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Voting Over a Distributed Ledger: An Interdisciplinary Perspective

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ABSTRACT

This work discusses the potential of a blockchain based infrastructure for a decentralised online voting platform. When compared to monograph based voting, online voting can vastly increase the speed that votes can be counted, expand the overall accessibility of the election system and decrease the cost of turnout. Yet despite these advantages, online voting for political office is subject to fraud at various levels due to its centralised nature. In this monograph, we describe a general architecture of a centralised online voting system and detail which areas of such a system are vulnerable to electoral fraud. We then proceed to introduce the key ideas underlying blockchain technology as a decentralised mechanism that can address these problems. We discuss the advantages and weaknesses of the blockchain technology, the protocols the technology uses and what criteria a good blockchain protocol should satisfy (depending on the voting application). We argue that the decentralisation inherent in

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the blockchain technology could increase the public's trust in national elections, as well as eliminate voter impersonation and double voting. We conclude with a discussion regarding how economists and social scientists can collaborate with the blockchain community in a research agenda on the design of efficient blockchain protocols and new voting systems such as liquid democracy.

1

Introduction

Despite elections being critical to the democratic process, their integrity around the world is continuously questioned both by independent observers and the voters themselves. Major examples include the latest Election Integrity Project review (Norris and Cameron, 2017) where independent researchers from Harvard and Sydney universities ranked only 19.5% of countries very high for election integrity. Similarly, in the 6th Round (2010–2014) of the World Values Survey (Neggers, 2018) more than 25% of the individuals questioned (in about 76% of the countries surveyed) stated that they believe that election officials are often unfair (biased).

The issue of questionable election integrity can affect both developing and developed countries. In the developing world, the Honduras general election (26th November 2017) suffered from major irregularities at the vote counting stage, which led the Organization of American States (OAW) to recommend that the election should be rerun (Palencia, 2017). Elections in Albania continue to suffer from vote buying allegations (Office for Democratic Institutions and Human Rights, 2017). In India the composition of the team of electoral officers can causally shift

votes towards favoured parties with magnitudes large enough to change election outcomes, as shown by Neggers (2018).

In the developed world, examples include the 2014 mayor election in the Tower Hamlets constituency of London in the UK that had to be rerun due to the discovery (after a court ordered investigation) of individuals voting multiple times and of votes casting from false addresses (BBC News, 2015). Another historical example from a country ranked highly on institutional independence, is the 1984 grand jury investigation into voter fraud in New York, USA. This investigation uncovered large scale and systematic fraud in the primaries of two of the borough's congressional districts between 1968 and 1982 (where 1000 to 2000 bogus registrants were discovered Lynn, 1984). More recently, a US government study states that a weakness of the American system is that poll workers are not dependable or sufficiently trained (Persily *et al.*, 2014). In Europe, another study (Leemann and Bochsler, 2014) shows that during a Swiss referendum in 2011, municipalities irregularly destroyed the ballots, therefore there was no valid record of votes in order to make a recount possible.

There is as yet no consensus on how to measure voter fraud – presumably it is the most sophisticated fraud that is the most difficult to detect therefore relying on cases brought to the courts is an imperfect indicator. The importance of finding appropriate tools for detecting and measuring fraud is emphasized in Deckert *et al.* (2011). Klimek *et al.* (2012) develop new methods from statistical physics to detect ballot stuffing and conclude that Duma and presidential elections in Russia in 2011 and 2012 suggest much ballot stuffing. The results of the field experiment (Enikolopov *et al.*, 2013) suggest that the extent of the electoral fraud in the 2011 Russian parliamentary election was sufficient to have had a substantial impact on the outcome, and that the presence of observers is important to ensure the integrity of the procedure. The latter is also supported by an experiment during the Ghana's 2012 elections (Asunka *et al.*, 2019), in which results show that electoral fraud was reduced at the polling stations where observers monitored the process.

Measures of voter fraud in US elections however suggest that at least double voting or voter impersonation is quite rare (Ahlquist *et al.*,

2014; Goel *et al.*, n.d.). In the UK, there is no consensus over the degree of voter fraud. Besides direct measures of fraud however, there is the issue of "trust" in elections which can be eroded if there is even a small incidence of fraudulent voting, leading to lower turnouts of honest voters. Much of the academic literature assumes that election authorities are honest and assume that it is at the level of voting where there is any chance of fraud, not at higher levels. This assumption may of course not hold in many democracies.

