisms and other governance elements may have a *process value* to participants independent of operational efficiency. One would expect that process value would be captured in token value because token holders will be willing to pay more to participate in a DAO with governance features they value. Three implications follow with respect to the auction mechanism.

First there is *rescue*. If the indeterminacies and potential pathologies of voting threaten the coherence or direction of the DAO during an open period, causing the value of the DAO to drop, an auction that initiates a control period is a remedy. The control party can set the DAO back on course during the control period and then reinstate the voting mechanism after addressing the threats. This feature may create a safe zone of operation for voting mechanisms that serve important participation or other normative goals despite their potential flaws.¹⁶ The voting mechanism may not be viable otherwise as a long-term way to operate the DAO.

Second, the auction mechanism is a means to promote process values, including various desired voting approaches by facilitating innovations in the default governance state. If an increase in token value is attainable by shifting the governance mechanism in a way that increases its process value without a fully offsetting loss in operational efficiency, then there is the potential for an auction to create the shift. The sequential aspect of the auction

¹⁶Hall (2022) describes elegantly how the history of democracy can inform the design of DAOs. Among other elements, he considers the various forms that delegation can take, including delegates of the token holders appointing “managers ... who could take certain operational decisions more expertly than tokenholder voting could,” but who remain “accountable to tokenholders because they can be fired by the elected delegates at any time.” He notes that this approach bears “similarities to corporate governance.” The mechanism here can be seen as an extension that adds a way to right the ship through temporary, contestable delegation of control to a competent party if the usual voting and delegation mechanisms break down. It is analogous to external corporate governance through the market for corporate control.

mechanism is designed to achieve this result. Successful implementation of a shift in the default governance mechanism after winning an auction will raise token value, ending the control period with a reversion to the new superior default governance mechanism.¹⁷ It may be difficult or impossible to achieve a possibly complex innovation in the default governance state through voting or other procedures that comprise the current state.

Third, the fact that process value is reflected in token value means that a DAO that has sacrificed operational efficiency to add an even larger amount of process value will be immune from a takeover through the auction mechanism that eliminates the process value to increase operational efficiency. A party intending to implement this move through an auction would be unable to initiate the auction if the DAO is currently fully valued and would lose in the auction if the DAO is currently undervalued.¹⁸

3 Conceptual Overview

We assume the subject DAO is an economic DAO. We consider a setting similar to Burkart and Lee (2021) in which various parties can use costly effort to increase the value of the DAO. In particular, suppose each party can engage in various projects that consist of expending effort, labor and resources equivalent to C monetary units, in order to increase the value of the DAO by $N(C)$ monetary units. Suppose that the DAO has q tokens outstanding and that the current market price per token is P_0 . Define $V = V(C) = N(C)/q + P_0$ to be the token value emerging from a particular business plan. This business plan will create social surplus $\psi = (V - P_0)q - C$. Consider that expectations about the nature of future value-additive projects and about the distribution of surplus from those projects will affect the initial

¹⁷The ideal situation is one in which the winning bidder sets the token target price just high enough to fully reflect the increase in token value from the shift in default governance mechanism. Execution results in an rapid if not instantaneous increase in token value to the target level, which ends the control period. If the winning bidder set the token target price too low, then the same result occurs. If the winning bidder sets the token target price too high, then, as discussed in section 4, the existing token holders will enjoy any overage at the expense of the winning bidder.

¹⁸Initiating an auction requires a bid with a token target price in excess of the current token value. If the DAO is undervalued but the current operational efficiency plus governance mechanism maximize the total value of the DAO, then a bidder maintaining the status quo will win the auction. See section 4 for details.

funding value of the DAO, possibly being critical to having enough funding to start up at all. In other words, the expected later treatment and facilitation of value-added projects will have an *investment impact* on initial funding for DAOs, and also, in an obvious way, on the on-going investment value of the DAO, which continues to depend on possible future projects.

The target is the following first-best outcome:

- A) At any point after initiation of the DAO, the mechanism will facilitate implementation of the value-additive project that results in the highest social surplus ψ .
- B) When such project is created and implemented, the mechanism will allow the creating party to cover its cost but will allocate the social surplus entirely to the other token holders.

If both targets are met, the result will be the highest positive investment impact as initial and on-going investors will receive the maximum possible benefit from future innovations. In addition, at each point in time the DAO will implement the on-going business plan that adds the highest possible amount of social surplus.

To aim at the target, we create a sequential auction mechanism that produces periods of temporary contestable control interspersed with periods in which the DAO reverts back to a vote-driven default governance state. The mechanism has the property that the highest social surplus project is chosen subject to some constraints that guarantee the continuation of market trading. Some social surplus necessarily leaks to the project creators, resulting in an outcome that falls short of first best.

To describe the setting further, we use some terminology from Burkart and Lee (2021): *Jensen-Meckling free riders* and *Grossman-Hart free riders*.¹⁹ Jensen and Meckling (1976) point out that when the party who manages a corporation, expending all the effort, owns less than all of the common stock, the costly effort is matched with only part of the gains. The other shareholders are Jensen-Meckling free riders, reaping gains without bearing any of the costs. These free riders, however, are the successors of the original investors or of parties who contributed effort previously. A policy of rewarding them encourages initial or subsequent investments in the corporate project, having the investment impact described above.

¹⁹The names derive from phenomena described in Jensen and Meckling (1976) and Grossman and Hart (1980).

The conventional picture of Grossman-Hart free riders is a corporate enterprise for which the equity holders consist of a large group of parties all of whom own a very small stake. The chance that any one such party will be decisive in a vote is minuscule, which, combined with the large number of holders, creates a collective action problem. Consider a project creator who can profit by building up a share ownership position and then announcing or implementing a project that increases the value of the equity. If the equity holders get wind of the project, they will free ride by refusing to sell at less than the post-project target value of the equity. Open market purchases by the creator will push the price up, and in the U.S., the creator will have to reveal its holdings and intentions once the holdings exceed 5% of the total equity. The free-riding by the equity holders will limit the surplus that the project creator can extract, potentially killing the project if the extractable surplus is lower than the creator's costs. Alternatively, creators will pick projects that do not maximize social surplus but are viable based on the limited surplus available from a modest toehold.²⁰

Burkart and Lee (2021) create a model based on the value impact of effort that captures the current situation for project initiation through activism and tender offers in the United States. The tender offer route is restricted by Grossman-Hart free riding after an offer is made, limiting the offeror to surplus from a toehold. Activists proceed through a costly campaign aimed at managers and other shareholders to initiate a new project, avoiding Grossman-Hart free riding, but still being subject to Jensen-Meckling free riders. Revenues from activism are again limited to a toehold, but the other shareholders potentially benefit from the activism without bearing any costs. Burkart and Lee (2021) also analyze a third route: activism directed at initiating a merger, which they term "takeover activism." In a merger, the price that shareholders receive is set by the managers of the two firms, allowing surplus to be made available by forcing the dispersed shareholders to accept

²⁰Quadratic voting is one possibility for DAOs. As discussed in Lalley and Weyl (2018), when it operates well, quadratic voting aggregates preferences and information accurately with respect to decisions. In the face of the asymmetric information problem discussed here along with the possibility of free-riding, it is doubtful that quadratic voting could play a strong role. Parties without adequate information will not be able to represent their own interests well by voting, and revelation of information will trigger free-riding. If the project creator expends a large amount in the quadratic vote, the project creator will not be able to cover it from token value surplus due to that free-riding. If the DAO returns amounts the creator paid for the votes required to prevail to the creator, voting incentives are distorted.

a price below the target price.²¹ Burkart and Lee (2021) survey the empirical evidence and note that among activist projects, the high-return ones for shareholders are concentrated among instances of takeover activism.

The mechanism created here addresses the potential value-reducing free-riding of both types through two devices. First, by creating a *freeze-out* feature as part of an auction, the mechanism allows the project creator to buy a proportion of the other token holders' positions for no premium. Those token holders will earn the full amount of surplus on the retained proportion that is not purchased by the creator. This feature makes the auction equivalent to a merger in which token holders receive only a portion of the surplus on their token position shares because they are forced to sell part of it at less than the target price.²² The bidding mechanism creates an incentive for bidders to limit the amount of surplus they attempt to claim via the freeze-out feature to the lowest possible value, the amount required to cover their costs. There is some leakage because the winning bidder has some scope to go beyond that.

Second, there is the problem of post-auction incentives in the face of Jensen-Meckling free riding. At the end of auction, the winning bidder has control but owns less than all of the tokens. The auction mechanism is designed to allocate surplus to the other token holders by limiting the stake held by the winning bidder, and that stake may be much less than half of the outstanding tokens. The mechanism restores full incentives to execute through the value deposit described in the Introduction and discussed more fully below. To the extent that the control party falls short of the target price, the control party has to pay 100% of the shortfall for the entire DAO. Thus, the control party has an incentive to execute that is at least as large

²¹Most states require shareholders to approve a merger by a vote. It will be in the interest of shareholders to do so despite not receiving the target price if a lower price is necessary to make the merger work by providing enough surplus for the acquiring party, here the project creator. Grossman and Hart free riding otherwise creates a collective action problem that potentially precludes shareholder gains entirely.

²²Although the mechanism creates an outcome somewhat analogous to a merger, no actual merger is involved. Trading in the DAO remains continuous, and the life of the DAO goes forward. A merger in which the acquiring party buys all of the DAO shares would mean the end of the DAO in its current form. It might be that the acquiring party, which may be a shell, is itself set up to be a DAO, perhaps one with a new set of smart contracts meant to upgrade the acquired DAO. We leave exploration of this possibility to future work, including the case in which the selling token holders receive tokens in the new DAO instead of a cash-equivalent in exchange for the tokens in the old DAO.

as a party that has 100% ownership, eliminating any impact from Jensen-Meckling free riding on post-auction execution incentives.

As discussed in subsection 4.1.1, the value deposit and also the surety deposit employed by the mechanism are equivalent to forcing the control party to take on option positions. Other researchers, most prominently, Burkart and Lee (2015), have described the strong potential role of requiring such positions in implementing a cogent market for corporate control.²³ We use deposits rather than requiring option positions because deposits are code feasible, while derivatives require counterparties which raise issues of trust.

The goal throughout is to create an example of a mechanism that has some plausibility and likely effectiveness in order to introduce the idea of auction-based temporary contested control for governing DAOs. No claim is made that the mechanism is optimal among the set of all such mechanisms. We discuss possible alternative features at many points, not attempting to come to a conclusion concerning whether they are superior or inferior to the main variant that we describe.

With this overview in hand, we present the mechanism formally and evaluate it in the next two sections along with two appendices. Section 4 contains three subsections, describing respectively, a single auction, post-auction operation, and subsequent auctions, along with some evaluation of the mechanism. Section 5 completes the task of evaluation, organized topically in separate subsections. One appendix consists of proofs. The other appendix explores the consequences of adding certain stochastic elements to the model developed in the text.

4 A Sequential Auction Mechanism

We construct a *sequential auction* consisting of a series of *basic auctions*, implemented via one or more smart contracts, collectively “the DAO Code.” The DAO Code creates periodic basic auctions, with a fixed *control period* between auctions, subject to early termination under some circumstances. The DAO Code also permits a basic auction to be initiated by any party

²³Burkart and Lee (2015) show that a signaling equilibrium in a setting in which there are private benefits to control can attain the full information outcome by combining a cash offer with an offer to sell a call option with an exercise price equal to the bid price. Here the required option positions implicit in the deposits serve different roles.

at any time, independent of the periodic auctions. These features make the control created by the auction both *temporary* and *continuously contestable*.

We develop the sequential auction mechanism in a deterministic setting in which the token price moves only because of the adoption of new business plans through the auction mechanism. In Appendix A.2 we examine what might happen in a stochastic setting, in particular possible adjustments to the mechanism and possible hedging by winning auction bidders.

4.1 The Basic Auction

4.1.1 The Basic Auction Mechanism

A basic auction is initiated at a time T_0 by a first bidder making a bid. The basic auction is open for the competitive bidding process up until a winner is determined at some later time T_1 , with the fixed total time length $T_{\text{auction}} = T_1 - T_0$ of the bidding period specified in advance by the DAO Code. Suppose that at T_0 the price of the DAO governance token is P_0 and q tokens are outstanding. A bid, $\beta = (S, R, t_b)$, consists of three parameters: a *value claim*, $S \geq P_0$, per token; t_b , the proportion of the q tokens held by the bidder at T_0 , hereinafter termed the *bidder's toehold*; and a *surplus claim*, $R \leq (t_m - t_b)(S - P_0)$ where t_m is a parameter set by the DAO Code. The bidder's toehold, $t_b q$, is deposited into the applicable smart contract simultaneously with the bid, becoming part of the bidder's required *token deposit* under the mechanism. The basic auction is an English auction, ascending in the *auction parameter* $A = (1 - t_b)(S - P_0)q - R$. All prices and quantities such as S , P_0 , and R are denominated in the units of a particular *reference fiat currency* designated by the DAO Code.

From this point on, we assume for convenience that the total number of tokens remains at q . Then token *price* differences translate linearly into *total value* differences through the multiplicative factor q even if the prices are realized at different times. This assumption avoids having to continually correct for possible changes in the number of tokens outstanding, which is trivial but cumbersome.

The rough intuition for the auction parameters, which will emerge with a more rigorous meaning in the Propositions below, is the following. S represents a claim by the bidder that the project will reach value Sq after the bidder gains control. A central feature of the basic auction is a *freeze-out* element which allows the winning bidder to force the other holders as of time

T_1 to sell $t_f q$ of their tokens to the bidder at price P_0 . The main function of the surplus claim R is to determine t_f , in particular, $t_f q = \frac{R}{(S-P_0)}$. If the value claim S ends up being correct, then the forced sale results in a transfer of surplus equal to $R = t_f(S - P_0)$ from the other holders to the bidder, the basis for the terminology “surplus claim.” t_f is the *freeze-out proportion*. $R < 0$ is possible, in which case $t_f < 0$, and the bidder will offer $|t_f|q$ tokens at P_0 to the other holders subject to the total holdings of the bidder, i.e., $|t_f| \leq t_b$. At the end of the forced sale or purchase of tokens, the bidder holds the proportion $t_d = t_f + t_b$ of the total tokens, and all of these tokens must be deposited in the applicable smart contract, resulting in the token deposit at the end of the auction totaling $t_d q$.²⁴

The DAO Code imposes a *market size condition*, $t_d = t_f + t_b \leq t_m$. This condition guarantees that a minimum proportion $1 - t_m$ of the total tokens remain in the market during and at the end of the auction, which may be necessary to ensure a functioning market after the auction is over.²⁵ Choosing any $t_m < 1$ limits the maximum size of the surplus shift to the winning bidder to an amount less than the total surplus available. If the bidder has high enough costs, this limitation may cause a surplus-producing business plan not to be viable under the mechanism.

In addition to the *token deposit* of the $t_d q$ tokens, the bidder is required to make three additional deposits in the form of stablecoins of types permissible under the DAO Code representing units of the reference fiat currency:

- 1) A *value deposit*: $D_v = (S - P_0)q$.
- 2) A *purchase deposit*: $D_p = \max \left\{ \frac{R}{S-P_0} P_0, 0 \right\}$.
- 3) A *surety deposit*: $D_s = \max \{ [P_0(1 - \gamma) - (S - P_0)] q, 0 \}$, where γ is defined and discussed below.

²⁴The bidder is not barred from buying tokens during the auction, that is between time T_0 and time T_1 . Any such token purchases do not need to be reported or added to the token deposit. It is likely that the announcement of the bid will drive the token price considerably higher than P_0 as Grossman-Hart free riding emerges during the auction period. The toehold position is discussed further in subsections 4.1.4 and 4.1.5 infra.

²⁵The freeze-out step is proportional, leaving each holder immediately after the auction ends with the proportion $\frac{1-t_f-t_b}{1-t_b}$ of their time T_1 holdings. I.e., the same time T_1 market participants have holdings, albeit proportionately reduced. This feature should allow the market to continue to function smoothly across the transition point.

The bidder is making a value claim, S , that the bidder’s business plan for the DAO will suffice to increase its value to at least Sq . The value deposit transforms this value claim into a commitment. The fact that this deposit is held by the applicable smart contract makes this commitment credible and immediately enforceable in a code feasible manner. The DAO Code refunds part or all of the value claim when a *value deposit refund condition* is met: If the token price, at some time T reaches a sustained price $P_v(T)$, where $P_0 < P_v(T) \leq S$, then the DAO Code will refund $(P_v - P_0)q$ of the value deposit to the bidder. “Sustained price” must be defined in a manner that is code feasible. For example the criterion might require that the token price as determined by some group of price oracles maintained by the DAO averages at least P_v for 30 days and sustains a value at or above P_v consecutively for at least 10 of those days. After this partial refund, the base level for application of the value deposit refund condition moves up from P_0 to $P_v(T)$, the new *value deposit floor* at time T , and the condition is met again when a sustained price greater than $P_v(T)$ occurs. Applying the condition repeatedly results in a cumulative refund as of some time T_r of $\min\{P_v(T_r) - P_0, S - P_0\}$ where $P_v(T_r)$ is the largest value of the DAO token price that met the value claim refund condition up until that time.²⁶

The purchase deposit ensures performance when a bid with $R > 0$ commits the bidder to buy $t_f q$ tokens at price P_0 .

