Futarchy Considered: a guide to blockchain-based prediction markets and futarchy

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Abstract

Futarchy attempts to solve democracy's failure to aggregate accurate information from an electorate by instead extracting information from prediction markets. Constituents "vote on values"—democracy still functions to fairly determine an electorate's single ideal welfare metric—and "bet on beliefs"—the consequence of monetary gain or loss incentivizes "experts" to direct markets towards the ideal state, measured against the chosen welfare metric. There are various theoretical shortcomings and potential attack vectors that have prevented a mainstream interest in and adoption of futarchy. Yet simplistic, futarchic DAOs can be successfully implemented, using the smart contract functionalities of Ethereum, for example.

1 The Knowledge Problem

You have the best possible knowledge about the world from *your* particular perspective in space-time, with resources of information immediately available for each fleeting circumstance of your life. Indeed, each of us has direct and exclusive access to her subjective phenomena, but hers only. Your personal knowledge is as perfect as possible, but accordingly, your knowledge of every other aspect of reality is imperfect. It is when we interact with each other on a daily basis, guided by our best knowledge of our wants, exchanging our insights, that we build sturdy interpersonal relationships, mutually benefit from transactions of goods and services, and grow our global supply of scientific and philosophical knowledge. The sum of experiences and expressions of each individual mind is what enables social order and makes up the fabric of functional societies. Yet, when it comes to policymaking, which has the utmost leverage on our lives and requires the utmost degree of knowledge, we often place absolute control of whole societies and whole organizations in the hands of few. We forget that because knowledge is distributed across time and space, because any single entity's knowledge of objective reality is outdated and imperfect, conventional policymaking is imperfect. This is "the knowledge problem", popularized by economist Friedrich Hayek. He waxes prophetic in his 1945 article "The Use of Knowledge in Society":

> We cannot expect that this problem will be solved by first communicating all this knowledge to a central board which, after integrating all knowledge, issues its orders. We must solve it by some form of decentralization ...because only thus can we insure that the knowledge of the particular circumstances of time and place will be promptly used. [1]

With the onset of effective blockchain technology in 2009, we can finally very seriously consider an uprooting of the established norms of centralized governance.

Since decentralized governance is still a budding field of research, the vast majority of systems of governance as yet established, from policymaking within private organizations to that of nation-states and intergovernmental alliances, do not address the knowledge problem. Central control of policymaking has, until recently, seemed an inevitable characteristic of organizational and state operation. However, experimental research on alternative and less centralized forms of governance has been done through activities such as "seasteading", during which groups of individuals live

as autonomous states on physical dwellings in unowned waters, or "floating cities", seeing if their methods of governance yield positive environmental, technological, and economic innovation [2].

Easier than packing up and going to sea, the other clear method of experimentation is purely software-based and exclusively accessible since the past few years—placing governance of a state or organization in the figurative hands of smart contracts on a blockchain, producing decentralized autonomous organizations, in which users, employees, and capital interact with each other based off of rules wholly defined and enforced through the smart contract code. Governance through blockchain has been or is currently being developed or researched to a limited extent, with target models such as liquid democracy, stakeholder vote, and holacracy [3]. In this paper we will focus on a concept of decentralized governance known as futarchy, invented by economist Robin Hanson in 2000.

2 An Overview of Futarchy

At its core, futarchy is a system of governance where constituents "vote on values, but bet on beliefs". [4] Originally outlined in Hansons paper, this alternative form of government is able to acquire more valuable input from constituents through the use of prediction markets for decision making. A detailed explanation is best conveyed through an example with a hypothetical futarchic nation-state.

Futarchic policymaking begins when the nation-state sponsors a nationwide vote to determine the value the nation wants to improve. This value should be a measure of welfare, such as GDP per capita or an index created specifically for the purpose—which will be discussed further later in the paper.