Our analysis will be guided by a few desirable criteria for a voting system. *Accessibility* and *trust* in the voting system seem to be two minimal properties of a good voting system. However, the more accessible a system may be, the higher the risk for fraud can be. On the other hand, forcing voters to go through exhaustive security checks (to maintain trust in the system) can make voting less appealing and less accessible. Despite the conflicting nature of these two objectives, an election system must be able to balance the need for accessibility with the need to establish trust in order to provide a high level of election integrity. More specifically, election authorities must be able to show that eligible voters can easily register and vote, especially for countries with compulsory voting where accessibility is of even greater importance. But the public's trust levels can disturbingly decrease when election fraud incidents occur. Such incidents can arise at multiple levels during the whole voting process, even from collusion between officials (entrusted with authority to run the election) such as ballot box monitors or other election insiders.

To further explore this issue, we analyse and view a voting system as a sequence of four main processes, which we refer to throughout this monograph:

- Voter registration
- Voter authentication
- Vote casting
- Vote counting

Note that each one of the mentioned sub-processes is vulnerable to some type of manipulation. Therefore, trust in a voting system (as a whole) implies that the possibility of manipulation should be minimised at each one of these steps. For example, the voting system needs to be able to show that no individual can be fraudulently added to the electoral roll (to achieve trust in the voter registration and authentication stages) while also showing that each vote has been accurately recorded and counted (to achieve trust in the vote casting and vote counting stages). But the more exhaustive the combined security checks for each stage are, the less accessible a voting system may become. For this reason, one of the main challenges of modern voting systems is to achieve a satisfactory level for both of these features (accessibility and trust) without compromising on one in favour of the other.

As additional desirable features of a voting system, we propose *speed* and *cost-efficiency* due to the following reasons. All paper ballot elections use an important amount of time and energy for the counting process, where an extreme example of this is Australia's House of Representatives and Senate vote counting, which takes an average of two weeks (Beaumont, n.d.). Using the single transferable voting system (Tideman, 1995), Australia compromises on the speed of the election results to achieve fairer results with respect to the proportional representation of citizens in the elected body. Lastly, organising and securing an entire election can incur a very large monetary cost to countries (especially to those running elections over multiple days). In India e.g., Electronic voting machines (EVM) were introduced in 1982 for the first time. An EVM takes about three hours to complete a vote count as opposed to paper ballots which could take 30–40 hours.[1] Therefore, to conclude, an election should cost as little as possible but without compromising on security, the speed to finalise the outcome or the fairness properties of the chosen voting mechanism.

In this monograph, we argue first that electronic voting can improve accessibility, leading to some positive outcomes as shown by Fujiwara (2015) for the case of Brazil. Fujiwara shows how the introduction of

[1] https://www.aljazeera.com/news/2019/4/11/india-elections-all-you-need-to-know.

electronic voting in Brazil led to de facto enfranchisement (via greater accessibility) of less educated voters with a correspondingly more responsive government. It can also lead to faster counting as discussed above and can be cost efficient. Second, we document the various problems with centralised electronic voting systems and finally we show how the blockchain can potentially overcome these problems. We introduce the concept of distributed ledger technology (DLT) (blockchains are a special case of DLT) and how they can improve both the accessibility and trust properties of an online voting system.

This monograph is organised as follows. In Section 2, we focus on centralised online voting systems (i.e., that do not use distributed ledger technology), where we describe their general architecture and outline their vulnerable areas for manipulation. Section 3 describes from scratch the distributed ledger technology and how its promising features can be used for online voting. Section 4 focuses on a special case of distributed ledgers, called blockchains, and analyses the multiple ways (consensus protocols) on reaching agreement on voting data. In Section 5, we discuss a possible conceptualisation on using a blockchain based infrastructure for voting systems. More specifically, we analyse its potential for increasing trust in future voting systems, we present an illustration of how ballots can be submitted on such a system and describe possible challenges that may require careful consideration during the development. In Section 6, we present existing blockchain based voting systems by categorising them according to the extend that they use this technology, concluding with details of a recent academic implementation. Finally, Section 7 concludes this work with open questions for economists and other social scientists in this area.

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