The surety deposit addresses the danger that the bidder will engage in value destruction after gaining control of the DAO. Note that the surety deposit is reduced to the extent of the value deposit. As will become apparent, these two deposits working in conjunction perform three functions: creating optimal bidding incentives, incentivizing performance of the business plan by the winning bidder after the auction ends, and deterring value destruction. The choice of the levels of the deposits and the applicable refund conditions for each deposit reflect the confluence of these three goals. We discuss the overall role of the surety deposit including the choice and significance of the parameter γ in subsection 5.2 after describing the auction mechanism further.

²⁶The value deposit and associated refund rules can be conceptualized as the bidder writing an in-the-money bear spread consisting of being long a put with strike price S and short a put at strike price $P_0 < S$ accompanied by a series of potential knock-in and knock-out put options triggered by the value deposit refund condition that causes the strike price of the short put to move up to the highest value that meets the condition.

Consistent with the lack of centralized management in a DAO, the auction is designed to be self-executing through the Auction Contracts. To reach that goal, the auction mechanism must be code feasible. All four deposits are useful in that respect. Because of the purchase deposit requirement, non-payment cannot derail the auction. There is no need to have recourse outside of the Code to legal process for purposes of collection. As noted in the margin,²⁷ the value deposit serves a function that also could be accomplished through derivatives. Use of a deposit eliminates the need for counterparties and the possible need to enforce counterparty compliance with the option contracts, elements that may not be code feasible without a great deal of added complexity or at all. Similarly, the token and surety deposits substitute for mechanisms that would rely on conventional derivative contracts and escrow arrangements enforced through the legal system.

All four deposits as well as a valid bid are required for the bidder to participate. If the bidder wins the auction, then the DAO Code uses the purchase deposit to purchase the freeze-out proportion of tokens for transfer to the winning bidder and retains the other three deposits, returning them if and only if certain conditions are met. If the bidder loses the auction, all four deposits are returned.

The auction is closed at time T_1 , a date which is analogous to a record date in corporate stock transactions, and the following *Auction Closing Steps* are implemented instantaneously:²⁸

- 1) The DAO Code identifies token holders of the $(1 - t_b)q$ total tokens other than the bidder's token deposit as of time T_1 , collectively, the T_1 *token holders* who hold the T_1 *token holdings*.
- 2) If $t_f \geq 0$, the DAO Code transfers a total of $t_f q$ tokens from the T_1 token holdings on a pro rata basis to escrow in the appropriate smart contract as part of the bidder's token deposit, using the purchase deposit to pay each T_1 token holder P_0 per token transferred.
- 3) If $t_f < 0$, the bidder has chosen to reduce its holdings from the baseline token deposit, $t_b q$, by selling $|t_f|q$ tokens at price P_0 , where $|t_f| \leq t_b$. The DAO Code initiates a sales process at T_1 when the auction ends,

²⁷See note 26 supra.

²⁸Blockchain technology allows for continuous identification of token holdings, and the steps outlined below can be implemented through smart contracts instantly with respect to the token holdings as of time T_1 when the auction closes.

making the offering at price P_0 first to the T_1 token holders and then to market maker external agents (human or automated smart contracts), if any, operating under the DAO protocol. Any proceeds are remitted to the bidder. If tokens remain unsold, they remain under the bidder's ownership as part of the token deposit. At the end of this process, the total token deposit is t_dq where $t_d = t_b + t_f \geq 0$, assuming all the tokens are sold.

- 4) The DAO Code creates a *dynamic vote pool* consisting of $v_T(q_T, t_dq)$ additional voting rights assigned to the bidder, an amount that is adjusted continuously based on q_T , the number of tokens outstanding and eligible to vote at each future time T , to ensure that the bidder retains majority control of the DAO. $v_T = (0.5q_T + 1) - t_dq$ where q is the number of tokens outstanding and eligible to vote as of time T_1 when the auction ends. The votes in the pool are empty votes since they are not matched with the corresponding economic interest inherent in the tokens.²⁹

4.1.2 The Optimal Business Plan and Bidding Strategy

Suppose a potential bidder can implement a business plan (V, C) that involves expending effort, consisting of labor and resources equivalent to C monetary units, that will result in a token value $V > P_0$. This business plan creates social surplus $\psi(V, C) = (V - P_0)q - C$. Suppose that among all the potential

²⁹The choice of giving the winning bidder majority control ($> .5$ of the votes) implicit in this arrangement leaves open the possibility that the winning bidder will not be able to prevail on DAO issues that require a threshold greater than 50% to pass the applicable proposal. The exact percentage established by the DAO Code for the vote pool needs to be sensitive to the hierarchy of voting thresholds and the associated issues set for the DAO more generally. If a less conventional choice method such as quadratic voting is employed by the DAO, the dynamic voting pool must grant whatever number of additional voting rights is required to establish control.

bidder's possible business plans, the business plan (V^*, C^*) creates the largest amount of social surplus, $\psi^* = (V^* - P_0)q - C^*$.³⁰

The potential bidder must choose both a business plan (V, C) and a bid $\beta(S, R, t_b)$. It will turn out that the parameter t_b is redundant with respect to winning the auction. Only S and R matter. The following Proposition characterizes the optimal business plan and bidding strategy:

Proposition 1. *The following is the optimal project choice and bidding strategy for a potential bidder:*

(i) *Regardless of the bidding strategy chosen, the potential bidder chooses the business plan (V^*, C^*) that results in $\psi = \psi^*$, the largest possible social surplus that the potential bidder can generate subject to the market liquidity constraint, $t_d = t_f + t_b \leq t_m$. If $\psi^* \leq 0$, the potential bidder does not make a bid.*

(ii) *The bid parameters that result in the strongest possible bid are:*

$$S = V^* ; \text{ and}$$

$$R = C^* - (V^* - P_0)t_b q$$

which result in an auction parameter equal to A^ , the largest possible surplus that the potential bidder can generate subject to the market liquidity constraint:*

$$A^* = (V^* - P_0) - C^* = \psi^*.$$

This bid results in zero profit for the potential bidder, with all the surplus shifted to the other token holders.

(iii) *If a profit level Π_b is feasible given the market liquidity constraint, then the strongest possible bid parameters are:*

$$S = V^* ; \text{ and}$$

$$R = \Pi_b + C^* - (V^* - P_0)t_b q$$

which result in the following auction parameter:

³⁰ We assume that the auction takes place in a "private values" setting with asymmetric information. Each bidder's potential set of business plans and their value-enhancing potential are known only to the bidder. All bidders agree on the value of the current operation. If there is a common values element in which bidders have different signals concerning the value of the current operation and bid based on perceived undervaluation at price P_0 , then the efficiency and surplus-distribution characteristics of the auction mechanism may be affected. However, choosing the English auction as a mechanism tends to make any such impacts benign or even beneficial. See note 51 infra.

$$A(\Pi_b) = (V^* - P_0) - C^* - \Pi_b = \psi^* - \Pi_b$$

This bid results in profit equal to Π_b for the potential bidder, with the remaining surplus, $\psi^* - \Pi_b$, shifted to the other token holders.

(iv) The largest obtainable profit level is $\Pi_b = t_m(V^* - P_0)q - C^* \leq \psi^*$ given $0 < t_m < 1$. The minimum surplus that must be transferred to the other token holders is $F = (1 - t_m)(V^* - P_0)q$.

Leaving a formal proof to an Appendix, we outline the proof here with an emphasis on intuition and then discuss the significance of the results.

The potential bidder's highest surplus business plan produces added value of $N^* = (V^* - P_0)q$ at cost C^* . The potential bidder will realize the proportion $t_d = t_f + t_b \leq t_m$ of the added value through a toehold of $t_b q$ tokens acquired before the auction plus $t_f q$ tokens acquired at P_0 from the T_1 token holders using the freeze-out feature of the auction mechanism. The parameter $0 < t_m < 1$ guarantees that the T_1 token holders will gain at least the proportion $1 - t_m$ of the added value as free riders. Under the auction mechanism, $t_f = \frac{R}{(S - P_0)q}$. For any fixed level of S , choosing R is equivalent to choosing t_f , a residual that completely determines the division of added value between the control party and the free riders. For this reason, the fixed toehold proportion t_b is irrelevant to division of the added value, which depends on $t_d = t_b + t_f$, where t_f is freely chosen subject only to $-t_b \leq t_f \leq t_m - t_b$.

Consider the auction parameter:

$$A = (1 - t_b)(S - P_0)q - R = (1 - t_f - t_b)(S - P_0)q.$$

It is clear that A is increasing in S holding t_f , and thus the potential bidder's share of the added value, fixed. Now consider the potential bidder's profit function expressed in terms of t_f when the potential bidder implements a business plan (V, C) :

$$\Pi_b = (V - P_0)(t_f + t_b)q - C - \max\{S - V, 0\}q.$$

The first term is the added value realized by the potential bidder, the second term is the potential bidder's project cost, and the third term is the expected loss from the value deposit given that the potential bidder expects the busi-

ness plan will result in a token value V . Overbidding with $S > V$ results in a loss $(S - V)q$. As result, the optimal value claim is $S = V$.³¹

The strongest possible bid will minimize R in addition to setting $S = V$. R must be large enough to cover the cost C less the gains on the toehold $(V - P_0)t_bq$, i.e., $R = C - (V - P_0)t_bq$. Then $A = (V - P_0)q - C$, which is equal to the total social surplus. Clearly the best possible bid will require choosing (V^*, C^*) , the business plan that maximizes total social surplus subject to being feasible in the face of the market liquidity constraint. That constraint allocates at least the proportion $1 - t_m$ of total added value to the T_1 token holders, who are free riders since they bear none of the cost of adding value. The constraint may bind in the optimization that determines (V^*, C^*) . Choice of $t_m < 1$ therefore may preclude execution of the optimal business plan from a social perspective.

Corollary 1. *If the market liquidity constraint, $t_f + t_b \leq t_m$, is binding with $t_m < 1$, then the bidder will choose a business plan that falls short of creating the greatest possible social surplus.*

Suppose there are n bidders and that bidder i 's best bid is A_i^* . In an English auction, the highest bidder will prevail at the second highest bidder's submitted auction parameter. The highest bidder can prevail with a bid of at most $A_1 = A_2^*$, and typically, $A_1 < A_1^*$, the highest bidder's highest possible bid. Then, subject to the market liquidity constraint, the highest bidder can increase R from its level $R^* = C^* - \Pi_{t_b}$, where $\Pi_{t_b} = (V^* - P_0)t_bq$ is the bidder's toehold profit, to $R^* + \min\{A_1^* - A_2^*, N^* - \Pi_{t_b} - C^* - F\}$. The term $N^* - \Pi_{t_b} - C^* - F$ is the maximum possible value of R that is feasible under the market constraint, given F , the minimum surplus that must be delivered to the free riders.

³¹The result does not follow simply from the loss. Choosing $S > V$ also affects the bid. In the formal proof set forth in Appendix A.1, we show that with $S > V$, earning the same amount of surplus requires a weaker overall bid versus choosing $S = V$.

This algebraic exposition can be visualized through a series of figures.

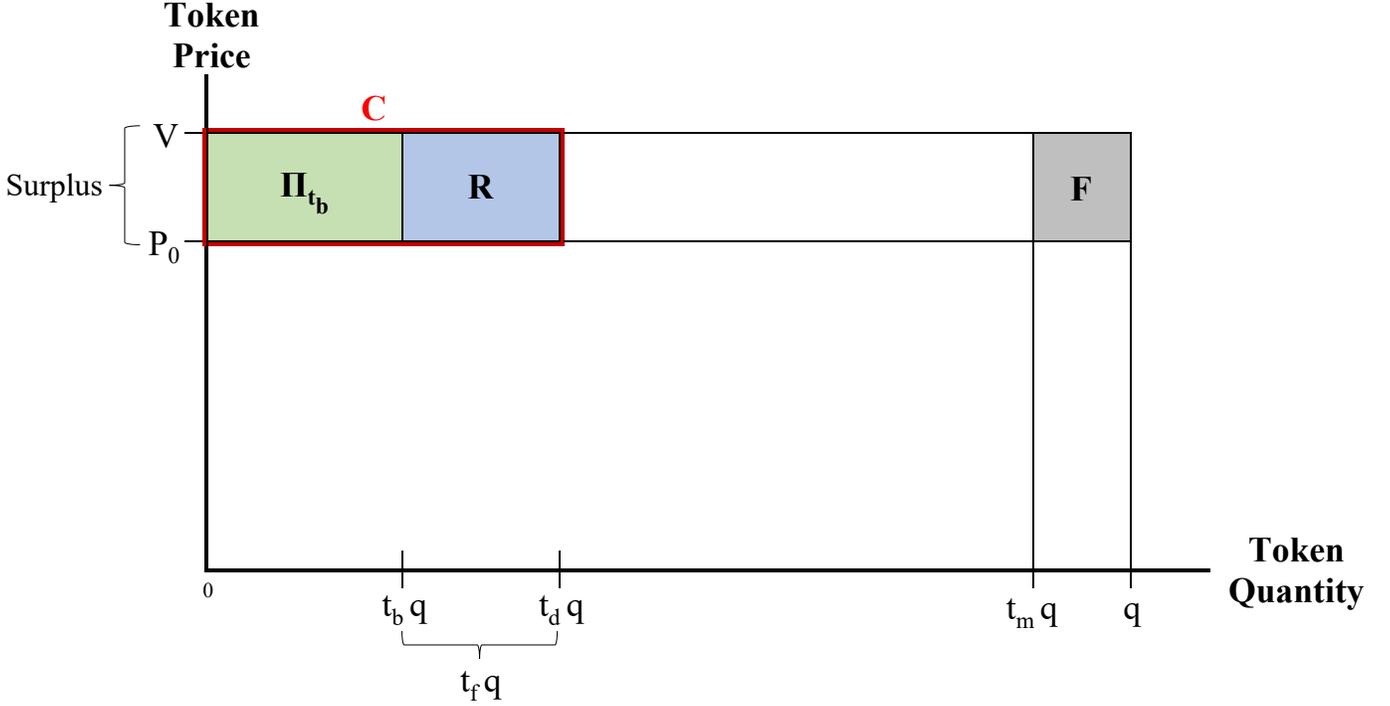


Figure 1

In Figure 1, the business plan (V, C) induces a value claim $S = V$ and a surplus claim value of R just big enough to cover the cost C , which results in the winning bidder purchasing $t_f q$ tokens at P_0 from the T_1 token holders through the freeze-out mechanism. This purchase results in the bidder realizing surplus equal to the blue R rectangle in the figure. The green rectangle Π_{t_b} is the surplus that the bidder realizes from the toehold position $t_b q$. The bidder's total surplus is the sum of the green and blue rectangles, which is equal in this instance to the red rectangle representing the cost C . The area F in the figure represents the minimum surplus that must be granted to the other post- T_1 token holders, the proportion $1 - t_m$ of the total, and these free-riding shareholders also gain surplus equal to the unlabeled white rectangle between the R rectangle and the F rectangle.

If $A_1^* > A_2^*$, the winning bidder will be able to appropriate part or all of the surplus represented by the white rectangle. Figure 2 illustrates the case where the winning bidder is able to appropriate part but not all of it.