After a value is democratically selected, parallel conditional prediction markets are created for each policy believed to improve the metric. For example, if the metric chosen by the people is GDP per capita, each policy market would consist of two options—a token in support of the policy and a token in opposition to the policy. Those with strong opinions would purchase the respective token reflecting their beliefs, thus increasing demand for and thus price of the token in question. Consequently, the resulting price of each token would be a crowdsourced prediction of the decisions effect on GDP per capita.

In the case that the markets become detached from reality, those more or better informed will have the incentive of personal gain to provide their knowledge in the form of purchasing undervalued tokens, thus driving up the correct tokens price and correcting the inconsistency.

Once a predetermined length of time has elapsed, the policy tied to the token with the highest positive effect is selected to be implemented. The tokens whose policies are not realized will have all their market transactions voided. Finally, the eventual impact of the policy implemented (across a fixed length of time) will be used to determine compensation for holders of the remaining valid tokens.

Such a system could be scaled down to the corporate level to decentralize the selection of direction and provide stockholders and employees with a voice in management.

Given the heavy reliance on prediction markets and the lack of necessity for the tokens to physically exist, promise-based solutions would be viable for the futarchy's foundation. Thus, smart contracts executed on a blockchain would be an ideal solution to ensure transaction integrity and transparency.

3 Prediction Markets

The core mechanism powering futarchy is the prediction market mechanism, which will be explained in more detail in this section. At a high level, futarchy merely extends prediction markets by proclaiming the lawfulness of their outcomes. Futarchy does not inherently remove the need for a central enforcer of laws—in fact, the anarchist concept of private law enforcement seems incompatible with futarchy.

3.1 Why Decentralize Prediction Markets?

Before looking into the role that blockchain technology can play in prediction markets, it is first important to understand how prediction markets have previously been implemented in centralized systems, and why these respective systems failed. A centralized prediction market relies on one single entity to maintain a ledger of wagers and to decide on the outcome of events. Thus, in order for a centralized prediction market to be effective, it must be run by a completely trustworthy entity that can effectively and securely manage the ledger and

consistently report the correct outcomes of events. As a result, the whole system can be compromised as a result of human error or corruption of the central entity.

The reliance on this central figure in the operation of a prediction market also creates a single point of failure at the top, and has historically prevented centralized prediction markets from achieving mainstream success. Intrade, a web-based centralized prediction market founded in 1999, was one of the first attempts to establish a centralized prediction market. While Intrade was able to reach over 82,000 users at one point, they eventually shut down after the US Commodity Futures Trading Commission prevented them from trading in the United States [5]. The presence of a central administrative figure requires prediction markets to abide by governing bodies, and allows outside interests to put pressure on or close down these markets—not to mention, it also renders the entire system more vulnerable to security breaches.

These two particular shortcomings of centralized prediction markets—the dependency on a central figure and the single point of failure—can both be addressed by moving prediction markets to a blockchain. A blockchain is a digital ledger that uses consensus mechanisms to validate and canonicalize its transactions in a decentralized manner. This fundamental idea of a blockchain allows prediction markets to have immutable and unbiased ledgers, ensuring that wagers and payouts are correct.

In addition to keeping an accurate ledger, a blockchain-based system also provides a number of opportunities for ensuring accurate reporting. Since there is no central figure behind the blockchain prediction market, the system of reporting on events also becomes decentralized—any peer can potentially function as an oracle. There are many different methods in which oracles are selected and assigned markets to report on, the simplest being that every user is required to report on a certain number of randomly assigned markets. There are also more creative systems, such as allowing users to buy permission to report outcomes through the form of a status or reputation token. Participants in the market could also vote on who they want to report on the market, which could either be another user or a third-party entity.

In some cases, oracles might not even be necessary. For example, if a market were based around the temperature for an upcoming day, the smart contract that contains the market would be able to receive data directly from a digital thermometer, rather than a human oracle.

