# The economics of crypto-democracy

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**Abstract.** Democracy is an economic problem of choice constrained by transaction costs and information costs. Society must choose between competing institutional frameworks for the conduct of voting and elections. These decisions are constrained by the technologies and institutions available. Blockchains are a governance technology that reduces the costs of consensus, coordinating information, and monitoring and enforcing contracts. Blockchain could be applied to the voting and electoral process to form a crypto-democracy. Analysed through the Institutional Possibility Frontier framework, we propose that blockchain lowers disorder and dictatorship costs of the voting and electoral process. In addition to efficiency gains, this technological progress has implications for decentralised institutions of voting. One application of crypto-democracy, quadratic voting, is discussed.

**Keywords:** Blockchain, Cryptoeconomics, Democracy, New comparative economics, New institutional economics, Transaction cost economics, Voting

## 1 Democracy as an economic problem

Democracy is an economic problem insofar as it consists of a choice subject to constraints made by acting agents with diverse preferences about their own ends (Buchanan and Tullock 1962). As in market exchange, in democratic choice these constraints are transaction costs and information costs, and are determined by the prevailing institutions and technologies available to individual voters, candidates, political parties, and electoral agencies. Democratic institutions include laws governing elections and participation, rules controlling the provision of political information (such as free speech or limits to free speech, speech or donation disclosure, truth in advertising laws, or electronic advertising bans), and norms about democratic participation. Democratic technologies include those which enable the distribution of information and knowledge about democratic choice (such as the printing press or social media) and facilitate the making of democratic choice (such as printed ballot papers). Constitutionally, societies have to determine who gets to choose (the franchise), the domain over which that choice is exercised (what social choices are to be governed democratically rather than through market processes), and the mechanism by which that choice is exercised (both the form of the democracy—i.e. representative or participatory—and the electoral system—i.e. proportional or majoritarian). At a lower level, the institutional choices consist of the timing and location of elections, mechanisms to enroll and verify the identities of voters, the physical means by which the vote is made and recorded, whether individual votes are made in public or are secret, the process by which votes are counted, along with how they are verified, protected from tampering, and reported to a body for tallying.

All these decisions are constrained by the technologies and institutions available. Voter identification provides an example of a democratic institution limited by the prevailing level of technology. Before the British Reform Act of 1832, "the would-be voter appeared at the poll, tendered his vote, and then there swore an oath prescribed by statute to the effect that he had the requisite qualification" (Maitland 1908, p. 355). While the number of eligible voters was small, this was a small burden – in small boroughs individuals were likely to be recognized at the ballot box. The Reform Act both expanded the franchise and mandated the creation of an electoral roll across Britain. These procedural changes prevented disputes about eligibility occurring at the ballot box itself, but were also expected by their proponents to reduce the cost of the election (Seymour 1915, p. 107). Enrolling to vote in Australia in the twenty-first century requires either an Australian driver's license or an Australian passport—each with a color photograph of the holder and digital security features—or the verification of an existing enrolled voter how has previously passed the same.

As this suggests, technological and institutional changes have both expanded democratic possibilities and helped develop trust that individual votes—i.e. choices—are inputs into the social choice governed by the constitutional system. Technological advancement opens up alternative systems through which democracy might be practiced. Representative democracy as it stands in the twenty-first century developed world has been set according to the technological and institutional limits of prior centuries. In order to underline this point, it is worth a brief diversion into the role that technology played in equally 'democratic' but significantly different forms of democracy that have prevailed in the past.

Ancient Athenian democracy was organised predominately by sortition rather than representation. Several hundred offices, including the membership of the governing Council of the 500, were filled each year by random allotment. Athenian juries were also filled by lottery, as they still are today. For Aristotle, sortition was the defining characteristic of Athens' identification as a democracy, and, as Headlam (1891, p. 1) writes, for the modern mind 'there is no institution of ancient history which is so difficult of comprehension as that of electing officials by the lot'. Nevertheless, Athenian democracy faced many of the same practical constraints involving the selection and identification of potential office-holders and jurors. Participation in the lottery was not compulsory, but for those who chose to do so, identification was verified by ownership of a bronze identity plate. These plates were slotted into a tall marble machine, the kleroterion, from which they were withdrawn according to the random roll of a dice. Offices were allocated on the basis of the order the plates were withdrawn. The machine was introduced first to reduce possible jury tampering (Ober 1989, p. 101), and Dow (1939) suggests that the potential for fraud to be committed by the operators of the machine was prevented by running the procedure twice. Sortition was valued in part as a response to agency problems derived from political power (Berg

2015; Rancière 2009). The introduction of the kleroterion, alongside the identification controls of the bronze plates, provided a material increase in the 'democraticness' of Athenian democracy, according to that society's own conceptions of participation. In that case, technology and technological change expanded the institutional possibilities of democracy and reduced the costs of those institutions.