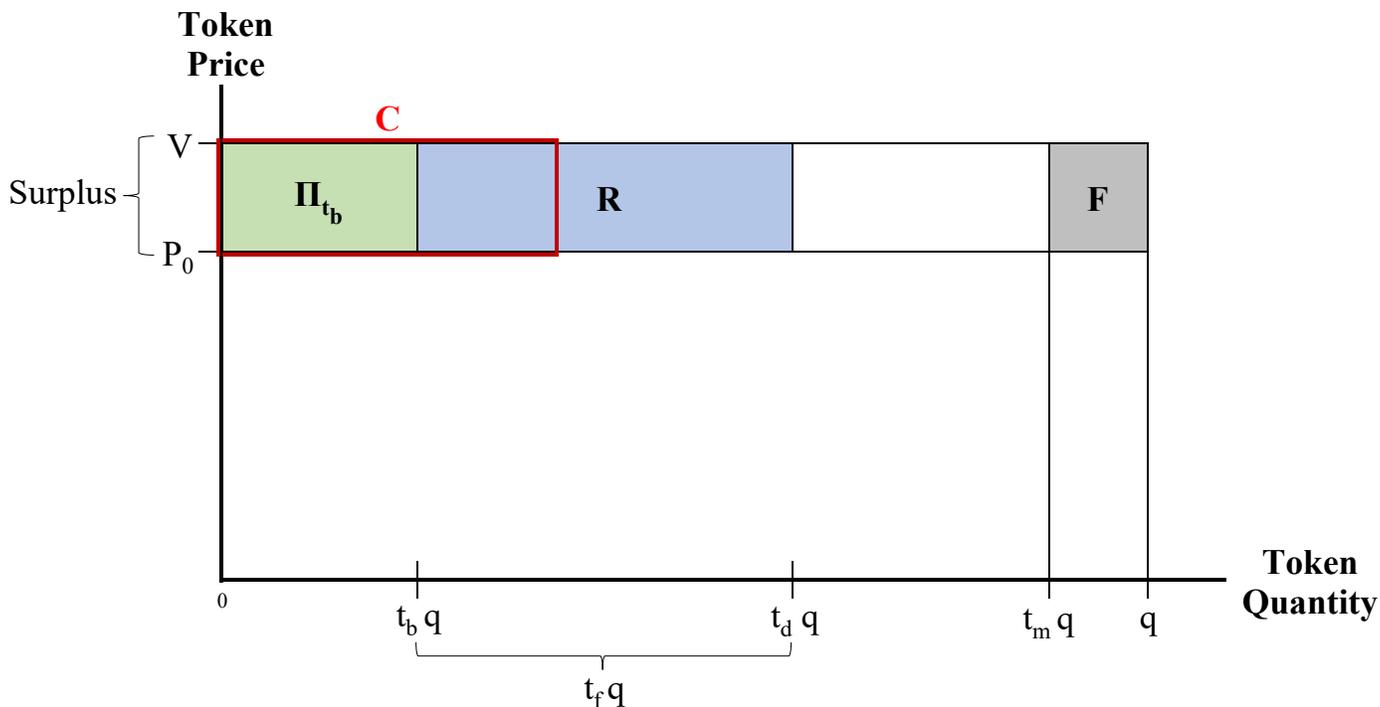


Figure 2

These figures illustrate a key feature that enables the mechanism to work. Burkart and Lee (2015) show that in deterministic tender offer games the ability to relinquish private benefits may be necessary for the existence of a separating equilibrium. The auction mechanism here allows bidders to relinquish benefits by choosing R , the surplus claim. A lower value of R results in a stronger bid but lower surplus. Because of the freeze-out feature of the mechanism, the possibility that free-riding will undermine signaling is eliminated. The bidder can specify an exact claim to surplus, R , that otherwise might be inaccessible due to free riding. Combined with the basic auction features that make revealing V^* truthfully a dominant strategy, the flexibility with respect to R sets up an effective signaling environment that leads to a separating equilibrium.

A^* proxies for bidder types, and a bidder with a lower A^* cannot profitably mimic one with a higher A^* . For bidder i , the strongest possible bid, A_i^* , is associated with zero profits. A higher bid results in net losses. As the English auction unfolds, if each bidder i moves up until the level A_i^* and then drops

out, V_i^* and C_i^* will be evident since the bid also reveals t_b . For the winning bidder, only V_1^* and an upper bound on C_1^* will be evident since it is possible that the winning bid, $A_1 < A_1^*$ so that $\Pi_{t_b} + R_1 > C_1^*$. In that case, the winning bidder is receiving more surplus than is necessary to induce that bidder to implement the best possible business plan. This situation appears to fall short of the first best which requires that all excess surplus remains with the free riding token holders in order to optimize initial and on-going investment in the DAO. But, as discussed in subsection 5.1, the full picture is more complex.

4.1.3 Bidding Intensity, Group Bidding, and Collusion

Two elements that are relevant to the investment impact of the mechanism are bidding intensity and the possibility of collusion among bidders. Krishna (2010, Chapter 11) lays out basic points about collusion in second price auctions. If there are n bidders, then conditional on winning the auction, bidder 1 expects to capture surplus in the amount $A_1^* - E(A_2^* | n - 1 \text{ and } A_2^* \leq A_1^*)$. The expectation in this expression is the expected value of the highest order statistic of the other $n - 1$ values of $A_i^* \leq A_1^*$. If a group of bidders collude, only the bidder with the highest value among them will bid. That strategy eliminates all the other bidders in the group from potentially lowering the highest bidder's surplus from winning by submitting the second highest bid. If the collusion group is a subset of size $n_c \leq n - 1$, then the expected surplus capture is with respect to a highest order statistic of a smaller number of other bidders, $n - n_c - 1$ instead of $n - 1$, and therefore is higher. In the extreme situation in which all bidders collude effectively, the highest bidder can prevail with a bid just above P_0 , thereby extracting the proportion t_m of the added value, the maximum possible subject to the market liquidity constraint. The winning bidder then splits the added surplus from collusion with the other colluding bidders, a division that motivates them to be part of the collusion group.

Collusion, especially involving more than a few potential bidders, requires costly coordination, but if it occurs, it will impact investment negatively. Collusion results in winning bidders extracting more surplus, reducing the attractiveness ex ante for initial and on-going investment. There are some situations in which collusion is a very plausible threat. For example, if there is a strong outside candidate to add value through an innovative business plan, the most likely competing bidders may be a handful of identifiable “in-

siders” who previously had been the most active in directing the DAO. Small numbers make collusion easier to coordinate, and if the small group includes the likely highest set of bidders, collusion is likely to be very effective. The fact that DAOs have been characterized by low participation rates and a few key players running the show suggests that this situation may be common. Outside candidate collusion with the insiders creates a substantial opportunity for reducing the surplus that otherwise would accrue to the other token holders.

A key parameter is the expected bidding intensity. If there is a continuum of potential bidders who have values of A^* that are dense in the interval $[0, A_1^*]$, then it will be impossible to collude and the winning bidder will only be able to cover cost. Investment incentives will be maximized. If there are only a handful of potential bidders, then collusion will be a bigger danger, and, even in the absence of collusion, the winning bidder will be likely to walk away with considerable extra surplus to the detriment of investment.

Bidding intensity and the viability of the mechanism itself depends on *capital market adequacy*, the depth and development of capital markets. Making a bid through the mechanism requires deposits of the same order of magnitude as the total pre-bid value of the DAO. For established DAOs such as Uniswap, Maker, or Compound, deposit amounts of a billion dollars or more may be required.³² A deep bench of institutional investors such as venture capital firms, private equity firms, and hedge funds is required to make the auction mechanism robust and create bidding intensity. At least on the venture capital front, a large number of such firms already exist and are very active with respect to cryptocurrency projects including many DAOs.³³ These firms would be a ready source of funding for auction bidders. The temporary contestable control created by the auction mechanism, if implemented, might itself spawn specialist institutions similar to hedge funds in the current corporate landscape that combine portfolio investment with selective activism in governance.³⁴

³²As of January 18, 2024, these three DAO governance tokens had market capitalizations of approximately \$3.8 billion, \$1.8 billion, and \$440 million respectively. Coinmarketcap (2024).

³³Crowdcreate (2021).

³⁴Yin and Zhu (2023) provide an empirical analysis. Such hedge funds typically engage in activism with respect to only a small portion of their portfolios. Burkart and Lee (2021) summarize the evidence that takeover activism aimed at or resulting in changes in corporate control generate higher target and activist returns.

One aspect of the auction mechanism is highly relevant to the possibility of collusion. There is nothing that prevents group bidding. A pool of outsiders, of insiders, or a mixture of both might combine into a bidding entity. It is possible to implement this combination via a smart contract, with the parties contributing the required stablecoins to fund bidding and then jointly holding the control position if their bid prevails. Group bidding may facilitate collusion, but it also may add valuable bidders who otherwise would not participate. For example, an entrepreneur with promising innovative ideas for running the DAO but with limited resources could form a bidding entity with private equity or venture investors who could fund the project.

As described in Krishna (2010), collusion in English auctions typically is illegal or subject to civil penalties in the non-digital world, but is it hard to see how collusion might be detected and policed in a code feasible manner. Group bidding via smart contracts may be detectible but whether it is merely collusive or has bid-formation advantages or is a mixture of the two would be a complex inquiry, requiring something akin to legal processes. Although there are mediation and adjudication tools available apart from the legal system, using these tools adds an additional element of complexity and requires trust in the tools.³⁵

4.1.4 Toehold Reporting and Post-auction Market Dangers

The basic auction mechanism requires that the bidder report any toehold position as part of the bid. As discussed above, the toehold proportion t_b has no effect on the bid level. The bidder takes the toehold position into account when choosing a post-auction ownership position $t_d = t_b + t_f$ that dictates the proportion of added value captured by the bidder. That proportion, t_d is the key choice that the bidder makes. Given the optimal value claim $S = V^*$, choosing R in light of t_b determines t_f and thus t_d . t_f is a residual that adjusts to whatever t_b is to yield the desired value of t_d .

³⁵ A prominent example of a mediation and adjudication tool is Kleros. Kleros (2023a). Greig (2022) describes how Kleros operates by rewarding jurors for their performance based on a Schelling point criterion. Kleros is active, with multiple open cases. Kleros (2023b). Guillaume and Riva (2022a) discuss use of dispute resolution vehicles, including Kleros, for DAOs generally, noting that they are most effective when remedies can be executed on-chain because the parties have assets at risk there. In the case of collusion, some relevant parties may not.

What then is the purpose of having the bidder report t_b and deposit $t_b q$ tokens as part of the bid? There are two purposes. First, although the *size* of the bid, A , is not affected by the toehold, an accurate report of the toehold is necessary for the bidding system to work. Recall that $A = (1-t_b)(S-P_0) - R$. We have seen that the $-t_b(S - P_0)$ portion of the first term is canceled out because $t_b(S - P_0)$ is a component of R in the optimal bid. Nonetheless, the first term depends on t_b and must be reported accurately for the cancellation to work. Second, the true value of t_b is necessary to enforce the market liquidity condition $t_b + t_f \leq t_m$, which guarantees that at least $t_m q$ tokens are held by others, creating a pool of market liquidity. Relevant to both purposes, nothing in the bidding mechanism itself creates an incentive for a true report, and, in fact, the incentive is to cheat by hiding some of the toehold to artificially inflate the bid, A .

Effectively addressing potential toehold concealment depends both on the *identifiability* of the control party's token holdings, defined as the ability to associate positions to the control party, and on the costs of doing so. Complicating matters, any identification method must be EV-robust. The potential threat is from hidden ownership, which is, as discussed in the introduction, the obverse of empty voting. Instead of voting with no economic ownership, hidden ownership involves economic ownership without voting. It can easily be implemented via an equity swap between the control party and a token holder. In exchange for the economic interest in the DAO, including token appreciation, the control party offers another economic position such as treasury bond returns to the token holder. The token holder continues to own the token and will be identified as the owner on chain, but, secretly, the control party is able to capture surplus without reporting the economic position as part of the control party's toehold. This maneuver may be very hard to detect. In effect, a much deeper level of identification is required, one that reaches beneath formal ownership.

Potential concealment of part or all of a toehold position is not the only threat that creates a need for identification. There are possible dangers arising from post-auction market manipulation by control parties. If the market is thin enough, the control party can engage in focused buying to drive the market up to sustained levels that substantially reduce the value deposit obligation, and then engage in selling to reverse the temporary position, similar to a pump and dump. Whether the market is robust or not depends both on the market capitalization of the DAO token and on the proportion

of tokens not held by the control party.³⁶ If the market liquidity constraint is binding, the control party will exit the auction with the maximum proportion of $1 - t_m$ of the total tokens outstanding, a situation that increases the danger of manipulation because of reduced market liquidity stemming from a lower traded-token supply. If the manipulation danger is salient enough, then for the auction mechanism to work it may be necessary to bar the control party from the post-auction market. Enforcing this bar would rely on an identification procedure that could operate effectively during the control period in the face of control by the control party.

For an identification method to work in a decentralized framework it must be code feasible as well as effective. We consider some possible methods in what follows, concluding with what appears to be the most promising one. We focus on the problem of concealment of a toehold position. The discussion applies in an obvious way to attempting to enforce a bar on market participation.

One method of identification is a *bounty system*. Any party that discovers and proves that the winning bidder concealed part of the toehold rather than reporting it would be awarded a number of tokens with current value equal to the value of the concealed part of the toehold at T_0 , the time of concealment, while simultaneously burning the corresponding quantity of concealed tokens held by the control party. If the value of the concealed tokens at the time the bounty is granted is less than their T_0 value, the shortfall can be made up by burning part of the control party's token deposit or by creating debits against the control party's stablecoin deposits.

Could a bounty system be effective and code feasible? DAO positions appear as a set of public addresses and token quantities. Commercially available technologies to trace and attribute token ownership exist and have a significant degree of effectiveness at what may be feasible cost.³⁷ But reliance on outside commercial parties inhibits code feasibility. The DAO may have to implement the bounty system via contracts with outside teams. Doing so effectively while the control party has control of the DAO may not be possible. The task is complicated by the possible need to resolve disputes about

³⁶Hamrick et al. (2018) provide substantial evidence that pump and dump manipulations are much harder, as measured by the induced percentage price increase, for heavily traded, high market capitalization cryptocurrencies.

³⁷See Yaffe-Bellany (2023) (discussing Chainalysis).

the veracity of identifications claimed by the bounty hunters.³⁸ And possible hidden ownership presents a major challenge to the effectiveness of a bounty systems.³⁹ Although a bounty system may be too difficult to implement, it is potentially a very powerful deterrent. Successful bounty recovery is a disaster for the winning bidder, involving loss not only of potential surplus, the motivation for concealment, but also of the base value, P_0 .

One set of approaches to address control party position reporting issues centers around using know your customer *registration systems* that make token holders identifiable. Requiring registration of all token positions at all times would be very costly both initially and the face of continual revisions as tokens are traded between parties. Registration might also raise privacy considerations requiring costly zero-knowledge proof or other technologies to make identities private yet verifiable. Nonetheless, use of registration limited to subsets of token holders and to particular points in time might be useful and cost-effective as we describe in what follows.

One particularly promising way to address the toehold reporting problem is to use a *flush sale* variant of the mechanism. This variant is characterized by the following differences from the mechanism described so far:

- 1) *Revised purchase deposit.* The purchase deposit is $D_p^f = (1 - t_b)P_0$, covering all the tokens other than the toehold rather than the smaller proportion $\max(t_f, 0)$.
- 2) *Flush sale.* The DAO Code uses this deposit to purchase all of the tokens other than the toehold at price P_0 . This purchase implements the flush sale.
- 3) *Adjust the token deposit.* The DAO Code adds or subtracts tokens from the token deposit to adjust that deposit by the quantity $t_f q$.
- 4) *Token auction.* At the end of the basic auction, the DAO Code initiates a token auction, selling $(1 - t_a)q$ tokens using a hard-coded auction

³⁸Dispute resolution is more difficult when the parties do not have accessible on-chain assets at risk. See note 35 supra. An approach such as requiring good faith deposits from bounty hunters might be required to implement a dispute resolution mechanism that is code feasible.

³⁹Bounty hunters do have some possible strategies in the face of hidden ownership. Counterparties to the hidden ownership position used for concealment have a big incentive to collect the bounty by disclosing the failure to report, presumably earning an additional token at the expense of the control party without violating the underlying contract. Bounty hunters may angle for a cut by advertising this opportunity broadly and offering assistance.

technology that aims at revenue maximization. Purchases by the control party are barred, enforced to the extent feasible by a registration system.

- 5) *Registration.* Parties can register through a know your customer process to demonstrate that they are not the control party or related to the control party.⁴⁰ All registered parties are eligible to participate in the token auction. The set of T_1 token holders who register will be eligible to receive surplus from the auction.
- 6) *Treatment of token auction surplus or deficit.* A token auction deficit caused by an average token auction price below P_0 remains a liability of the DAO. Any token auction surplus is distributed pro rata at a specified *flush sale surplus distribution date* to the set of registered T_1 token holders based on their relative T_1 holdings. This date is set by the DAO Code to give sufficient time for T_1 token holders to register before the flush sale surplus distribution date if they did not do so prior to the token auction.

The flush sale variant attempts to address the problem of non-reporting of the full extent of the winning bidder’s token position. Some or all of it is hidden among the $1 - t_b$ proportion remaining after the proportion t_b is declared and deposited. The flush sale is just that: It flushes out any hidden control party positions among that remaining proportion by forcing sale of the entire remaining proportion at P_0 .

It is likely that the auction purchases will be at prices significantly higher than P_0 . For that reason, even without the success of a bounty system, registration, or similar measures, the winning bidder is faced with a potential reduction in surplus on any positions that were concealed even if accompanied by corresponding repurchases after completion of the token auction. In contrast, declaring and depositing the pre-auction positions puts them in a safe harbor that allows the winning bidder to collect 100% of any surplus that arises. The registration system is crucial for establishing these incentives because the system ensures that any surplus from the auction flows to

⁴⁰Registration can be made consistent with privacy through approaches such as requiring a zero-knowledge proof confirmation that they are not a restricted party linked to the winning bidder. For example, Rosenberg et al. (2022) describe a zero-knowledge proof credentialing system that they call “zk-creds.” In one instantiation, parties embed their passport in a zero-knowledge privacy layer that allows proof of identity.

T_1 token holders other than the control party. Registration for participation in the token auction also plays a role because market trading after the auction is likely to be accompanied by substantial additional demand for tokens and a corresponding sharp price increase similar to what happens in a successful initial public offering in equity markets. Registration requirements block control parties from enjoying these gains. Use of a registration system aimed at blocking control parties from making auction purchases is likely to be particularly effective compared to alternatives such as relying on bounty hunters, and, because it can be limited, relatively low cost.