It is important to understand how a decentralized oracle system on a blockchain-based system leads to prediction market reporting being completely trustless. The policy used by Augur, a prediction market platform built on Ethereum, is just one example of how this quality control can be ensured on a blockchain without a central, trusted reporter [6]. First of all, to be an oracle on Augur, you must first hold tradable reputation tokens. Multiple users are then randomly assigned to report on a given market, and Augur declares the simple average of the reports as the outcome. If an oracle reports against this average, or fails to report on the outcome at all, then it loses reputation tokens. In the event that the simple average of reports is incorrect, any user can challenge this decision after putting up a small bond. Following the challenge, all of the users in the market vote on what the true outcome really was. If the challenger is correct, then the outcome is changed. However, if the challenger is incorrect, then they lose their bond. In summary, Augur's report process hinges on the idea that users will incur a financial loss if they fail to report the correct information, incentivizing correct reports.

Alongside ensuring that transactions and reports from prediction markets are valid, building prediction markets on a blockchain gives them protection from outside interests—a major failure of centralized prediction markets. Since they are decentralized, blockchains cannot be shut down once created. For example, Bitcoin has faced resistance from financial institutions and governments, but it has been able to continue growing since its decentralized structure prevents targeting any single point of vulnerability. This allows decentralized prediction markets to stay alive in the face of regulating and governing bodies, which were able to succeed in targeting the central entity behind markets like Intrade and TradeSports. Thus, the use of a blockchain is vital in creating a reliable and sustainable prediction market.

3.2 How to Decentralize Prediction Markets

It is clear that the characteristics associated with blockchain systems—immutability, trustlessness,

security—are able to overcome the shortcomings of a centralized system and allow for the existence of successful prediction markets. Now, let's specify how each stage of a prediction market is implemented on a blockchain. While there are a few different technologies that can be used, such as Bitcoin Core or other private blockchains, I will focus on the implementation in terms of Ethereum [7]. Ethereum's advantage over other blockchain technologies lies in its functionalities for smart contracts—programmable contracts written in a Turing-complete language that are set into motion when certain conditions are met. This allows for an easy representation of many of the different market mechanisms. Both Augur and Gnosis—two notable blockchain-based prediction market platforms—are built on Ethereum.

In order for events to be created and bet on by users, there first must exist a market in which the event can exist. Using Ethereum, these markets can be created by anyone. First, when creating the contract, the user must determine the maximum loss they are willing to incur, and enter this into their contract as a parameter, and the creator must send this amount of Ether to the contract in order for it to begin. The reason for this is to ensure that all bets are paid off—if there are not an equal amount of buy and sell requests in a given event in the market, then this subsidy will pay off the imbalance. This parameter also determines the size of events in the market, as events are not allowed to have payouts that exceed the maximum loss. This initial subsidy then goes to the market pool, or the balance of the smart contract from which bets will be paid out. Events are able to join the market by buying into the market smart contract. After an event has bought into the market, the market creates an infinite amount of shares for the specific event, which can be bought by users. Users that trade shares for these events are then also subject to a trading fee, which is decided by the creator of the market as either a flat fee or a percentage of the share price. This trading fee goes partly towards the market pool, and partly back to the original creator of the market.

Another smart contract must be written for each individual event in the market. For each event, the creator must clearly define the question they are looking to answer, and provide options for the possible answers to this question. Answers can be standardized by type, such as binary events with yes or no shares, or scalar values with defined maximum and minimum inputs. Events must also include a time at which they will mature, and after this time, the smart contract will no longer distribute shares for this event. The creator must also pay a fee for the event to be included in a given market. In order for the event to later be settled and reported on, it also must define some metric from which the oracles can define its effect.

After an event has been created and included in a market, users are now able to trade on this event. To buy a given share for an event, the user sends their payment and a transaction fee to the market contract, and includes the event identifier as a parameter, as well as the outcome they wish to buy. The mechanism for determining the price of each share is called the market maker. Different market makers can be used, and each contributes differently to the liquidity of the market. The most common market maker is called a logarithmic market scoring rule, which determines the cost of each share based on a logarithmic function which uses the number of inputs and maximum loss. After the transaction is received by the market contract, the user is then sent the amount of shares that they purchased, and the money from the purchase is sent to the event contract. The transaction fee is then split between the market creator and the market pool.