In this paper, we consider the same potential with blockchain technology. The next section will introduce the blockchain technology and consider its application for the institutions of voting and elections, drawing on new comparative economics and transaction cost economics to provide a theoretical framework for analysis. In the final section, we consider quadratic voting as an implication of crypto-democracy.

## 2 Blockchain and crypto-democracy

In 2008, Satoshi Nakamoto authored a white paper introducing blockchain technology (Nakamoto 2008). Using the complex mathematics of cryptography, blockchains enable dispersed and pseudonymous people to coordinate information and govern exchange in a decentralized way. A blockchain acts as distributed publicly accessible and secure ledger of information (Barta and Murphy 2014; Swan 2015). The first and most famous application of blockchain was through the digital currency Bitcoin (Antonopoulos 2014; Böhme et al. 2015; Godsiff 2015). This was an effort to provide a trusted non-territorial digital currency that was not reliant on a centralized bank and to operate through financial intermediaries. But the potential applications of blockchains are much broader than currency. For instance, blockchains may disintermediate and decentralize law, contracts and government (Atzori 2015; Economist 2015a; Mougayar 2016; Popper 2015; Vigna and Casey 2015; Wright and De Filippi 2015). They can facilitate self-executing smart contracts in areas such as financial derivatives and gambling (Buterin 2014; Kõlvart et al. 2016; Szabo 1997), and create distributed autonomous organizations (De Filippi and Mauro 2014). Most generally, blockchains compete with centralized hierarchical organization, such as firms and governments. Functionally this implies blockchains are a technology for creating new decentralized institutions (Davidson et al. 2016). To the extent that modern economic growth is explained through the evolution of effective institutions, blockchain may prove to be a general purpose institutional technology impacting many sectors and industries (Allen 2016; MacDonald et al. 2016).

Blockchains have also been raised as a potentially efficient solution for voting (Barnes and Brake 2016; Daniel 2015; Osgood 2016). This application has been termed 'crypto-democracy' (Davidson et al. 2016). The successful entrepreneurial application of blockchain involves outcompeting existing institutions for solving particular economic problems. Using the institutional possibility frontier (IPF) framework (developed within new comparative economics) we can compare the existing institutions for voting and the electoral process and examine the effect of the introduction of blockchain.

There is no single institution for managing the voting and election process; rather we can observe several institutional forms that exist on a spectrum of institutional possibilities. In making institutional choices society face a tradeoff between the costs of disorder, and the costs of dictatorship. How different institutions minimise these costs can be mapped as an IPF (Djankov et al. 2003). Before examining the costs of dictatorship and disorder in the electoral process, it's first important to note that these costs are subjectively perceived by each political actor (Allen and Berg 2016). Therefore, we can, for instance, use experts' perceptions of electoral integrity to understand this cost tradeoff (Norris and Grömping 2017), as well as other historical examples of social losses from the democratic process.

The costs of disorder for voting and the electoral process refer to the risk of private expropriation such as individuals committing fraudulent registration, impersonation, or voting multiple times. Prosecutions following elections provide evidence that these are more than hypothetical risks to the system (e.g. The Electoral Commission 2016). To the extent that voters have a preference in any poll, the failure of these preferences to be captured by the system—e.g. measured by voter turnout—also represent disorder costs.

The costs of dictatorship are the public expropriation of the voting process by public actors. This could include overt practices such as ballot-stuffing, vote rigging and manipulated results, which may happen where electoral officials favor the incumbent candidate or ruling party (Norris and Grömping 2017). Dictatorship costs will be present where the centrally controlled electoral register is inaccurate, either through ineligible voters being registered or eligible voters left off the list (Norris and Grömping 2017). Dictatorship costs include not just public malfeasance, but also negligence. An example of this is in the Australian 2013 Federal election, where the High Court ruled that the Senate election for the State of Western Australia was invalid because the Australian Electoral Commission had lost 1370 ballot papers (*Australian Electoral Commission v Johnston* [2014] HCA 5, 2014). Some phenomena will reflect costs of both disorder and dictatorship. One example of this is bribery, where the distinction will depend on whether it is a public or private actor that is collecting the bribe. The same can be said of integrity of the system, and the costs of enforcing the results. Violence is yet another example. That is, disorder is present when private actors deny other individuals from exercising their voting rights, such as through violence or fear of violence (e.g. Norris and Grömping 2017), whereas dictatorship will be present in instances of state-sponsored violence (e.g. Schedler 2002).