The flush sale combined with registration can be combined with bounty hunting or other measures aimed both at the pre-sale concealed positions and at any purchases during the token auction. More than one such measure may be employed simultaneously. For the flush sale variant to be successful, registration and any other accompanying measures combined with the safe harbor aspect of reporting must make concealment in order to improve the bid, A , unprofitable, unattractive, or infeasible.

The stakes are significant. To the extent that the winning bidder can evade reporting the toehold position, it will gain an artificial bidding advantage equal to the amount of surplus associated with the concealed position. Auction efficiency is imperiled because a bidder with a larger toehold may prevail over another bidder who has a superior business plan.

4.1.5 The Role of the Toehold and Activism Strategies

Toeholds play a crucial role in the current market for corporate control. Burkart and Lee (2021) show that under current law both activists and tender offerors profit primarily from toeholds in the face of Jensen-Meckling and Grossman-Hart free riders respectively. Furthermore, Burkart and Lee (2015) prove that the toehold can play a signaling role because choosing the level of the toehold is a way to claim or relinquish control benefits.

Under the basic auction mechanism, there is no reason for a potential bidder to accumulate or add to a toehold if the potential bidder is confident of winning the auction and toehold reporting is enforceable. The size of the toehold does not affect bidding strength or potential profits. When a potential bidder is contemplating initiating an auction, buying more tokens to accumulate a bigger pre-auction toehold is a dominated strategy. Doing so will only drive up the price during accumulation when the potential bidder can use the freeze-out feature of the basic auction to force sale of the tokens

at the lower pre-accumulation price. Furthermore, any potential signaling role of the toehold is extraneous because the basic auction allows the bidder to claim or relinquish control benefits directly.

One remaining question revolves around the role of traditional activism in which the activist buys a toehold and then engages in a costly campaign to influence management. In the case of a DAO, the targets of influence would be the control party during a control period and the most active governance parties otherwise. If the activist has a concrete value-increasing plan that the activist could implement alone or after assembling a bidding group, the activist is better off initiating an auction if the activist is confident of winning. The activist could acquire shares more cheaply through the auction freeze-out feature than by buying a toehold and would not have to incur campaign costs to convince the control party or the active governance parties to adopt the activist's business plan.

Any potential bidder, activist or not, has to consider the possibility of losing the auction that they initiate. Losing the auction means there was a higher bid, and if the winning bidder's business plan is credible, then a losing bidder can profit from a toehold position. However, there are better ways than a toehold position to insure against losing the auction. Suppose that the potential bidder contemplates a bid that includes a value claim V_b^* when the token price is P_0 . Simultaneously with making a bid, the potential bidder can purchase a suitable quantity of out-of-the-money call options with a strike price of V_b^* . If the bidder loses and the winning bid includes a value claim $V^* > V_b^*$, then the call option will yield what would have been the toehold profit. If the bidder wins, the bidder can liquidate the call option position, most likely at a profit because it is plausible that the token price will be greater than P_0 when the auction closes at T_1 and possibly substantially greater.

4.1.6 Auction Efficiency and Market Liquidity

Like second price auction frameworks in other contexts, the English auction that embodies the basic mechanism here has strong efficiency properties. The bidder who can produce the most social surplus wins, with appropriation of that surplus limited by the level of the second highest bid. As discussed, there is another limitation: The mechanism is subject to the market liquidity constraint. This constraint limits the surplus available to the winning bidder, reducing it by the minimum amount $F = (1 - t_m)(V^* - P_0)$ that must accrue

to free riders. Consider the project (V^*, C^*) that creates the highest possible social surplus $\psi^* = N^* - C^*$ and produces total surplus $N^* = (V^* - P_0)q$. If $\psi^* = N^* - C^* > 0 > N^* - C^* - F$, then this best possible project will not be implemented because it cannot cover its cost and also distribute F to the free riders.

The purpose of the constraint is to enable the token market to operate continuously, which is important because the market value of the DAO tokens is a key input for the auction mechanism. Other approaches are possible, but it is not clear that they would resolve the trade-off between having a continuous active market and avoiding the danger that some socially valuable projects will be precluded by free riding that limits the available surplus. One possibility is a variant of the flush sale and subsequent token auction discussed in section 4.1.4. If the market liquidity constraint is binding, then the flush sale at price P_0 consists of the $(1 - t_m)q$ tokens that are not held by the winning bidder at the conclusion of the auction. The variation applied when the constraint is binding is that instead of surplus from the token auction being directed to the T_1 token holders, it would be paid, up to the amount F , to the winning bidder, giving that bidder some or all of the surplus that previously would have flowed to the free-riding T_1 token holders. At the same time, the token auction would reestablish market liquidity.⁴¹ It is unclear what portion of the missing surplus, F , that the winning bidder would in fact realize from this forced sale plus token auction approach. Market participants might be skeptical of the ability of the winning bidder to fulfill the V^* value claim by bringing the token value to that level. Addressing this situation by allowing the winning bidder to delay the forced auction to create time to demonstrate the value of the business plan would create a period with no market prices.

There is another possible source of inefficiency arising from the auction mechanism here. Burkart (1995) shows that in an English auction, it may be optimal for participants with toeholds to bid higher than their valuations. Overbids create a danger of overpaying if the overbidder wins, but they also may push up the winning auction price, benefiting the toehold position if the overbidder loses. Burkart (1995) proves that for sufficiently small overbids, the potential toehold benefit outweighs the danger of loss from

⁴¹A bounty system or alternative enforcement mechanism would be required to block the winning bidder from participating in the token auction directly.

winning the auction with an overbid.⁴² Under the mechanism here, successful overbidding would induce the winning bidder to reduce its surplus claim in order to prevail in the auction, the reduction accruing in part to the overbidder. Successful overbidding is socially desirable because more surplus is shifted to the T_1 token holders, which results in a positive investment impact while not affecting the result that the best business plan is put in effect.⁴³ Unsuccessful overbidding, however, has negative social properties. The winning bidder implements an inferior business plan. To the extent of the overbid, additional surplus flows to the T_1 token holders, which will result in a positive investment impact. However, this impact is larger than is optimal, since it is more surplus than would be generated even by the best business plan.⁴⁴

4.2 Post-auction Operation

In this subsection we examine post-auction operation absent a subsequent auction, deferring discussion of subsequent auctions to the next subsection. After the basic auction, the winner bidder is now the *control party* because the empty votes held in the dynamic vote pool plus the votes associated with the token deposit give the winning bidder more than a majority of the

⁴²The potential gain on the toehold is of the order of magnitude of the overbid while the potential loss from the overbid is of the order of magnitude of the overbid squared. Burkart (1995) assumes a private values setting in his main inquiry. Bulow et al. (1999) show that overbidding tends to be a much more serious problem in common values situations. Note also that the potential loss of efficiency from overbidding is a function of bidding intensity. If the bidders are dense in the possible valuations up the maximum one, then the winning bidder will be pushed up to its maximum value and earn no surplus. Overbidding does not have any benefit. Burkart (1995) developed his results in a setting with only two bidders, a very low bidding intensity with a subsequent high likelihood of a substantial gap in valuations between the two bidders.

⁴³Recall that a smaller surplus claim reduces the proportion of T_1 token holdings that must be sold to the winning bidder at P_0 and increases the corresponding proportion on which the T_1 token holders can earn the full amount of surplus. Note that the strategies of raising the value claim and lowering the surplus claim are equivalent for the overbidder. An overbidder facing a breakeven bid level of A^* expects to lose the full amount of the overbid $A - A^* > 0$ in either case.

⁴⁴Investment is over-encouraged if we look at this auction event in isolation. It is possible that the excessive surplus generated by this type of event offsets the failure to shift the full amount of surplus to the T_1 token holders in other auctions. In short, it is possible that the shift in excess of surplus is second best optimal in some instances.

DAO votes outstanding. Control persists for a *control period*, the time period between the end of the basic auction and the time when the DAO Code closes the dynamic vote pool. In the meantime, the control party's token deposit, value deposit, and surety deposit are locked in appropriate smart contracts, to be released in part or entirely when certain conditions are met.

There are various circumstances under which the DAO Code will end the control period arising from a previous basic auction. One such circumstance, discussed in the next subsection, is when there is a later, supervening auction. However, there are situations in which the DAO Code will end the control period in the absence of a supervening auction. We examine one such situation next.

A *Success Termination* occurs if the value deposit refund condition is triggered at the price S , that is, the token price reaches at least S on a sustained basis as defined by that condition. A Success Termination has the following consequences:

- 1) The dynamic vote pool is closed, removing all the empty votes associated with the pool from the control party, and ending the control period.
- 2) Any funds remaining in the value deposit and surety deposit are returned to the control party.
- 3) The token deposit is released from the applicable smart contract and returned to the control party.

After a Success Termination, the DAO returns to the default governance state with the control party holding at least t_dq tokens, where q is the quantity of tokens outstanding when the previous auction ended at time T_1 . If the control party wants to retain control and holds less than 50% of the outstanding tokens at termination, the control party will need to initiate and win a new basic auction. Otherwise, the control period ends, and an *open period* begins, during which the control aspects of the auction mechanism do not operate.

4.3 Subsequent Auctions

Subsequent auctions to an initial basic auction are of two types. First, any party can initiate a basic auction either prior to the termination of control

from a previous auction or at a time which is not within a control period. There is nothing new about a basic auction initiated outside of a control period, but when a basic auction is initiated during a control period, the DAO Code will need to specify how that auction interacts with the control framework in place following the previous auction. Second, the DAO Code specifies potential *periodic auctions*. These potential auctions commence when the *control period* reaches the time limit specified by the DAO Code.

4.3.1 Basic Auctions During a Control Period

During a control period, the entire control structure including a token deposit, a value deposit, and a dynamic vote pool along with all of the associated parameters will be embodied in one or more smart contracts. If a party initiates a basic auction during a control period, then there are two cases: (i) the control party bids in the auction and wins; (ii) some other party wins the auction whether or not the control party bids.

In the first case, there will be an *Auction Reset* implemented via a set of *Auction Reset Steps*. These same Auction Reset Steps apply to periodic auctions when the previous control party bids and wins. Suppose that the parameters from the auction that initiated the control period with subsequent adjustments are: S , P_0 , $P_v(T_{c1})$, D_v , D_p , D_s , and $t_d q$ where the new auction begins at T_{c0} and ends at T_{c1} . Denote the corresponding parameters emerging from the new auction and the associated winning bid with a superscript “ w ,” except that as stated above we assume for convenience that the number of tokens outstanding remains at q . The Auction Reset Steps are:

- 1) *The purchase deposit.* The control party made a purchase deposit of $D_p^w = \max \left\{ \frac{R^w}{S^w - P_0^w} P_0^w, 0 \right\}$ as part the current auction. The appropriate smart contract deploys the purchase deposit to buy $t_f^w q$ tokens at P_0^w from the T_{c1}^w token holders pro rata based on their T_{c1}^w token holdings. The DAO Code adds the purchased tokens to the control party’s token deposit.
- 2) *The token deposit and dynamic vote pool transition.* The token deposit shifts from $t_d q$ to $t_d^w q$ after appropriate token deposits or withdrawals by the control party. The token deposit is retained in the appropriate smart contract during the subsequent control period. The dynamic vote pool continues in place, adjusting the parameter t_d to the new value t_d^w .

- 3) *The value deposit transition.* When the new auction concludes at time T_{c1} , two control party value deposits are outstanding: a *previous value deposit* arising from the prior auction, with a current balance of $[\max\{S - P_v(T_{c1}), 0\}]q$,⁴⁵ and a *current value deposit* equal to $(S^w - P_0^w)q$ that the control party made at the time of submitting the control party's final bid in the just completed auction. The current value deposit is retained, subject to adjustment during the newly initiated control period whenever the value deposit refund condition is triggered. Out of the previous value deposit, the amount $\max\{\min\{S, S^w\} - P_v(T_{c1}), 0\}q$ is returned to the control party, and the remainder is paid to the T_1 token holders from the previous auction pro rata based on their T_1 token holdings.
- 4) *Treatment of the current surety deposit.* Parallel to the value deposit, there are two surety deposits outstanding at the end of the auction: a *current surety deposit*, D_s^w , and the *previous surety deposit*, D_s . The current surety deposit is retained in an appropriate smart contract.
- 5) *Treatment of the previous surety deposit.* Define the following three shortfall parameters:
- (i) The *value shortfall*: $H = \max\{(P_0 - P_0^w)q, 0\}$.
 - (ii) The *adjusted value shortfall*: $H^* = \max\{H - (S - P_0)q, 0\}$.
 - (iii) The *bid shortfall*: $B = \max\{(P_0 - S^w)q, 0\}$

The DAO Code returns $\max\{D_s - B, D_s - H^*, 0\}$ to the control party and transmits the rest to the T_1 token holders from the previous auction pro rata based on their T_1 token holdings.

The initiation of a new value deposit renders $P_v(T_{c1})$, the old bottom of the value deposit range as of the *end* of the new auction irrelevant. The new bottom, P_0^w , set at the *beginning* of the new auction may be less than or greater than the old bottom, which was based on price activity both before *and* during the new auction.

As will be discussed more extensively in section 5.2 below, the surety deposit is designed to protect against value destruction by bidders who gain

⁴⁵ Note that $P_v(T_{c1}) > S > P_v(T_{c0})$ is possible if the maximum sustained value rose from $P_v(T_{c0})$ to $P_v(T_{c1}) > S$ during the new auction period. If $P_v(T_{c0}) \geq S$, then there would have been a Success Termination instead of a new auction.

control of the DAO. We make some observations for the case we are considering in which the control party wins the new auction. Loss of part or all of the surety deposit only comes into play if: (i) the value of the DAO has fallen below P_0q at the time the new auction commences, creating a value shortfall $(P_0 - P_0^w)q$; and (ii) this value shortfall is greater than the initial value deposit $(S - P_0)q$ for the previous auction. Even if these two necessary conditions are met, if $S^w \geq P_0$, the entire previous surety deposit is returned. The control party can therefore block losing any part of the previous surety deposit by bidding at least P_0 . However, in the case where there is a value shortfall $(P_0 - P_0^w)q > 0$, the entire value shortfall becomes part of the current value deposit and is at risk. The potential of loss remains to that extent.

In the second case, the control party loses the new auction. The winning bidder is treated according the Basic Auction rules with respect to all aspects, including deposits, the creation of a dynamic vote pool, and the initiation of a new control period. Again denoting the parameters emerging from the new auction and the associated winning bid with a superscript “ w ”, the losing control party is treated according to the following *Control Party Auction Loss Steps*, which include exactly the same treatment of the previous value and surety deposits as under the Auction Reset Steps:

- 1) *Closing the previous dynamic vote pool.* The previous dynamic vote pool is closed, removing all the empty votes associated with the pool from the losing control party, and ending the control period associated with that party.
- 2) *Return of the previous token deposit.* The previously existing token deposit is released from the applicable smart contract and returned to the losing control party.
- 3) *Treatment of the previous value deposit.* At the end of the new auction, the balance on the previous value deposit is $[\max\{S - P_v(T_{c1}), 0\}]q$.⁴⁶ Out of this balance, the amount $\max\{\min\{S, S^w\} - P_v(T_{c1}), 0\}q$ is returned to the control party, and the remainder is paid to the T_1 token holders from the previous auction pro rata based on their T_1 token holdings.

⁴⁶See note 45 supra.

4) *Treatment of the previous surety deposit.* Define the following three shortfall parameters:

(i) The *value shortfall*: $H = \max\{(P_0 - P_0^w)q, 0\}$.

(ii) The *adjusted value shortfall*: $H^* = \max\{H - (S - P_0)q, 0\}$.

(iii) The *bid shortfall*: $B = \max\{(P_0 - S^w)q, 0\}$

The DAO Code returns $\max\{D_s - B, D_s - H^*, 0\}$ to the losing control party and transmits the rest pro rata to the T_1 token holders from the previous auction based on their T_1 token holdings.

Several features of these rules are noteworthy with respect to their role in creating participant incentives through the auction mechanism. First, the losing control party avoids forfeiting the value deposit to the extent that party was able to bring the DAO token price above P_0 for a sustained period of time. The higher the sustained price $P_v(T_{c1})$ attained, the lower the potential loss with respect to the original value deposit. Second, if the winning bidder bids at S or above, then the losing control party is off the hook. If the losing control party bids at least S , in effect renewing a commitment for the DAO token to reach this level, then unless opposing bidders can win with a bid below S because they have significantly lower costs, the control party will not lose any of the value deposit.

As noted, the treatment of the previous surety deposit is exactly the same as in the case in which the control party wins the auction and the Auction Reset Steps apply. We add some observations with respect to losing control parties, leaving a comprehensive discussion of the surety deposit for later in subsection 5.2. A winning bid with a sufficiently high value claim will guarantee return of the previous surety deposit, the previous value deposit, or both. In particular, $S^w \geq P_0$ results in a return of the previous surety deposit, and $S^w \geq S$ guarantees the return of any remaining balance on the previous value deposit. The return of these deposits under the applicable conditions is justified by the following reasoning. First, the condition $S^w \geq P_0$ based on a value claim by an independent bidder suggests that the control party did not engage in significant value destruction, justifying return of the entire previous surety deposit. Second, by losing the bid, the losing control party loses the opportunity to bring the token price to S or above and thus redeem the previous value claim. At the same time, given $S^w \geq S$, the winning bidder is asserting that it will be able to do so. And the losing control party's

value-building efforts or identification of an opportunity may have been part of the basis for the winning bidder's value claim of at least S . Under these circumstances, withholding return of any portion of the previous value claim is not consistent with creating appropriate incentives for bidders who are capable of adding value to the DAO through their efforts.