After the market has matured, it then must be reported on for the bets to be settled. As discussed before, there are many different mechanisms for choosing one or multiple oracles for a given event. Regardless of how the oracles are chosen, they must report on the event based on the metric determined for the market. To report on a given event, they must send their report as an input to the event contract, along with some form of payment (Ether, reputation tokens, etc.). Once a consensus is determined between the different oracles, the event contract then sends back the corresponding payment, with a loss if they reported incorrectly and a reward if they responded correctly. The balance of the event is then distributed to pay off the winning bets for the event, and is sent as outputs to the given users. If there is not enough money in the balance of the event contract, the event contract must then send a request to the market contract to pay off this discrepancy using the market pool.

In order to use the mechanisms defined above in a futarchy platform, it is important to note that the events created must be based around condi-

tional events. For example, while normal prediction markets can bet on the event, "What is the likelihood that the CEO will be fired within the next 30 days?", futarchic prediction markets must bet on the result that an event would have given it has occurred, such as, "What would the stock price be in 30 days if the CEO were fired today?" Thus, when events are created, they must be created in pairs: one event for the effect an event would have on a given metric if it were to happen, and one event for the metric if the event were not to happen. When the events have matured and a decision is made, the event that did not happen, or the off-bet, is voided. In this case, the smart contract simply sends back the money that was sent to it by the users.

4 Measuring Welfare

A crucial assumption that proponents of futarchy make is that we can, to adequate success, determine a "welfare metric" by which to measure the effects of certain policy decisions. Measuring welfare, however, has been a contentious issue since the beginning of moral and economic philosophy.

The pursuit to measure welfare is an inevitable part of the human condition, which demands a method of coping with its fundamental economic problem, scarcity. In the plight of scarcity, utilitarians claim that we are morally obligated to abide by a quantifiable welfare index in order to make tradeoffs that maximize utility. With finite means to infinite wants, we endeavor to reap the highest possible benefit through choices we make every day. Utilitarianism, in more detail, is a threefold ethical theory—made up of consequentialism, hedonism, and aggregation. Consequentialism states that morally ideal actions are the ones that result in the best consequences; hedonism states that the best consequences are those that bring about the most pleasure or utility; and the principle of aggregation states that we must weigh the utility of every participant in society, whether in sum or in average. Together, utilitarianism is born and has persisted in ethical thought to today. Many insist the principles of utilitarianism be applied not only by individuals in our daily acts, but also by communities, businesses, and legislators in social, commercial, and political decision-making processes.

The budding movement of "effective altruism", which is a passionate attempt from tens of thousands of individuals worldwide to quantify altruistic thinking in order to make the most positive global impact, relies heavily on this very assumption that utility can be precisely measured [8]. Ironically, the movement has splintered into several different tracts, that of existential risk research, global poverty relief, and vegan advocacy, among many. This splintering is the result of the notion of utility being inherently subjective—to some it means future welfare, to others it means longevity or quality of current lives, to others still it means the welfare of all conscious beings. With this in consideration, the pursuit of a precise and comprehensive utility metric seems futile.

Yet, returning to the economic problem of scarcity, when we consider how businesses and organizations cope, we realize that measuring welfare is not only necessary for the distribution of scarce means within a heterogeneous system, but also necessarily, to some extent, arbitrary. Through methods like cost-benefit analysis, businesses are able to make important and decisive governance decisions, usually to optimize profit or market capitalization. Welfare indicators that governments use typically take the form of an economic growth indicator, such as gross domestic product, Index of Sustainable Economic Welfare, and Genuine Progress Indicator [9][10]. While none of these indicators may be objectively flawless, as "welfare" will mean slightly different things to different parties, the fact that measuring costs and benefits is a necessity for effective decision-making within businesses and legislation means that an indicator must exist and cannot be perfectly non-arbitrary. In a Hansonian futarchy, constituents will democratically "vote on values" before markets are created—they either directly vote on welfare metrics, or elect delegates to do so for them. With this voting mechanism, a vestige of our current-day democracy, approved welfare indicators will, to the best possible extent, represent the needs and desires of the electorate.