Centralised and decentralized institutions manage these dual costs in different ways. Centralised institutions limit the perceived costs of disorder by having a centrally managed voter registry and having full authority over the conduct of elections, and limits costs involved in duplication, but increases the perceived costs of dictatorship because these circumstances introduce risks that the process could be (internationally or negligently) manipulated by state actors to favor a party or candidate. Laws maintaining the electoral commission's independence guard against the worse of the perceived dictatorship costs. In contrast, decentralised institutions limit the dictatorship costs associated with concentrated power by introducing competition and choice between jurisdictions, but this introduces the risk of perceived costs of disorder by giving more power to individuals and relying on private collective action.

At this point, we can begin to construct an institutional possibilities frontier for managing the voting and election process, illustrated in Figure 1. First, on the right of the IPF, a single centralised electoral authority, controlled by the ruling candidate or party in an election. Second, a centralised electoral authority established as impartial and independent of the government of the day (e.g. the Australian Electoral Commission, responsible for conducting the electoral system for federal representatives across the country). Third, a decentralised system with several electoral authorities (e.g. in the United States, each state is responsible conducting elections of their own federal representatives). Fourth, on the left of the IPF, an arrangement of multiple privately managed systems (e.g. there are several for-profit services that provide voting and election services, used mainly by public companies and membership organisations).

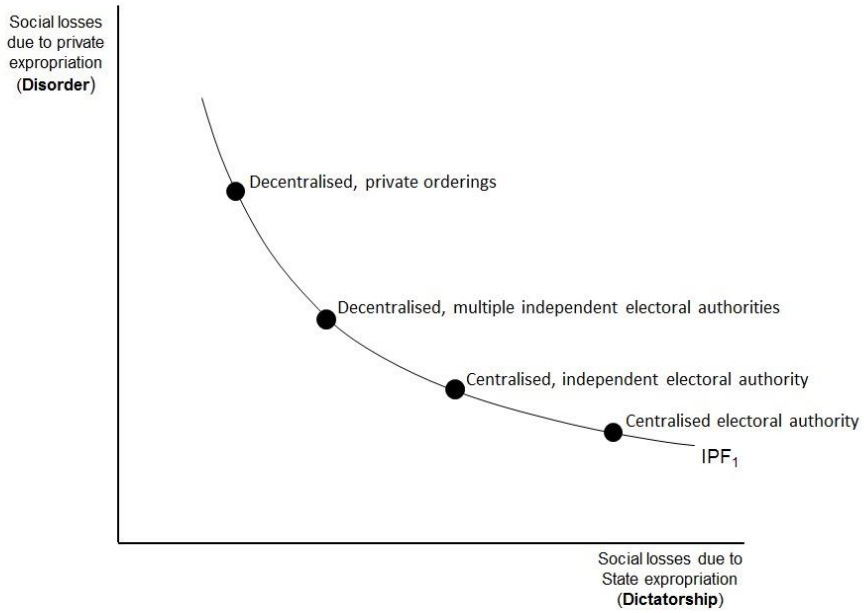


**Fig. 1.** Institutions of voting and the electoral process

Let us now return to the effect that blockchains have on the institutional environment. Blockchains are a governance technology reducing the costs of consensus, coordinating information, and monitoring and enforcing contracts. Indeed, given that democracy is itself an economic problem of coordinating preferences—with various potential comparatively efficient institutional solutions—it is somewhat unsurprising that blockchains may be applied to democracy. At the time of writing the most prominent application for blockchain for online voting is FollowMyVote.com, who claims to embody "all of the characteristics that a legitimate voting system requires: security, accuracy, transparency, anonymity, freedom, and fairness" using blockchain (followmyvote.com 2017). Claims over the potential of blockchain technology for voting are in effect arguing that blockchain technology comparatively decreases the various costs of dictatorship and disorder, including “robustness, anonymity and transparency” (Lee et al. 2016). Put another way, following the transaction cost economics framework of Oliver Williamson (1975), we can view blockchains as economising on the costs of uncertainty and opportunism in a decentralized way.