Finally, note that the portions of the value deposit and surety deposit that are not returned to the losing control party remit to the T_1 token holders from the previous auction regardless of whether or not they have retained their T_1 token holdings. Potential return of the deposits attaches to the *holders* and not to the *tokens*. As a result, potential return of the deposits does not affect the market value of the tokens. Otherwise, buyers would price in the probability of deposit returns, increasing the value of the tokens above the level that would follow from future business prospects alone. This kind of distortion would be problematic because the auction mechanism relies on the token price being a meaningful signal of the value of the DAO.

The control party may want to relinquish control in the absence of a supervening auction by *Abandonment*. In this case, the Control Party Auction Loss Steps apply, setting $S^w = P_0^w$, as if the control party lost the auction to a bid that included a value claim equal to current market value at the time of Abandonment.

4.3.2 Periodic Auctions

If the entire control period elapses without early termination due to success or a supervening auction, then the DAO Code triggers a new basic auction. The new auction starts at the end of the control period, and the parameter P_0 is set at the value of the DAO governance token, P_0^p , as of that time.

If there is at least one bidder, then the approaches of the previous section apply directly. If the control party wins, the DAO Code implements the Auction Reset Steps. If the control party loses or does not bid, then the Control Party Auction Loss Steps apply. If no one bids, then the control party is treated as losing an auction in which the winning bid included a value claim of P_0^p : The Control Party Auction Loss Steps apply, taking $S^w = P_0^p$ and $P_0^w = P_0^p$ in terms of the notation used in the Steps.

It is worth considering some situations in which a periodic auction is triggered by the passage of time. Suppose that the control party is still confident of attaining a sustained token price of V^* as the business plan plays out. The fact that a periodic auction is taking place means that to date only

a lower sustained level has been attained. In this situation, the control party has a strong incentive to bid in the periodic auction with the bid including a renewal of the previous value claim so that $S^p = S = V^*$ where S^p is the new value claim applicable to this particular periodic auction. This bid means that the control party will not lose any remaining part of the previous value deposit. That will also be the case if another bidder wins with an even higher value claim.

A second situation is where the control party engaged in extreme value destruction, dropping the initial token value from P_0 to some small but nonzero value. If no one including the control party bids, the control party will lose P_0q . The control party can forestall loss of both the value deposit and the surety deposit by submitting a new bid that renews the previous value claim.⁴⁷ Given that the DAO has nominal value, it is a near certainty that there will be no competing bids. But unless the control party puts resources and effort into the DAO, the low value will persist until the next periodic auction. In effect, the value deposit will be stuck in the DAO and effectively lost.⁴⁸ A more profitable strategy for the control party is to allow its control to expire whether or not there is a bidder in the periodic auction, thereby releasing its entire remaining token deposit, which the control party can sell to at least recover some money. In fact, the control party may want to abandon the control position before even reaching a periodic auction. Abandonment has the same consequences because the same Control Party Auction Loss Steps apply that pertain to loss of a periodic auction of the case where there are no bidders in that auction.

⁴⁷The value deposit from the previous auction is returned to the control party because the new value claim is at least as high as the value claim from the previous auction. The surety deposit from the previous auction is returned to the control party because the bid shortfall is zero. But the value deposit for the new auction exceeds the sum of these previous two deposits.

⁴⁸The DAO Code could create a maximum number of sole-bid control periods to close out the stuck position, but this might entangle honest control parties with projects that take a long time to prove out.

5 Further Evaluation of the Mechanism

5.1 Impact on Investment

As discussed in the introduction, an important consideration is the impact of the sequential auction mechanism on initial investment in DAO projects. The first best is to offer winning bidders only the amount of surplus required to cover their costs and execute their business plans. If initial investors expect that retained surplus will be higher in subsequent auctions, they will pay more for the venture in the first place. A mechanism with the highest expected retained surplus will result in the highest possible funding for the DAO at the start-up point as well as the highest possible on-going investment value.

One question is whether full surplus extraction (“FSE”) is possible. At present, it appears that FSE is attainable only under prescribed, relatively narrow conditions. In particular, Crémer and McLean (1988) show that if types are a finite set, the types are correlated, the joint probability distribution of types is known to both the mechanism designer and the bidders, and that probability distribution meets certain conditions, then it is possible to design an FSE mechanism. A large literature surrounds and extends this result, encompassing, for instance, a continuum of types, applicable here because V^* and C^* are real numbers.⁴⁹

These possibility results are almost certainly not relevant here. The assumption that the joint probability distribution of types is known to both the mechanism designer and the bidders is highly implausible. Fu et al. (2021) show that sampling without prior knowledge from this distribution may suffice to achieve FSE, but is unclear how that sampling could occur in the context here.

Robert Wilson’s statement of the so-called “Wilson doctrine” in Wilson (1987) is particularly apt in the context of designing mechanisms for DAOs:

Game theory has a great advantage in explicitly analyzing the consequences of trading rules that presumably are really common knowledge; it is deficient to the extent it assumes other features to be common knowledge, such as one agent’s probability assessment about another’s preferences or information. I foresee the progress of game theory as depending on successive reductions in

⁴⁹Borgers (2015, pp. 120-128) contains a good general discussion.

the base of common knowledge required to conduct useful analyses of practical problems. Only by repeated weakening of common knowledge assumptions will the theory approximate reality.

Trading rules are code feasible, and reducing them to code makes them common knowledge among all potential bidders. But it is unreasonable to expect other common knowledge elements to be present and available to the mechanism, especially because essential elements such as the bidding participants and the surrounding circumstances may not be known until shortly before or during the auction itself.

The problem of extracting surplus is equivalent to designing a revenue maximizing auction. Here the “revenue” is the surplus that remains from the business plan after subtracting the surplus, $B + \Pi_{t_b}$, that accrues to the winning bidder. We have used an English auction, which can be thought of as a second price auction variant because the winning bidder prevails and pays the amount of the second highest bid. Various other auction types may raise more revenue under particular circumstances. For example, if bidders are risk averse, a first price auction will raise more revenue but may also result in an inefficient outcome, which in our case means that the business plan creating the most social surplus may not be selected. Furthermore, adding some additional realistic assumptions such as bidders whose outcome possibilities differ because of different levels of skill, make it unclear whether a first price auction indeed would raise more revenue than an English auction.

Another consideration is that sealed-bid first price auctions may avoid the collusion problems that can arise in second price auctions. Collusion coalition parties in a sealed-bid first price auction can defect by bidding above an agreed upon low price chosen to enable the highest valuing bidder to prevail at that price and thus collect the largest possible amount of surplus for the coalition. In a second price auction, the highest valuing bidder will submit their best bid, and other coalition members cannot win the auction by deviating. Deviating only reduces the joint surplus for the coalition. The potential considerations in choosing among auction forms are myriad, and we do not attempt a detailed discussion here.⁵⁰ Instead, we simply rest on a claim that given current knowledge, the English auction is a strong

⁵⁰A good starting point is Krishna (2010).

candidate with respect to efficiency and raising revenue compared to other standard auctions.⁵¹

An English auction has other strong traits worth mentioning. An English auction is “obviously strategy proof” in the sense of Li (2017). In intuitive terms, it is an obvious dominant strategy to bid until one’s true value is reached and then drop out, at least when there is a continuum of bidder types.⁵² This quality minimizes the possibility that the auction will go awry due to the inability of some subset of bidders to understand what they should do under the mechanism.⁵³

Another feature that relates to surplus extraction is the reserve price. The mechanism requires $S \geq P_0$, setting a reserve price equal to the token price at T_0 , the start of the auction period. This reserve price makes market dynamics and market efficiency important. Token holders anticipate that the DAO project might be improved in the future, and an efficient token market implies capitalization of these expectations in the form of a higher token price. To the extent that the expectations are cogent, the auction will involve much less surplus. In effect, some surplus was already extracted and accrued to the investors through the impact of the capitalized expectations. If the expectations err to the high side, the token will be overvalued, potentially blocking implementation of even the highest surplus business plan. However, when no innovations emerge after a period of time, it is likely that the token

⁵¹ We have been assuming a “private values” setting with asymmetric information in which bidder business plans are known only to each bidder and bidder valuations of the plans are independent. See note 30 *supra*. If, instead, there is a common values element in which bidders have different signals concerning the value of the current operation and bid based on perceived undervaluation at price P_0 , then the efficiency and surplus-distribution of various auction methods are potentially different than under the private values assumption. However, the English auction performs relatively well in a common values setting. Under certain assumptions such as the average crossing property, the English auction remains efficient in the sense that there is an ex-post equilibrium in which the bidder who can add the most value will win. (Krishna, 2010, pp. 134-143). In this setting, the English auction tends to raise more revenue than other approaches, including sealed-bid first price and second price auctions. (Krishna, 2010, pp. 97-100). In the context here, raising more revenue equates to extracting more surplus from the winning bidder, one of our desiderata.

⁵²As discussed in subsection 4.1.6, when there is not such a continuum and especially when there is a small number of bidders, there may be an incentive to overbid.

⁵³On a similar note, Neeman (2003) demonstrates the robustness of the English auction to the seller’s degree of “Bayesian sophistication” with respect to setting a reserve price in particular private-values environments.

price will fall until an innovation becomes feasible under the auction mechanism. It is not clear how prevalent and potent these phenomena might be, but it is clear that they might have big impact on surplus extraction and thus on initial investment.⁵⁴

5.2 Preventing Value Destruction

The danger of value destruction arises from the possibility that the control party will take the equivalent of a negative economic position in the DAO, one that would increase in value if the DAO flounders, and then will use control to cause the DAO to perform poorly or even to fail entirely. The value of the control party's token deposit consisting of t_{dq} tokens would decline in the event of value destruction, but the deterrent effect of this deposit is not EV-robust. The control party can remove the economic aspect of this position, converting the position to empty votes, through a variety of empty voting strategies. As pointed out in the introduction, some of these strategies are not costly and would be hard to detect by any available means, much less by code feasible methods. The rest of the control party's votes are from the dynamic vote pool, and these votes are empty votes by design.⁵⁵ Thus, the control party can arrange to secure control entirely through empty votes. The control party can then construct a substantial negative economic position in the DAO through buying puts or otherwise and use control to engage value destruction, potentially a very profitable strategy. The auction mechanism makes this strategy easier to implement because of the empty votes created through the dynamic vote pool.

Both the value deposit and surety deposit are at risk if the control party engages in value destruction. Although the value deposit also plays a role in eliciting bids and incentivizing post-auction performance, the sole purpose of

⁵⁴One possibility is to create a multiple-stage model, such as the one in Ordóñez-Calafi and Bernhardt (2022), with the initial investments in the DAO occurring at the first stage and auctions at later stages. This type of model would permit examining the impact of the degree of surplus extraction in the auctions on initial investment and how that impact depends on various parameters. We leave development of such a model or analogous ones to future work.

⁵⁵The creation of empty votes through a dynamic vote pool is extremely useful. It allows the winning bidder to secure control with less than a majority of the tokens, thereby enabling the T_1 token holders to secure a greater proportion of the surplus generated by the bidder, which will have a positive investment impact.

the surety deposit is to supplement the value deposit in order to deter value destruction. Recall that the surety deposit is:

$$T_s = \max \{P_0q(1 - \gamma) - (S - P_0)q, 0\}$$

where γ is a choice parameter. $(S - P_0)q$ is the value deposit. If $\gamma = 0$, then the surety deposit is set such that the sum of the surety deposit and the value deposit is P_0q , the entire value of the DAO at the beginning of the auction. If the control party engages in value destruction that drives the value of the DAO to 0, then the control party will forfeit both deposits in their entirety. Loss of these deposits is EV-robust. As discussed in subsection 5.4, the control party would have to pay substantial sums to construct a derivative position that covered loss of both deposits.

The surety deposit is useful in deterring potential value destruction, but it also may deter bidders who intend to create value. Despite being confident that their business plans will move the DAO value up from P_0q to Sq , there may be an interlude in which the DAO governance token price falls below P_0 before the business plan proves itself. An auction during that interlude, including a periodic auction if the control period ends during the interlude, creates the danger of loss of part or all of the surety deposit under the applicable Auction Reset Rules or Control Party Auction Loss Rules. In the deterministic setting we have been assuming, there will be no problem if the control party remains confident in the business plan. In that case the control party will reinstate the previous bid, which includes a value claim $S > P_0$, ensuring the return of the entire surety deposit because there is no bid shortfall under either set of Rules. On the other hand, if the control party no longer has enough confidence in the business plan to bid with a value claim of at least P_0 , a bid that would trigger return of the entire surety deposit, then there is a loss. But this loss is appropriate because it is due to the failure of the business plan, a failure that drove the expected token price below the original starting value, P_0 .⁵⁶

By choosing the parameter $\gamma \leq 1$, it is possible to calibrate the surety deposit appropriately to the level of threat posed from potential value destruction by a control party. In particular, γ can be set to a value consistent

⁵⁶In the assumed deterministic setting, only auction-initiated business plans and the timing and degree of their success determine token prices. Low token price outcomes may occur due to stochastic elements not associated with the cogency of the business plan. As discussed in Appendix A.2, an appropriate response to that possibility is particular ex-ante reductions in each of the deposits.

with the operating and financial environment of the DAO. We have seen that if $\gamma = 0$ is chosen, then between the surety deposit and the value deposit, a control party engaging in value destruction risks forfeiting up to P_0q , the entire pre-auction value of the DAO, through loss of the surety and value deposits. Circumstances may dictate that γ does not need to be that low. For example, if value destruction is time-consuming, and there are many potential, informed bidders available to step in, then it is likely that value destruction will be prevented, at a loss to the control party, by a new auction.

Adding stochastic elements to the deterministic picture presented so far may warrant setting γ at a value less than zero. Shortly after taking control, there is a probability of a positive *stochastic shock*, that the token price might rise due to stochastic influences that are independent of the cogency of the business plan. A control party intent on value destruction would then enjoy a reduction in the value deposit prior to implementing a plan to damage the DAO and reduce its value. Setting γ at a value less than 0 would address this situation, but it also would potentially cause more damage from negative stochastic shocks to non-malicious control parties intent only on increasing value. Appendix A.2 details stochastic considerations and concludes that a surety deposit reduction is a desirable corrective to maintain incentives for non-malicious parties to implement the best business plan. A lower value of γ requires a larger corrective reduction, partially offsetting the disincentives to value destruction, requiring the final value of γ to be set even lower and the corrective reduction to be even higher.⁵⁷

5.3 Undervaluation and Treasury Raid Scenarios

Potential “treasury raid” scenarios provide an interesting perspective on how the mechanism would operate. DAOs typically have treasuries consisting of cryptocurrency tokens that can be used for further development of the DAO. Treasuries can store retained earnings as well as funds received from investors.

⁵⁷A lower value of γ requires a larger surety deposit. Non-malicious parties will lose the added increment of the surety deposit only in the face of more extreme, less likely events involving net negative stochastic shocks. The larger corrective reduction covers these losses in expectation. As a result, the additional corrective reduction will fall short of offsetting the increase in the potential penalty for value destruction arising from lowering γ . Consequently, γ can be set sufficiently low and the corrective reduction sufficiently high to both deter value destruction to the extent desired and insulate non-malicious parties from damage due to negative stochastic shocks.

Treasuries may be under the direct control of token holders who can direct their use by voting on proposals.⁵⁸ Direct control by token holders creates the danger of “treasury raids.” The most pernicious example of a treasury raid is one in which a party gains control of the DAO and then transfers the entire treasury to itself by voting positively on a suitable proposal. The party is stealing the other token holder’s stakes, and the term “raid” along with its negative connotations is apt.

Other cases and situations are not so clear. A relevant parameter is whether the token market capitalization is above or below the value of the treasury. The “underwater” situation in which the market capitalization is substantially below the value of the treasury is consistent with multiple, contradictory possible realities, each of which calls for a different perspective and optimal response. We consider three possible realities that illustrate challenges for the mechanism in addition to the case of a direct raid on the treasury. These three realities and the direct raid possibility can occur whether or not token prices are underwater, but starting with the underwater case makes the challenges clearer.

First, there may be an expectation that the parties currently guiding the DAO, although good-intentioned, will engage in foolish business plans, gradually wasting the treasury assets. The foolish business plans may be the result of the exhaustion of the original guiding purposes of the DAO. In this case, the social optimum is to end the DAO and distribute the treasury to the token holders, permitting re-investment of the treasury assets in more promising projects. In a situation of capital market adequacy, there will

⁵⁸In some cases, there are other parties who have that formal power or a veto on token holder proposals for spending treasury resources. In one common organizational structure, the DAO is embodied as a Swiss Foundation. The Foundation acts a wrapper, creating legal personhood for the DAO, with concomitant limited liability. Under Swiss law the Foundation must have formal legal control over the DAO treasury. Although the Foundation may in practice typically defer to token holder votes, there is the power to veto vote outcomes if they involve disbursing treasury funds.

be “vulture investors,” who facilitate this result via a takeover or through activism in the face of reluctant guiding or control parties.⁵⁹

Second, the guiding parties might have a very promising business plan but are keeping it secret from competitors. Current operations that lay the groundwork for that business plan may appear substandard to market participants, resulting in a market capitalization less than the value of the treasury. In this case the socially optimal outcome is for the guiding parties to continue in control until the business plan can play out and reveal its superiority.