5 A Holistic Evaluation

Pitfalls of futarchy do exist. However, they must be assessed in relation to the governance systems currently in place. Futarchy is not meant to be a virtual panacea to the problems of governance—it is meant to be an improvement over the status quo.

Futarchy's primary goal is to address the systematic failure of information distribution. Those with information are frequently not the ones in

charge of making decisions, thus resulting in policy that is inferior to known alternatives. By using prediction markets instead of elected representatives and public referendums, futarchy passes the baton of decision making to those willing to put their money where their mouth is, rewarding those with insight and disincentivizing those without. By allowing all with opinions to participate, these markets act as aggregators of information, ensuring all voices who want to be heard are heard. Assuming the dysfunction visible in democratic institutions is to the failure of information systems, futarchy is an unqualified improvement.

Another issue with democracy that has picked up steam in recent years is the issue of voter apathy. Futarchy resolves voter apathy by streamlining the participation process, only requiring widespread input for the determination of the welfare index to be improved. The specific details become the domain of those with the information to engage in the policy prediction markets.

Thus, a potential pitfall arises. Information can be wrong. However, given the financial incentive to provide one's knowledge if the markets become improperly skewed, those with better information will act as a rebalancing force in the proper direction. In the same vein, a malicious actor with a sizeable amount of resources could conceivably tip the markets one way or the other; however, the financial incentive would motivate others to push back and restore order.

Prediction markets are futarchy's biggest asset against poor decisions. Consequently, the liabilities that undermine prediction markets also also serve to undermine futarchy, the most notable of which is the fact that markets are self-referential—that is, decisions are often made based on the decisions of others. For example, a high token value on a poor policy might belie its insidious effects, motivating even more individuals to jump on board. However, this effect has the potential to be mitigated by the financial incentive to make good decisions.

Of note, the heavy reliance on financial incentive might prove misguided to those seeking higher values, but the financial incentive can easily be exchanged for those higher values or other items of societal interest.

Futarchy, at its core, is meant to solve problems arising from information. It has its flaws, dependencies, and potentially hairy situations, but all improvement lies in a solution being better, not necessarily perfect. And if society deems information the source of its many governance woes, futarchy might just be that better solution.

6 Integrating the Technology

If futarchy is evaluated to be the next step forward in governance, a clean transition is vital to success. Given the violence that has pervaded previous regime changes, proper implementation of futarchy must occur in a systematic and comprehensive fashion.

To advance understanding of the possibilities of real world applications for futarchy, Gnosis has announced the commencement of a series of tests to give a clearer outline of the governance system's strengths and weaknesses. The first of these tests will be centered around examining the effects of market manipulation on prediction markets, a key obstacle to overcome if futarchy is to become a reality.

Small scale trials such as Gnosis's are made possible by the self-contained nature of the markets, a trait that lends itself well to additional testing, and thus should be encouraged to better assess the validity of futarchy and prediction market-based decision making. [11]

Perhaps the biggest hurdle for futarchy is the level of technical expertise required to understand the underlying blockchain technology. Considerable abstraction is possible by focusing accessibility around the ability to buy and sell prediction tokens; however, market transparency is of the utmost importance to ensure decision integrity.

Ideally, the basis of futarchy would be laid during the creation of a decentralized autonomous organization, or DAO. Prediction markets built with smart contracts on a blockchain ledger with the express purpose of governance would ensure transparency, stability, and security. Determination of the welfare measure would be done with a simple majority vote, ensuring the will of the governed is at the core of every decision made. Ideally, with an organization built from the ground up with futarchy in mind, growing pains would be minimal.