Of course, there is the potential that crypto-democracy could be applied within a centralised institutional possibility. A centralised electoral commission could, for example, use blockchain technology to maintain their electoral roll which has integrity and transparency benefits, meaning that the voting process would be harder to manipulate and it would reduce the possibility of human error. But we anticipate that the major benefits for crypto-democracy will be for decentralized institutional possibilities ordinarily typified by higher perceived costs of disorder, as a decentralised ledger decreases the many of those costs (e.g. fraudulent registration, security, enforcement, duplication, etc.) without needing to rely on central control. For this reason, we propose that the introduction of the blockchain technology to the voting process—crypto-democracy—causes an inward shift in the IPF, skewed towards reducing the perceived costs of disorder. This is shown in Figure 2.

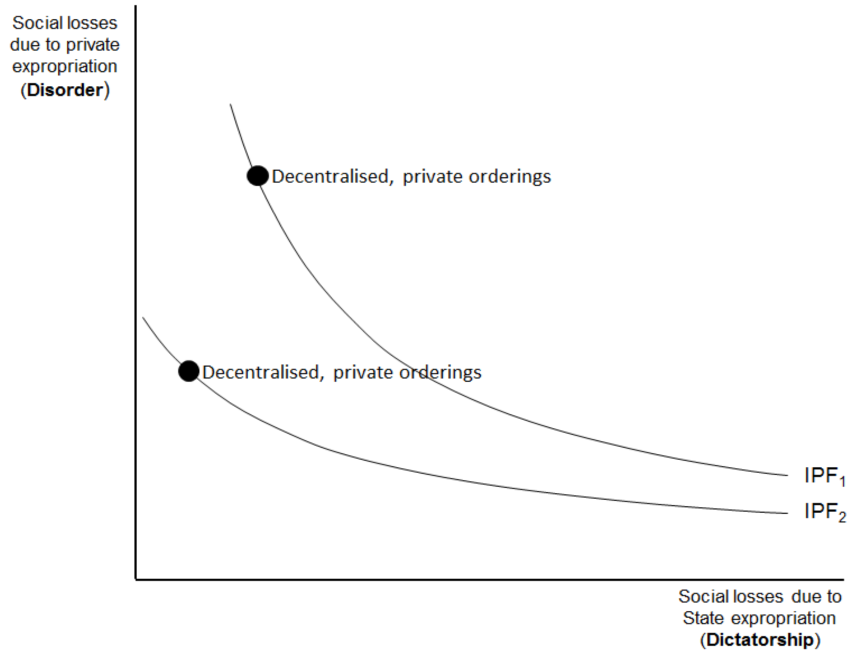


**Fig. 2.** Introduction of the blockchain technology

The majority of current proposals focusing on using blockchain for voting examine what appear to be pure efficiency gains for voting on the blockchain. However, an inward shift in the IPF due to the discovery of blockchain technology also presents the possibility of institutional entrepreneurship to discover new possibilities within the IPF space for solving the broader democratic problem (see Allen and Berg 2016). That is, the implication of an inward shift of the IPF implies more institutions are possible, not what those institutions are in practice. We explore one new institutional possibility to solve the democratic problem in the following section, quadratic voting.

## 3 A new institution of democracy: quadratic voting on the blockchain

Quadratic voting (QV) is a new voting mechanism proposed by Lalley and Weyl (2014). Posner (2016) suggests that "Quadratic voting is the most important idea for law and public policy that has emerged from economics in (at least) the last ten years". The basic idea is that the millennia old democratic franchise model of one-person-one-vote (1p1v) has the unfortunate but well-known flaw in that it is economically inefficient because it entirely ignores intensity of preference. If I care only a little about an issue and you care a lot (maybe it affects you more), we both have an identical voting margin. This leads to well-known problems with 1p1v such as tyranny of the majority. This means that issues that affect a minority of citizens, yet have significant welfare consequences for them (Lalley and Weyl offer gay marriage as an example), can be blocked by a casually indifferent majority. This is Pareto inefficient: there are clear opportunities for gains from trade. Lalley and Weyl (2014, p 2) explain that "1p1v offers no opportunity to express intensity of preference, allowing inefficient policies to persist. … The basic problem is that 1p1v rations rather than prices votes, resulting in externalities across individuals." They propose that the QV mechanism can resolve this problem (see also Posner and Weyl 2014).