Third, the guiding parties may not be totally good-intentioned, and may be diverting treasury assets to themselves short of an explicit distribution of the entire treasury that could be characterized as a single “raid” incident. Some of the diversions may be ambiguous or subtle, such as overpaying DAO contractors that are related to the guiding parties. Significant diversions might cause the DAO to underperform noticeably, resulting in an underwater token price. Diversions are tricky from a social optimality perspective. The diverted assets are not lost, only redistributed. Furthermore, if the diversions are anticipated at the time of investment, investors can give the guiding parties a lower stake for the same amount of funding, resulting in “normal” returns to the investors.

Assuming capital market adequacy, the mechanism can address all of these situations effectively. Suppose first the token value is underwater. Then a bidder can initiate an auction at just above the current token value, P_0 , when the value per token of the treasury is $P_{treasury} > P_0$. If the bidder wins, the bidder can terminate the DAO and distribute the treasury pro rata to the token holders. Capital market adequacy ensures that the winning bid will be close to $P_{treasury}$ and that most of the surplus will flow to the existing token

⁵⁹ Vulture investors already exist in the cryptocurrency space. The saga of Rook DAO, recounted by Gilbert (2023) and Nelson (2023), is an example. Rook DAO encountered an internal conflict and was trading below the value of its treasury. Co-founders and members of the core team proposed shifting 75% of the tokens to themselves to continue the project, leaving 25% to the rest of the token community. Activist investors facilitated an increase in the community’s share to 60%. Liu (2023) details the claimed role of Arca, one of the activist investors. As described in Arca (2023) and Dorman (2020), Arca’s operations include some that resemble a hedge fund that both makes portfolio investments and engages in activism.

holders.⁶⁰ Therefore, it is unlikely that the token value will be significantly underwater, and the situation in which the guiding parties are engaging in foolish projects will be terminated by liquidation of the DAO.

If, instead, the token value was underwater because the guiding parties have a superior business plan that requires secrecy, capital market adequacy means that these parties can obtain funding in confidence to outbid parties intent on liquidation. The other token holders receive at least their pro rata share of the treasury and possibly also some of the surplus from the envisioned superior business plan. If the guiding parties *think* they have a superior business plan but cannot convince any funding party of that opinion, then upon liquidation, the guiding parties at least receive their share of the treasury, possibly amounting to enough to implement their business plan through a new project.⁶¹

The mechanism provides a corrective to the diversion situation. A bidder can initiate an auction with the “business plan” being carrying out the DAO operations without the diversions. This business plan will increase the token value of the DAO, creating room for the bidder to profit. At least some of the surplus will flow to the other token holders.

Finally, the mechanism will tend to cause the aggregate token value to equal or exceed the value of the treasury. As a result, a treasury raid executed by using the mechanism to gain control will not be profitable. The DAO value will fall by an amount that at least approximates the missing treasury assets, and the winning bidder will lose that degree of its deposits, with the lost deposits flowing to the other token holders, reversing the stealing inherent in the treasury raid.

⁶⁰The “business plan” of liquidating and distributing the treasury and hedging the treasury value over the required short interval of time is unlikely to have high costs, and because the situation is so clear, it is likely that there will be many potential bidders and that most of the surplus will be bid away, accruing to the existing token holders. Bidder deposits will be effectively collateralized by the value of the treasury.

⁶¹The outcome in the Rook DAO events described in note 59 *supra* appears to represent these kinds of splits between parties intent on implementing a business plan and parties who want to exit through a liquidation that brings the DAO value up to the level of the treasury. The Rook DAO treasury assets were divided between two such groups of parties. The bidding competition central to the mechanism creates a way to divide the surplus more cogently, with the key question being whether the parties who want to continue can outbid the liquidation value. If they can, the other parties receive at least the pro rata treasury value of their tokens and likely more. If they cannot, they receive their share of the treasury and can pursue the project with those funds.

5.4 Post-auction Incentives and EV-robustness

At the end of the auction, ignoring any additional token or token-derivative positions taken on during the auction period, the winning bidder has a toehold consisting of $t_d q$ tokens on which it hopes to earn surplus and faces the task of avoiding loss of part or all of the value deposit by executing the business plan in order to move the token price up to V^* , the *target price*. Since the value deposit is reduced dollar for dollar by sustained increases in the token price above P_0 , the control party's initial incentives to increase token value are $1 + t_d$ dollars per dollar of value increase, assuming that the control party does not hedge the toehold position. Effort is over-incentivized up to the point at which the target value is reached or exceeded on a sustained basis. Further effort then is under-incentivized because the control party will reap only the proportion t_d of any gains but will bear the full cost.

This picture is what exists immediately when the auction ends. As time unfolds, the market evaluation of the control party and the business plan may fluctuate. If a sustained level $P_v(T_{c1}) < V^*$ is reached and then the market falls back temporarily, the marginal gain per token point will fall back to the toehold proportion t_d but with strong incentives to engage in efforts that drive the token price above the previous sustained level $P_v(T_{c1})$.

Nearly costless hedging equivalent to a temporary sale of part or all of the toehold may be available through the use of derivatives or otherwise. In the case of a control party intent on the business plan and on increasing token value to the target price, any such hedging will be undesirable because it will reduce the amount of surplus that the control party will capture. For control parties intent on value destruction, the opposite is the case. Hedging avoids any loss on the toehold as a result of the value reduction and giving away the upside in a hedge is costless for such a party. A hedge equivalent to a sale sets up an empty voting position, exactly what the control party intent on value destruction desires.

It is clear that no arrangement is going to be EV-robust with respect to token holdings. It is easy enough to hedge them in a way that is equivalent to a sale. But the same cannot be said of the value deposit and security deposit, which are key deterrents to value destruction and simultaneously incentivize achievement of the business plan. These deposits are EV-robust. Hedging the value deposit requires purchasing the opposite derivatives position, effectively buying a put with a V^* strike price and selling a put with a P_0 strike price and then including a dynamic element of knock-in and knock-out put options that

raise the short put strike price up to increasing sustained $P_v(T_{c1}) < V^*$ levels if and when the token price reaches them. This position would be expensive in the sense that it would cost a significant proportion of the deposit. With respect the surety position, a large put position with strike price P_0 would be required, also costly, and possibly difficult to assemble without moving the token price downward.

There are alternative mechanism approaches that have different incentive properties and hedging costs. One alternative is to require a value deposit of $(S - P_0)(1 - t_d)q$ that covers only the tokens not held by the control party instead of $(S - P_0)q$ which covers all of the tokens outstanding. This approach would avoid over-incentivizing the control party initially but also would require a larger surety deposit. A second would be change the structure of the value deposit. For example, the value deposit refund condition might be all or nothing based on reaching V^* on a sustained basis. This approach would prevent a control party intent on value destruction from benefiting from a reduced value deposit due to temporary but erroneous positive market judgments about the control party's business plan ideas. Many elements of comparing these approaches with each other and with the approach currently included in the mechanism design transcend the deterministic model and require consideration of stochastic elements.⁶² Given that the primary goal here is to show that there is at least *one* plausible mechanism, we leave the further analysis of choosing an approach on this front to future work.

Finally, a major advantage of the mechanism and the alternative versions we have discussed is that control itself is completely EV-robust. Contesting parties can only succeed by being the highest bidder in the auction enabled by the mechanism. Holding or assembling empty votes has no impact. The arbitrariness that can be associated with empty voting cannot occur.

5.5 Code Feasibility

The auction mechanism is code feasible by design. Deposits take the place of derivatives that would require counterparties. The mechanism itself is an easy-to-code algorithm.

Many DAOs contain structural governance limitations that specify which DAO Code or DAO operation changes can be achieved by majority vote, and which changes are subject to more stringent procedures. Control parties face

⁶²See Appendix A.2 *infra*.

the same governance restrictions as other parties. Winning an auction only guarantees that a control party can prevail with respect to any issue that is subject to a majority vote ($> 50\%$), even if the control party holds less than half the tokens eligible to vote. If a higher voting percentage is required, the control party can only succeed unilaterally through actual token ownership, as is the case with all other parties.⁶³

There is a strong argument for making the code governing the auction rules themselves immutable or nearly so.⁶⁴ As long as this code is intact, auctions remain as a powerful tool to address governance issues and to overturn any hold on the DAO by pernicious control parties, whether or not the control originated from a previous auction. In addition, immutability of the auction provisions prevents incumbents from distorting the auction process to their advantage by making control shifts via the auction more difficult or by creating rules that favor incumbent bidders.

The biggest difficulty regarding code feasibility is the task of bolstering toehold reporting discussed in section 4.1.4 above. It is not clear that detecting failures in toehold reporting is amenable to simple code solutions. Possible measures include recourse to outside parties, such as bounty hunters or implementation of a suitable registration system requiring know-your-customer verification. Perhaps the most powerful approach is to build a flush sale into the mechanism that includes a registration system that directs surplus from concealed control party positions away from the control party. But all of these approaches require interactions with the outside world and some level of trust that goes beyond secure code.

⁶³Careful consideration is required with respect to whether the control party can count its empty votes from the dynamic voting pool as eligible token votes with respect to issues that require a supermajority vote to resolve. If so, a further question is whether such votes count in both the context of supporting a revision and the context of opposing it. The answers to these questions may depend heavily on which issues are involved and also upon the overall governance structure and philosophy of the particular DAO.

⁶⁴If the auction provisions are immutable, it will be impossible to improve the auction process itself, a move that potentially would increase the value of the DAO. If some flexibility is permitted, the danger of possible manipulation suggests creating a substantial barrier to revision such as a very high supermajority vote possibly combined with deposits or other vehicles that shift the risk of any loss in DAO value upon the proposing parties.

5.6 Decentralization, Regulation, and Legal Aspects

A major question is the relationship of the mechanism presented here to decentralization, a desideratum for DAOs. This question also has significant legal and regulatory implications. The auction mechanism is a control device, creating the possibility of temporary contestable control by a single party, which itself may be an entity or group of persons. That may appear to be a move toward centralization, but arguably it is the opposite. As mentioned, many DAOs appear to be under the de facto control of a relatively small group of active token holders, often connected to the founders, surrounded by a mass of other token holders who rationally do not participate in governance. Even if that control shifts, the shifts will be subject to the vagaries of voting procedures and empty voting.

The mechanism improves on that situation by making control transitions more effective, not the result of voting procedures that are subject to social choice flaws and also not subject to the arbitrariness that can arise from empty voting. Most important, control is *continuously contestable*. Any party can initiate an auction. Even a majority token holder cannot maintain control in the face of an auction except by being the highest bidder. That is a very different picture than a DAO with entrenched control held implicitly or explicitly by founders or large token holders. It also is important to keep in mind that mechanism creates the possibility of alternation between control periods and open periods in which the DAO reverts to a less organized mode of operation, including voting approaches that may be valued for reasons other than promoting operational efficiency.

Regulation of DAOs is not fully defined or developed and there often is considerable uncertainty, especially in the United States where three major quite different regulatory approaches are possible even for the near future. Because these same three regulatory approaches are the major candidates across jurisdictions, we consider the mechanism in light of each of them. We present multiple examples of the approaches, but, to create a more enduring discussion in light of the unsettled nature of cryptocurrency regulation, we focus on the approaches in general rather than on specific current instances.⁶⁵

A first approach is *decentralization-focused* in the sense that the degree of decentralization determines whether and to what extent DAOs and other cryptocurrency applications are regulated. There are many variants that fall

⁶⁵The set of current regimes, even limited to the most important ones, is likely to be obsolete within months, if not weeks, of publishing this paper.

into this category. Under the recently implemented European Union laws governing cryptocurrencies, the key role of decentralization is explicit with an exemption from regulation for the case in which “crypto-asset services ... are provided in a fully decentralized manner without any intermediary.”⁶⁶ In the United States, the test set forth by the Supreme Court in *SEC v W.J. Howey Co.*⁶⁷ determines which cryptocurrencies will be considered “securities,” subject to registration with the Securities and Exchange Commission (“SEC”) and on-going regulation by the Commission. Cryptocurrencies that are not “securities” generally fall under the regulatory ambit of the Commodities Futures Trading Commission (“CFTC”) as “commodities.”

One branch of the *Howey* test requires investor dependence on the “efforts of others” to make a profit as a necessary condition for a token to be a security.⁶⁸ If the token is decentralized, in the extreme case just code running on its own, arguably there is no such dependence. Furthermore, disclosure of the backgrounds and plans of the key managing parties is a major objective of registration and on-going regulation under the securities laws.⁶⁹ If there are no such parties, regulation loses its primary rationale. In addition, if there are no managing parties, it is unclear who would be available to comply with regulation in any event.

An example in which the degree of decentralization affects the type of regulation rather than creating a potential exemption from regulation is H.R. 4763, a recent U.S. House of Representatives legislative proposal that would create a comprehensive regulatory framework for cryptocurrencies.⁷⁰ This legislation would grant the CFTC primary jurisdiction over any blockchain network or application that is functional and decentralized.⁷¹ If the system is not yet functional or is not decentralized, then it is regulated by the SEC. SEC regulation is much more onerous because it requires formal registra-

⁶⁶European Parliament and the Council of the European Union (2023) (Directive (22)).

⁶⁷328 U.S. 293 (1946).

⁶⁸*Id.*

⁶⁹Hinman (2018).

⁷⁰H.R. 4763 is known as the Financial Innovation and Technology for the 21st Century Act. H.R. 4763 was approved by the House Financial Services Committee on July 26, 2023, creating the possibility of consideration by the full House. House Financial Services Committee (2023).

⁷¹The proposal defines both a “decentralized network” and a “decentralized governance system.” In each case, the focus is on whether there is a person with effective control. In the case of a “decentralized network,” there also is the requirement that no party has 20% or more of ownership or voting power.

tion of the project, along with periodic reporting requirements. In contrast, unless the project is an exchange, CFTC regulation is largely limited to addressing fraud and market manipulation. There are no registration or reporting requirements. This difference is critical for DAOs because DAOs lack centralized management, and, as a result, compliance with registration and reporting requirements will be difficult if it is possible at all.

A second kind of regulation can be described as a *joint and several responsibility approach*. Some party or set of parties *must* be responsible for meeting traditional regulatory requirements, and in the absence of a designated party or parties, a wide variety of participants are effectively at risk of being held responsible with ensuing penalties or liabilities for the failure of the DAO to comply. There is a danger that this approach would preclude decentralized operation entirely. In the United States recent developments with respect to both the SEC and CFTC rules governing exchanges are striking examples.

In a case involving Ooki DAO,⁷² a commodities exchange operated through a DAO, the CFTC claimed that Ooki DAO was an exchange that was required to register under the Commodities Exchange Act and be subject to regulation by the CFTC but that had failed to do so. The founders had switched the exchange from operating as an LLC to a DAO, publicly stating that the purpose was to avoid regulation. After settling with the founders, the CFTC proceeded against the DAO itself despite the lack of identifiable parties managing the DAO, with the result being a default judgment for money damages in excess of \$600,000, an injunction, and an order requiring that Ooki DAO end its internet presence.⁷³ The CFTC took the position that Ooki DAO was comprised of token holders who had voted on any proposal, whether or not related to any regulatory matter. Because Ooki DAO is an unincorporated association, these token holders most likely will be jointly and severally liable for the full amount of the money damages.

On the SEC side, developments are even more threatening. The SEC recently reopened the comment period for proposed new rules covering the definition of exchanges that are required to register with the SEC and comply on an on-going basis with a complex set of regulations (the “Reopening Release”).⁷⁴ The Reopening Release was motivated largely by the goal of

⁷²Commodity Futures Trading Commission v. Ooki Dao (N.D. Cal., Dec. 20, 2022).

⁷³Commodities Futures Trading Commission (2023).

⁷⁴Securities and Exchange Commission (2023).

clarifying the SEC’s position on the applicability of the rules to token-based decentralized exchanges, including those governed by DAOs.⁷⁵ As part of the new rules, the SEC had proposed expanding the definition of an exchange by adding a “*group of persons* that constitutes, maintains, or provides a market place or facilities for bringing together buyers and sellers of securities” to entities that can comprise an exchange.⁷⁶ Commentators pointed out that for decentralized projects, code replaces intermediaries, and a “group of persons” could include a very wide range including developers and miners. The SEC responded first with the general principle that: “The existence of smart contracts on a blockchain does not materialize in the absence of human activity or a machine (or code) controlled or deployed by humans.”⁷⁷ The SEC then made clear the astonishing breadth of parties that might be included in the “group of persons” collectively held responsible for securities law compliance: interface providers, code developers, DAOs, validators, and issuers and holders of governance tokens if they act in concert or share common control.⁷⁸ Related more directly to DAOs, the SEC stated that “... significant holders of governance or other tokens ... could also be considered part of the group of persons and thus an exchange if they can control certain aspects of it.”⁷⁹ The aspects included: securities available for trading, requirements and conditions for participation, determining who can share profits or revenues, or having the ability to enter into legal and financial agreements on behalf of or in the name of the market place or facilities.⁸⁰ The SEC was not willing to exclude software developers, who, acting independently and separately from the project, published code that later was picked up and used in the project by an unrelated person. These parties were only “less likely” to be acting in concert.⁸¹ The SEC also made clear that liability exists for persons or entities that initially created or deployed the system’s code even though “the system, once deployed, typically cannot be significantly altered or controlled by any such persons.”⁸²

⁷⁵Id. at 6-7.