However, due to the complexity and nuance of shifting from centralized to decentralized governance, small steps are advisable to mitigate systemic failure. Initial use of futarchy should be to limited to smaller, less impactful decisions be-

fore a full conversion is made. For example, if an organization with a traditional hierarchical governance structure such as **Blockchain at Berkeley** decided to pursue a shift of governance to futarchy, decision-making would be ported to futarchy in phases of increasing importance. With minimal impact to long-run success, semester-long project selection would be the first item transitioned to the futarchic system. In contrast, the fundamental mission and goals of Blockchain at Berkeley would be last, ensuring all inconsistencies and potential points of failure are ironed out before long-run success is irrevocably harmed. In this way, the benefits of futarchy are reaped whilst minimizing the potentially toxic fallout if issues arise.

Ultimately, revolutions have their time and place. However, in a world where the peaceful transition of power is one of the most notable shows of strength, incremental implementation, reflection, and revision, the road less taken, is the road that should be travelled should futarchy be deemed desirable.

7 Translating Information into Decisions

It is important to note that a prediction market platform is not necessarily futarchy. Rather, prediction markets are the tool that a futarchic system of governance uses in order to gather information for its decisions. Thus, in order for futarchy to exist, there also must be a process for making decisions based on the data that the prediction markets reveals. There is no one single process that is ideal for every futarchy—rather, the mechanism for making decisions should depend on the size, scope, and characteristics of the system that it governs. These processes can range from simple advisory markets to fully autonomous organizations, with each better suited to different situations.

In his paper, Hanson discusses a few approaches for making decisions based on prediction markets [4]. The first mechanism he discusses is an advisory decision market, where anyone can create and consult these markets for information about their decisions. This function is an obvious improvement over current information systems, as currently markets like this are mostly illegal. However, Hanson also notes that participants in a system like this have shown to lack incentive to participate, and that markets like this can be distorted when decision makers know more than others in the market. Thus, advisory markets are most advantageous in matters that are time-sensitive, as it pressures its participants to bet on what they know now, rather than waiting to gather more information in the future. It is also better suited for smaller groups rather than on a larger scale, as many may feel discouraged to participate if they dont feel that their voice is being heard.

The next system that Hanson mentions gives decision markets the power to veto legislative votes. The advantage this system is that it aligns the decisions of legislators with the knowledge of its constituents—that is, if the public clearly thinks that the bill will clearly have a negative effect on a given metric relative to the status quo, the information markets will reveal this and prevent this change. This is an advantage in a system of governance where external factors—such as political parties, donors, or social groups—may cause those in power to make decisions that are widely considered to be negative. However, giving decision markets veto power would only be useful for large scale, straightforward decisions. Hanson notes that, "a vetoed bill could probably be approved anyway, if broken into many smaller changes, none of which was clearly enough bad to trigger the veto" [4].

The last process that Hanson explains is the most involved; that is, using decision markets to propose and accept new laws or rules. While Hanson gives a number of different examples and ideas on how this system would be implemented at its base, the mechanism is as follows. Proposals of a new rule, or a change to an existing rule can be submitted to a governing member, and and are selected by an agenda process. Once selected, a prediction market is created for these proposals on their effect on a defined metric, and if a clear price difference exists between the value of the new proposal and that of the status quo, the new proposal is adopted. Given that the welfare metric is representative of the values of those within the system, this mechanism allows those with the best information to have the most influence in policymaking. Thus, for organizations with policy in many different areas, decisions are influenced by the leaders in their respective fields, rather than one central figure or body that must weigh the ideas of many.

8 Conclusion

The onset of blockchain technology has certainly rendered small-scale futarchy possible and reignited interest in the decades-old concept, as we can see through projects like Gnosis and Aeternity [12][13]. The goal of this paper was to provide a comprehensive description of the theory and existing research on blockchain-based prediction markets and futarchy, as well as present an evaluation and possible applications of the governance mechanism. Looking forward, our research team plans to build our own futarchic application on a smart contract platform like Ethereum, or even create an experimental blockchain-based futarchic community, similar to the seasteading community.

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