QV works by introducing a payments mechanism into voting but, crucially, each voter is on both sides of the market: you pay to vote (buying votes along a quadratic pricing schedule, e.g. if 1 vote costs $1, 2 votes costs $4, 3 votes costs $9, 10 votes costs $100, 100 votes costs $10,000), but you also get paid after the vote (the payments go into a pool to be redistributed among all voters). QV is therefore both a vote pricing schedule and a reallocation mechanism. Lalley and Weyl (2014) show that the QV mechanism is, in the limit, 'robustly efficient' (Lalley and Weyl 2014, p 1) (recall the 1p1v mechanism is not efficient): QV induces revelation of true preferences, aggregates those preferences, and then compensates those affected by the decision.

There are several points to note about the QV mechanism: it overlooks persuasion; it has implementation challenges; and it has high transactions costs. First, it implements an exchange and compensation mechanism (which is the logic of seeking to improve the Pareto efficiency of an outcome where all citizens have given preferences). But an alternative mechanism—implicit in the 1p1v mechanism when understood in the context of an economy—is that citizens may seek to persuade each other to change their preferences, or to adopt better preferences.[1] The economic logic of this has recently been developed by Almudi et al. (2017) and Potts et al. (2017) in an evolutionary group selection (replicator dynamic) model they call 'utopia competition', in which agents use their own economic resources to seek to persuade other agents to adopt their own 'utopia' preference bundle. Evolutionary utopia selection model preserves 1p1v, but the compensation mechanism works through costly persuasion rather than transfer. However, the claim is that the utopia selection is also more efficient than 1p1v.

Second, as an abstract mechanism QV is asymptotically efficient. But there are still a number of implementation challenges for secure voting in relation to verifiability, robustness against false accusations, and secrecy. Park and Rivest (2016) have proposed a number of specific mechanisms using cryptographic techniques (including homomorphic encryption and zero-knowledge proofs) to resolve the issues of anonymity and payments efficiency using cryptocurrency. However, they acknowledge that the problem of overcoming collusion (which is an inherent instability in QV, which Lalley and Weyl acknowledge but offer no solution) remains problematic. However, the central message of Park and Rivest (2016) is that many of the problems of robustness in implementation can be resolved by adding cryptography to the mechanism.

A third constraint on QV, and arguably the most immediately practical problem at any non-trivial scale of application, is high transaction costs. That makes it infeasible in practice compared to 1p1v, which is for all its Pareto economic inefficiency is actually a low cost solution in exchange and contract because there is no exchange and contract (and thus has high transactions cost efficiency). This is a point that neither Lalley and Weyl (2014) nor Posner and Weyl (2014) really address. We therefore emphasise that the 'crypto' solution to robustness suggested by Park and Rivest (2016) also extends to a general transaction cost solution in the form of QV on the blockchain.

Quadratic voting should be understood as a mechanism that is inherently implemented on a blockchain at the point of voter identification, robustness and verification of the bidding and tallying mechanism, and security and transactional efficiency of the vote buying, fund pooling, and redistribution mechanism. By envisaging and implementing the QV mechanism in the context of a platform such as Ethereum, which enables smart contracts in which a citizen preprogram their preferences and then allow their software agent (or Distributed Autonomous Organization) to in effect automate the trades and voting and to make and receive payments, the transactions cost constraint on QV in an analog world is significantly reduced. The shift to a blockchain-platform also suggests other prospective applications that address problems of collective decision making over distributions of preference intensity, but which for

[1] This critique was also made by Tyler Cowen on his blog *Marginal Revolution*: http://marginalrevolution.com/marginalrevolution/2015/01/my-thoughts-on-quadratic-voting-and-politics-as-education.html

transactions costs reasons get caught in low Pareto efficiency mechanisms, such as the turgid representative democracy of corporate governance or city councils.[2]

## 4 Conclusion

The basic economic problem of democracy is to coordinate preferences between distributed people. This is an institutional problem, constrained by transaction costs and information costs, and therefore available technologies. Given that blockchain is an institutional technology for creating decentralized institutions, in this paper we have examined the potential for blockchain to open up new institutional possibilities of crypto-democracy. We focused on one new institutional possibility opened up through blockchain, quadratic voting, and its potential to more effectively solve the democratic problem.

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[2] For instance what Potts et al (2017b) call *quadratic zoning* (Quadratic voting + blockchain = quadratic zoning). This weighted voting mechanism combined with redistribution of funds enables efficient coalition formation and internal transfers to create welfare maximizing urban rezoning. With quadratic zoning there is no need for urban planning, but rather urban zoning can evolve.

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