⁷⁶Id. at 6 (emphasis added).

⁷⁷Id. at 22.

⁷⁸Id. at 27.

⁷⁹Id. at 25.

⁸⁰Id. at 25.

⁸¹Id. at 28.

⁸²Id. at 29.

The SEC went on to discuss compliance costs. The SEC noted that “factors associated with certain technologies ... might increase compliance costs” and that compliance might “significantly reduce the extent to which the system is ‘decentralized’ or otherwise operates in a manner consistent with the principles that the crypto asset industry commonly refer to as ‘DeFi.’”⁸³ The SEC singled out DAOs as a case for which the highest possible compliance costs might occur.⁸⁴ The SEC continued, stating that “the holders of governance tokens, or other tokens that carry voting rights, may bear the responsibility of ensuring compliance with the system,” suggesting that the token holders should create an organization or delegate persons to undertake the activities required for compliance, putting money into the DAO if the costs are not covered by fees.⁸⁵ Furthermore, the token holders would have to have the power to alter the relevant smart contracts by vote if necessary for compliance, and in the case of immutable smart contracts, miners or validators would have to alter the smart contracts via a hard fork.⁸⁶

While it is true that these positions were asserted in a Release soliciting additional comments, they are the responses to concerns raised by previous comments suggesting that the scope of the Rules should be limited to create an exemption or at least breathing space for decentralized projects, including DAOs. And although the Rules only apply to exchanges, the same reasoning would apply to inclusion of DAOs in the general category of “securities” subject to regulation.⁸⁷

It also is noteworthy that the SEC was deeply divided concerning the position taken in the Reopening Release, with the minority group in the 3-2

⁸³Id. at 122.

⁸⁴The Commission put it this way (Id. at 124-125):

The Commission preliminarily believes that a reasonable case, in which the highest possible compliance costs would result, would be a ... system that performs exchange activities in part using smart contracts, but in which control over changes to the smart contracts is given to a token-based voting mechanism, which may use governance tokens as discussed above, and where the tokens are dispersed among a large number of investors.

⁸⁵Id.

⁸⁶Id. at 126-127.

⁸⁷This reasoning would greatly weaken the scope of the “efforts of others” branch of *Howey* as a restrictive necessary condition for a token to be considered a security, and, if pursued, most likely would trigger legal challenges and a possible reconsideration or clarification of *Howey* itself.

Commission split being sharply critical of that position. Commissioner Hester Pierce articulated the critique in a dissent to the Reopening Release.⁸⁸ She characterized the Release position as an “approach to exchange regulation as something that must not – indeed cannot – be altered to allow room for new technologies or for new ways of doing business.”⁸⁹ In a later videotaped interview Commissioner Pierce took the position that the Commission should “set true decentralized protocols aside” because the “technology itself is a substitute for many of the regulatory protections” otherwise required when interactions are with “an intermediary, a centralized firm.”⁹⁰ She noted that you can lose money and get hurt but “you are opting into that when you are entering into decentralized transactions.”⁹¹ This approach is very similar in flavor to the newly enacted E.U. rule that exempts a crypto application that operates “in a fully decentralized manner without any intermediary.”

A third regulatory approach, which can be termed *regulatory gradualism*, consists of observing a new technology and its operation and then, after a period of observation, deciding on a new, appropriate regulatory regime. Part of Commissioner Pierce’s dissent to the Reopening Release advocated this approach. She pointed out with approbation that the SEC had used a regulatory gradualism approach in the 1990s, permitting new, electronic exchanges to operate for a period of a few years despite being non-compliant with the prevailing strict regulatory requirements for exchanges, resulting in successful development and implementation of a new body of regulations tailored to such exchanges. Closely related to this 1990s example is the idea of creating a “regulatory sandbox” in which new cryptocurrency technologies operate and within which participants understand that they are on their own with respect to possible losses prior to the imposition of an existing regulatory regime or the implementation of a new one.⁹² If the dissenters gain a majority on the Commission in the future, policy may well move toward this third

⁸⁸Pierce (2023).

⁸⁹Id.

⁹⁰Hamilton (2023). Choi et al. (2021, pp. 2-3, 7-9) describe this situation as one that involves “functional and regulatory equivalence.” The application is the same as one that normally would be regulated, functional equivalence, and elements in the technology achieve the same purpose as regulation, regulatory equivalence.

⁹¹Id.

⁹²Commissioner Pierce has advocated this idea separately from her dissent from the Reopening Release. See Piro (2021).

approach or back to the first decentralization-focused approach that would follow from classical adherence to *Howey*.⁹³

Use of the mechanism raises four sets of regulatory considerations. First, there are the potential impacts of shifting to the mechanism under existing regulation. Second, the mechanism creates regulatory opportunities, ways in which DAOs could more easily fit within regulatory regimes without adverse impacts on their mission and structure. Third, regulation may directly impact the effectiveness of the mechanism itself. Fourth, the mechanism itself raises regulatory questions if the DAO is subject to the core aspects of securities or commodities regulation.

The regulatory impact of shifting to the mechanism from the previous DAO governance regime is unclear. For decentralization-focused approaches, the impact of the mechanism on decentralization looms large, especially in Europe where a finding that the DAO provides “services ... in a fully decentralized manner without any intermediary” would lead to exemption. As mentioned above, the possibility of asserting temporary contestable control created by the mechanism arguably enhances decentralization compared to current DAO governance. At the same time, visible control during control periods creates the opposite impression. The outcome is uncertain, especially given that the E.U. rules are brand new.

In the United States, the creation of control parties by the mechanism can lead to the claim that the “efforts of others” branch of the *Howey* test is met because, in the words of *Howey*, the control party’s efforts are the “undeniably significant ones,” essential to overall success and profitability. Contestability likely is of no help here given the disclosure rationale of the securities laws. Even if control is for a brief period, investors would profit from knowing about the background and plans of the control party in deciding whether to invest or divest. On the other hand, it is clear that large token holders and parties that participate in implicit control would be in the same boat under *Howey*.

The mechanism creates some regulatory opportunities, ways in which a DAO may fit more easily within regulatory regimes without compromising its central purposes. First, at least during the control period, there is clear party who can coordinate and interact with regulators, parallel to the managers of

⁹³The SEC has five Commissioners appointed by the President, but only three can be from the same party. The current 3-2 split is along party lines, with the Republican Commissioners in the minority. Thus, the regulatory approach can change sharply every time there is a Presidential election.

a traditional corporation. That is not the case if there is only implicit control or a group of large token block holders. The ability of the control party to interact with regulators creates a shield for other parties such as developers, validators, and token holders. This shield may be especially valuable in the face of a joint and several responsibility regulatory approach such as the one suggested by the SEC in the Release that envisions a very broad set of actors being subject to potential regulatory obligations and liabilities. Otherwise, this approach might well, in the words of dissenting Commissioner Pierce, “render innovation kaput.”⁹⁴

Second, various aspects of the mechanism create a case for establishing an exemptive safe harbor or reduced regulatory regime for DAOs that use it. As we have seen, there is a strong argument that the mechanism enhances decentralization in the face of both implicit and explicit control possibilities, and in many cases actualities, that emerge from token ownership and voting regimes. The mechanism also aims at the *socially* optimal outcome in each auction. And during control periods, there is a party that is an ideal subject of disclosure, the central goal of securities regulation. All of these qualities make a DAO using the mechanism a very attractive candidate for inclusion in a regulatory sandbox or for temporary forbearance by regulators under regulatory gradualism approaches.

Some aspects of regulation may make it easier to implement the mechanism itself. As discussed above, one of the biggest challenges for the mechanism is toehold reporting. If the DAO is a security, then Schedule 13D reporting or a modified version of it would apply, creating a legal obligation to report a non-negligible toehold position.⁹⁵ This legal obligation and its enforcement is external, not a code feasible part of the mechanism itself.

⁹⁴Pierce (2023).

⁹⁵Under section 13(d) of the Securities Act of 1934 any person who “directly or indirectly” becomes the beneficial owner of more than 5% of any class of registered equity securities, and certain equity securities that are exempt from registration must within ten days report to the issuer, to any exchange on which the security is traded and to the SEC certain information. “[I]f the purpose of the purchases or prospective purchases is to acquire control of the business of the issuer of the securities,” the information must include “any plans or proposals which such persons may have to liquidate such issuer, to sell its assets to or merge it with any other persons, or to make any other major change in its business or corporate structure. Securities Exchange Act of 1934, Pub. L. No. 73-291, 48 Stat. 881 (codified at 15 U.S.C. §78a (2012)). Schedule 13D is the form used to make the disclosures required by section 13(d).

Nonetheless, it could go a long way toward filling what might be a significant implementation gap for the mechanism.

Even if the DAO is not considered a security under U.S. law, it will be considered a commodity if it is publicly traded and thus subject to the ability of the CFTC to police fraud. The DAO can leverage this potential fraud liability with respect to the toehold position. Being able to submit an artificially low bid by failing to report the entire toehold position is fraud. The full enforcement and adjudication power of the CFTC comes into play. The control party would be subject to discovery and required testimony under oath. Hiding part of the toehold would create potentially serious consequences for the control party. This potential fraud liability is another external device, not part of the code feasible core of the DAO. But again, it can help address a difficult implementation gap for the DAO.⁹⁶

The mechanism rules may have legal and regulatory implications if the DAO is held to be a security or if it is an exchange subject to SEC or CFTC registration and oversight. If the DAO is a security, then in the U.S., various state and federal laws covering corporate governance might apply. Although the mechanism does not involve a tender offer or a merger, it is possible that state corporate law requiring shareholder (here token holder) votes for certain actions might apply to the auctions. The freeze-out feature might be the subject of scrutiny even though it treats all of the T_1 token holders the same. Jurisdictional issues are present. State law generally will not apply unless the DAO is incorporated in the state. The ways in which this class of rules apply and the extent to which they apply at all are complex, and we leave full consideration to future work. The inquiry is important because it also addresses the question of whether the mechanism here could be used more generally rather than being limited to DAOs. In particular, the strong points of the mechanism are equally cogent for traditional corporate governance.

Finally, there are legal considerations in addition to regulation. Most prominent is the issue of legal liability for DAO participants. This issue exists with or without the mechanism. DAOs can be “wrapped” in LLC or other legal forms to provide limited liability for participants, including token

⁹⁶It also might be possible to create some structure in the DAO to aid the applicability of this liability. For instance, the DAO might trigger notice of an auction and the toehold reporting obligation to the CFTC, or, if the DAO is a security, to the SEC, along with disclosure of the identity of the control party. The CFTC and the SEC could build this notice as a trigger for possible inquiry into their regulatory regimes.

holders and any parties that might be seen as “management.”⁹⁷ Limited liability might be particularly valuable for the control party due to the high visibility of being in that position. That is the main new element created by the mechanism. The question of the legal status and use of wrappers is a quickly developing field and the choices are complex. We do not discuss that question further here.

6 Concluding Thoughts

We have shown that there is a plausible mechanism for DAO governance that is code feasible, EV-robust, and efficient in the sense that it favors the business plan with the highest social surplus. The auction aspect of the mechanism provides a way out of the potential indeterminacy and pathologies that arise from pure voting mechanisms. At the same time, the sequential aspects of the mechanism create the ability to secure and enhance value that stems from DAO voting and other non-market governance approaches. The fact that empty voting is irrelevant to prevailing under the mechanism also removes the possible arbitrariness or deliberate harm that might result. The form of the mechanism permits the possible resolution of some major regulatory dilemmas. The mechanism tends to minimize the surplus received by project creators, thereby tending to maximize the investment value of the project, albeit imperfectly. In the rest of this section, we consider the mechanism in light of web3 and DAO governance norms.

One idealism of some web3 enthusiasts is that DAOs will create a new kind of democratic community that is free from exclusive focus on token value or domination by monied parties. It is not clear if the token value critique is apt for economic DAOs, which are characterized by token value being a measure of the value of the DAO activities. As discussed in the Introduction, cases of economic DAOs extend way beyond DAOs that primarily have a commercial purpose. Rather than being an evil, token value in the case of economic DAOs creates the opportunity to provide superior governance through mechanisms such as the one detailed here.

With respect to community, “democratic” has many possible meanings. Here we have taken the position that the goal is to maximize the value of each DAO project with respect to an extended community that includes

⁹⁷See, e.g., Guillaume and Riva (2022a), Guillaume and Riva (2022b), Kerr and Jennings (2022), Jennings and Kerr (2022), and Brummer and Seira (2022).

both present and potential future participants. That value includes process value inhering from “democratic” aspects of DAO voting or other non-market DAO governance mechanisms. If present or potential token holders value certain democratic elements in excess of any associated losses from weaker operational performance, the mechanism will favor those elements.

More generally, the mechanism permits an infusion of new participants and approaches with respect to both DAO operation and governance. It is impossible for large token holders, including founders or parties holding a token majority, to retain control if there are parties who will outbid them in an auction. That openness to innovators seems solidly in the spirit of DAOs, especially given that the auction mechanism places them on an even footing with the current governing interests in the DAO who also can bid and win.

Observers have pointed out that many DAOs currently are “undemocratic” due to implicit control by founders or others who may have relatively large token holdings while being surrounded by many small, disinterested holders of the rest of the tokens. It may be that this situation is a tendency inherent to governance through token voting, with implicit control shifting from one group of such parties to another. In that case, DAOs are already characterized by a succession of control parties, and the auction mechanism only creates a more efficient and fair way to implement that succession. Fairness here is not only with respect to potential control parties who are freed from elements such as empty voting but also with respect to smaller, more passive holders. These holders may be portfolio investors or may be less active for Jensen-Meckling reasons: The benefits of costly effort to become informed will accrue almost entirely to others. The mechanism encourages value-increasing transitions and attempts to distribute a significant proportion of the resulting surplus to the passive holders.

It is important to note that auction mechanism does not ban conventional voting or vote buying regimes such as quadratic voting. These approaches and the ensuing wisdom of crowds or attractive aggregative properties would operate fully during the open periods interspersed among control periods. Furthermore, even during control periods, the control party can abstain partially or fully on particular votes in order to allow the aggregative benefits of voting to be realized based on the control party’s calculus of how much expertise it has on those votes compared to the mass of other voters.⁹⁸ Some DAO projects already conform to a rigid version of this more flexible possible con-

⁹⁸See Bar-Isaac and Shapiro (2020).

trol period behavior. A foundation or other centralized element implicitly or explicitly makes certain decisions with respect to the DAO while others are left entirely up to the decentralized DAO governance mechanism. The auction mechanism here could extend to some current projects as a unified whole, encompassing both the centralized and decentralized portions of the projects. This approach would create on-going flexibility to make certain decisions through voting mechanisms and others through more centralized direction both during control periods and afterwards by restructuring the balance between the on-going centralized and decentralized elements during the previous control period. The ability to renew and redesign the structure in a coherent way would be perpetually available.

That perpetual ability to renew and redesign the unified enterprise also addresses another rigidity, one that is intertemporal. Many enterprises begin with centralized incubation of the DAO element and then reach a point where governance passes entirely to a “fully decentralized” state, relying only on the DAO governance mechanism.⁹⁹ One potential serious problem with this approach is that the enterprise may benefit at a later point from a major reorganization or revamp, perhaps with innovation in mind, that is critical to maintaining on-going dynamism or even for survival of the project. This reorganization or revamp may be difficult or impossible to accomplish without reinstating a later period of centralization that incubates a rebirth of the

⁹⁹MakerDAO is a prominent example. Maker Foundation was a centralized entity used to develop the MakerDAO system. As described in MakerDAO (2020), the Maker Protocol Whitepaper:

The Maker Foundation currently plays a role, along with independent actors, in maintaining the Maker Protocol and expanding its usage worldwide, while facilitating Governance. However, the Maker Foundation plans to dissolve once MakerDAO can manage Governance completely on its own.

In July 2021, MakerDAO reached a point described by the Maker Foundation CEO as being “completely decentralized,” with the transfer of all Foundation functions to the DAO and the subsequent envisioned formal liquidation of the Foundation. Christensen (2021).

DAO in a renewed and more valuable form.¹⁰⁰ It is very hard to see why restricting centralization to the beginning of the project is optimal in general. The auction mechanism leaves open the possibility of major reform during a control period by enabling consistent and coherent execution of a new plan similar to the plans used to birth DAOs during an initial period of centralized incubation. A control period for major reform can be invoked through the mechanism on a when-needed basis, with the most promising plan the odds-on favorite to be implemented.

We believe that the mechanism here fits well within the ideals that have inspired DAOs. Control over the direction of the DAO under the mechanism is continuously contestable. Founders and other parties no longer can maintain an iron grip through implicit control. The DAO is safe for democracy of various kinds because an auction followed by a control period can correct the adverse consequences of voting mechanisms if necessary, defeat empty voting if it becomes a problem, and overturn attempts of malicious actors to damage the DAO. The interests of passive small holders are protected. The value of the DAO project is maximized to the benefit of all participants. Constructive innovation is facilitated.

The goal here has been to present one possible mechanism that has promise. No claim is made that this mechanism is the best one. We have suggested alternatives for a variety of mechanism aspects throughout. If this kind of auction-based approach is found to be promising, there is much more work to be done.

¹⁰⁰Relevant in this regard is Vitalik Buterin’s lament concerning Ethereum in 2022. Buterin (2022). Buterin stated that he had “diminishing influence” over Ethereum and that it was “becoming harder to make big changes to the Ethereum protocol due to the many stakeholders that have a say in the decision-making process,” creating an Ethereum that was “definitely more vetocratic.” He stated that: “Even now, I feel like the window is closing on substantial things. It’s getting harder to do big things even today.” Ethereum is not governed by a DAO, but the possibility of getting to a stale point is equally applicable. Reorganization and major revamps are frequent in the corporate and non-profit world. It is not clear why DAOs or Ethereum would be any different with respect to the possible benefits of occasional major overhauls.

A Appendices

A.1 Proof of Proposition 1 and Corollary 1

Suppose that a potential bidder can implement a business plan that involves expending effort, consisting of labor and resources equivalent to C monetary units, in order to increase the value of the DAO by $N(C)$ monetary units. Define $V = V(C) = N(C)/q + P_0$ to be the token value emerging from this business plan. The basic auction is a vehicle for the potential bidder to gain control in order to implement the plan. We compute the strongest potential bid, (S, R, t_b) , the one that maximizes $A = (1 - t_b)(S - P_0)q - R$, based on the plan.

The total surplus generated by the plan is $\psi = (V - P_0)q - C$. The bidder's profit function conditional on winning the auction based on a bid (S, R, t_b) is:

$$\Pi_b = (V - P_0)t_bq - C + \frac{R}{S - P_0}(V - P_0) - \max\{S - V, 0\}q.$$

The first term, $\Pi_{t_b} = (V - P_0)t_bq$ is the bidder's expected profit on the bidder's toehold tokens, which have value P_0 at the time of the bid. The second term is the bidder's cost. The third term $\frac{R}{S - P_0}(V - P_0) = t_fq(V - P_0)$ is the bidder's expected profit on the proportion t_f of the total q tokens for which the bidder has forced purchase or voluntarily sold at price P_0 using the freeze-out feature of the auction mechanism. The fourth term reflects the fact that the bidder expects to lose $(S - V)q$ if the bidder chooses $S > V$.

Consider first the case where $S \leq V$. To create the best possible bid, the bidder will choose $R = \frac{S - P_0}{V - P_0}(C - \Pi_{t_b})$ which is the smallest R subject to the constraint of breaking even, $\Pi_b = 0$. Assume for the moment that this value of R satisfies the market size constraint $t_f \leq t_m - t_b$ required for a valid bid. Then:

$$\begin{aligned} A &= (1 - t_b)(S - P_0)q - R \\ &= \frac{S - P_0}{V - P_0} [(1 - t_b)(V - P_0)q - C + \Pi_{t_b}] \\ &= \frac{S - P_0}{V - P_0} [(V - P_0)q - C] \end{aligned}$$

Clearly A is maximized by the choice $S = V$, which yields:

$$A = [(V - P_0)q - C]. \tag{1}$$

A is the total surplus from the business plan, which equals the social gain from implementing it. It represents the strongest bid *conditional* on adopting this business plan.

But there may be a better business plan that produces even higher surplus, and A^* , the best overall bid will emerge from maximizing total surplus, $\psi(C) = V(C)q - C$. Assuming that $V(C)$ is twice continuously differentiable, that $V'(0) > 0$, and that $V''(C) < 0$, there will be a maximum defined by $C^* = \arg \max_C V(C)q - C$, and $V^* = V(C^*)$. The strongest possible bid from a bidder characterized by the value function $V(C)$ is:

$$A^* = [(V^* - P_0)q - C^*]. \quad (2)$$

So far we have ignored the possibility that a pair (V, C) and in particular (V^*, C^*) are infeasible because they violate the market size constraint $t_f \leq t_m - t_b$ required for a valid bid. In the case of a break even bid, violating this constraint means that the bidder cannot acquire enough tokens through the freeze-out feature combined with the bidder's toehold position, if any, to cover the cost C through surplus realized on the bidder's token position. The bidder can acquire at most the proportion t_m of the total tokens by these means. Note that if $t_m = 1$, violation of the constraint implies that $\psi(C) < 0$. In that case, the business plan destroys value.

For a pair (V, C) , the highest possible break even bid requires $R = C - (V - P_0)t_bq$, i.e., proposing an R that just covers the cost C . This choice of R along with $S = V$, which is necessary for the break even bid to be the highest, result in:

$$\begin{aligned} t_f &= \frac{R}{(V - P_0)q} \\ &= \frac{C}{(V - P_0)q} - t_b. \end{aligned}$$

The market size constraint becomes:

$$(V(C) - P_0)q \geq \frac{C}{t_m}.$$

If the constraint is binding, then $V'(C) = \frac{1}{t_m q}$ versus $V'(C) = \frac{1}{q}$ in the case of unconstrained optimization. The higher value of $V'(C)$ implies lower values for V^* , C^* , and the surplus, ψ^* , in the constrained optimization. Equation

(2) still applies, but with these lower values. Given a lower value for the surplus ψ^* , the consequent bid, A^* , also will be lower.

Suppose that the bidder in fact can make the highest break even bid A_1^* of any of the auction participants and that the second highest break even bid is A_2^* . Then the bidder can capture $\psi_e = \min\{(1-t_m)\psi^*, A_1^* - A_2^*\}$ of additional surplus from the business plan (V^*, C^*) . The bidder accomplishes that by adding ψ_e to R in the bid as if it were an additional cost, which will reduce the bid by ψ_e .¹⁰¹ Retaining the business plan (V^*, C^*) and adjusting A_1^* as indicated dominates changing the business plan and submitting a different bid based on the alternative plan. Because the alternative plan will result in total surplus $\psi_a < \psi^*$, a bid based on the alternative plan that directs the same amount of surplus to the bidder will be lower than the corresponding bid under the original plan.

Now consider the case $S > V$. We will contrast this case with the previous one in which the optimal value bid was $\bar{S} = V$ accompanied by a surplus bid of \bar{R} and an auction parameter \bar{A} . The value bid $S > V$ will create an additional loss of $(S - V)q$ because the bidder will lose that amount of the value deposit given than only the level $V < S$ is attainable through the bidder's efforts. Furthermore, to maintain the same amount of surplus that would accrue with a value bid of $\bar{S} = V$, the bidder will need to secure the same value of t_f by scaling \bar{R} , the surplus bid accompanying the value bid $\bar{S} = V$, by the factor $\frac{S-P_0}{V-P_0}$. The bidder also will need to increase the surplus claim by $\frac{S-P_0}{V-P_0} [(S - V)q]$ in order to cover the anticipated value deposit loss. The change in the bid is:

$$\begin{aligned}
\Delta A &= A - \bar{A} = (1 - t_b)(S - V)q - \left(\frac{S - P_0}{V - P_0} - 1 \right) \bar{R} - \frac{S - P_0}{V - P_0} (S - V)q \\
&= -t_b(S - V)q - \left(\frac{S - P_0}{V - P_0} - 1 \right) (\bar{R} + (S - V)q) \\
&= -t_b(S - V)q - \frac{S - V}{V - P_0} (\bar{R} + (S - V)q) \\
&= -t_b(S - V)q - t_f(S - V)q - \frac{(S - V)^2}{V - P_0} q \\
&= -(t_b + t_f)(S - V)q - \frac{(S - V)^2}{V - P_0} q.
\end{aligned}$$

¹⁰¹The bidder can increase the resulting reduced bid by a small amount ϵ if there is a need to defeat a competing bid of exactly A_2^* .

where we use the fact that $\frac{S-P_0}{V-P_0} - 1 = \frac{S-V}{V-P_0}$ and the fact that $\bar{R} = t_f q(V - P_0)$ to arrive at the third and fourth lines. Given $S > V$, $t_b \geq 0$, and the fact that $|t_f| \leq t_b$ when $t_f < 0$, ΔA is clearly negative, and the bidder must submit a weaker bid to earn the same amount of surplus when choosing a value bid of $S > V$ versus choosing a value bid of $S = V$. Thus, choosing a value bid of $S > V$ is a dominated strategy.

A.2 Hedging and Stochastic Adjustments

We developed the sequential auction mechanism in a deterministic setting where changes in the token price are driven solely by winning bidder business plan innovations. We now assess the mechanism in a stochastic setting, first discussing winning bidder hedging strategies and then possible mechanism adjustments that, in effect, provide hedging at the DAO level.

Honest bidders, those that are not aiming to engage in strategies such as value destruction, enter an auction because they believe they can enhance the value of the DAO and potentially profit from those enhancements themselves. Doing so in a stochastic environment involves taking a risky token position and exposing themselves to potentially losing part or all of their value deposit or surety deposit due to token price fluctuations not associated with the effectiveness of their efforts to add value. In addition, unless off-setting adjustments are made, these *stochastic elements* will tend to create imbalances in winning bidders' portfolios, especially if the required position in the DAO is large relative to the other positions in those portfolios. As a result, winning bidders will want to hedge the position they are taking in the DAO. We sketch how the hedging might operate, leaving aside a more formal development in favor of creating an accurate but more intuitive perspective.

Suppose that absent the winning bidder's project, the token price would evolve as a random variable, \widetilde{W}_b , the *base outcome*, and that the outcome of the winning bidder's efforts changes the random variable to $\widetilde{W}_b \pm \widetilde{W}_e$ where \widetilde{W}_e is the *effort outcome*, with $E(\widetilde{W}_e) = V^* - P_0$. Typically \widetilde{W}_e will not be stochastically independent of \widetilde{W}_b . For example, if a high outcome of \widetilde{W}_b occurs, it also might mean that the winning bidder's effort is more productive in creating value, with a consequent high outcome for \widetilde{W}_e . The past history of DAO token prices creates insight into \widetilde{W}_b . But as of the end of the auction, there is no history for \widetilde{W}_e , and its qualities, to the extent surmisable, are private information of the bidder.

These two random variables each contain both systemic and idiosyncratic elements. The market prices systematic risk components, ones that cannot be diversified away, but does not price idiosyncratic risk, which can be diversified away because it nets out to zero across the market portfolio.

The identity of the winning bidder matters. Consider two extreme cases. On the one hand, there is a “bare bones” entrepreneur with limited resources and wealth, who will be unable to diversify away idiosyncratic risk and who may have difficulty fully hedging systematic risk. The danger is that this entrepreneur will forgo undertaking a project with high social surplus because of the accompanying high risk and portfolio distortions.

On the other hand are institutional investors, such as a hedge funds, private equity firms, or venture capital firms that exist in part because they are vehicles to solve exactly these hedging and diversification problems. These firms typically create portfolios of investments and themselves are owned by other investors, sometimes large pools of them. Idiosyncratic risks are thereby shifted to the broader investment system and can be diversified away. Systematic risk is absorbed by outside parties in the broader investment system hedging or adjusting their portfolios. We begin the analysis with the winning bidder being an institutional investor and then consider the case of a bare bones entrepreneur.

There are three separate elements of concern with respect to hedging and diversification for a winning bidder: (i) the token position consisting of $t_d q$ tokens; (ii) the value deposit liability; and (iii) and the surety deposit liability. An institutional investor will simply absorb the token position. The idiosyncratic risk will be diversified away and the systematic risk shifted to appropriate parties through the broader investment system. The institutional investor can focus purely on the question of choosing a business plan that maximizes surplus creation and surplus extraction, aligning their motivation exactly with the auction mechanism. The deterministic analysis applies directly, interpreting V^* as an expected value rather than a certainty.

The same expected value relationship does not apply for the value deposit and surety deposit. These deposits function as derivatives positions under the associated DAO Code rules. The value deposit is equivalent to a bearish put spread combined with knock-in and knock-out options.¹⁰² The surety deposit is analogous to a long put position from the perspective of the T_1 token holders who benefit if the deposits are forfeited in part or entirely by

¹⁰²See note 26 supra.

the control party. When the control party succeeds in bringing the token value up to V^* in the deterministic setting, both deposits are fully refunded and the T_1 token holders receive nothing. In a stochastic setting, V^* is an expected value, not a certainty. There is a probability that the token price will never reach V^* due to stochastic elements unrelated to the cogency of control party's business plan and the effectiveness of execution of the plan. In that case, the control party will lose part or all of the value deposit, and if the stochastic elements are strong enough on the downside to result in a token price below P_0 , part or all of the surety deposit. There is no corresponding upside: The deposits are fully refunded if V^* is reached on a sustained basis, but attaining a higher level than V^* results in no additional benefit. The overall result is that in the stochastic case, the implicit derivatives positions inherent in the two deposits both have a negative expected value for the winning bidder, while in the deterministic case they had zero expected value.

As in the case of the token position, an institutional investor can pass on the idiosyncratic risk and systematic risk associated with the implicit option positions arising from the deposit arrangements to the broader investment system, which can eliminate the idiosyncratic risk and absorb the systematic risk. But the institutional investor cannot avoid the negative expected value hit associated with these positions, a hit that artificially lowers the appeal of surplus-creating business plans. Adjustment of the auction mechanism itself is required to address this problem.

Adjustment, at least to a good approximation, is possible in a code feasible way. The stochastic characteristics of the token price, $\widetilde{W}_b + \widetilde{W}_e$, such as volatility are key to the adjustment. With elements such as variance and skewness in hand, one can calculate the expected value of the loss on both implicit derivatives positions and reduce the two deposits accordingly along with appropriate changes in the rules for returning the deposits. However, as discussed and summarized in Khotari and Warner (2007), these elements must be estimated, are not stable over time, and post-event values are superior for purposes of estimation. The superiority of using post-event rather than pre-event values is particularly clear in the case of the basic auction because the token price process shifts from \widetilde{W}_b to $\widetilde{W}_b + \widetilde{W}_e$, a shift that typically will alter the distribution of returns, including the volatility parameters relevant to making adjustments. Because the control party has an interest in the outcome of the estimation, an estimation method would need to be hard-coded at the constitutional level of the DAO to avoid manipulation by the control party. Oracles might be necessary to retrieve the necessary data.

Given the data and protection from manipulation, estimating basic volatility parameters seems quite feasible, at least to a good approximation.¹⁰³

These estimation difficulties are only a small taste of the problems that would attend deeper mechanism revisions to address stochastic elements. At the highest level of ambition, the mechanism would isolate the impact of the new business plan by estimating the value impact of that business plan. A classic way to perform this kind of estimation is an event study. Khotari and Warner (2007) point out that event studies can be fairly accurate and robust in the short run but that they are unreliable in the long run, often failing to detect large effects at all in simulations, much less determine their magnitude accurately. Thus, even if embodying event study methodology in a DAO were code feasible, it is not likely to be effective. It certainly would fall short of letting the bulk the adjustments occur externally through institutional control parties shifting risk to the general market, leaving only the relatively easy adjustments for the intrinsic option positions to the DAO Code.

We now turn to the opposite polar case in which the potential bidder is a bare-bones entrepreneur instead of an institution that provides flow through to the general investment market and has deep resources. We have highlighted the danger that the bare-bones entrepreneur may choose to forgo a project with high social surplus due to unacceptably high risk. The entrepreneur also may need substantial funding to cover the value and surety deposits as well as the cost of the business plan. A classic market solution to these problems is to put the entrepreneur in a management role, with one or more intuitional investors providing the funds, and then to create a management contract that gives the entrepreneur incentives to choose and implement the highest value-added project net of cost, where the cost itself is covered by investor funding. The investors are diversified and are not affected by idiosyncratic risk. In this context, Park and Vrettos (2015) discuss the design of management incentives through compensation contracts, summarize much of the previous literature, and show that a management contract that includes convex compensation such as call options is superior if it is set up with a diversified index as the baseline. Call options reward

¹⁰³A full analysis also requires examining the impact of stochastic elements on preventing value destruction, which we have done in subsection 5.2 *supra*. As discussed in that subsection, setting parameters to deter value destruction through larger surety deposits will require a larger corrective reduction to offset the impact of negative stochastic shocks on non-malicious control parties.

the manager for achieving the high token values envisioned in the business plan and, combined with salary and other stable elements, align the manager's financial returns with attaining success with the business plan. The diversified index baseline moves the focus of risk-taking to idiosyncratic risk, which is immune to manager hedging. Suitable levels of the call option compensation will create the required incentives for the manager to fully execute on the business plan despite the attendant risks.

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