Thwarting Vote Buying Through Decoy Ballots

(Extended Abstract)

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ABSTRACT

There is increasing interest in promoting participatory democracy, in particular by allowing voting by mail or internet and through random-sample elections. A pernicious concern, though, is that of *vote buying*, which occurs when a bad actor seeks to buy ballots, paying someone to vote against their own intent. This becomes possible whenever a voter is able to sell evidence of which way she voted. We show how to thwart vote buying through *decoy ballots*, which are not counted but are indistinguishable from real ballots to a buyer. We show that an Election Authority can significantly reduce the power of vote buying through a small number of optimally distributed decoys, and model societal processes by which decoys could be distributed.

1. INTRODUCTION

The goal of participatory democracy [9, 11] is to engage citizens more frequently and with more granularity in the decision-making processes of government bodies. Technologies that can help with this transition are those that support voting from the home by mail or over the internet, and that make use of *random sample elections*, in which a representative subsample of the population is tasked with voting on a particular issue, allowing participatory democracy to function without everyone needing to be concerned with every issue.

A significant concern, though, is that of *vote buying*, where a bad actor attempting to gain improper influence in an election by purchasing ballots from voters and paying them to vote against their intent. The practical implications of this are manifold, since the social construct of elections relies on the perception of reliability and fairness. Vote buying has been an ongoing threat to democracy, and new technologies can make the situation worse. For example, web platforms can serve as middlemen, digital currency supports anonymous payments, and abundant data coupled with machine learning can help buyers discover entrapment schemes as well as identify voters to target with offers.

In this short paper, we highlight our results that show that vote buying can be thwarted by distributing *decoy ballots*, which are not counted, in addition to real ballots. A vote buyer will not know whether a ballot is real or decoy, and thus, decoys (if sold) may deplete a buyer's budget. Voters who know that they have a decoy ballot are motivated to sell their ballots to a buyer, both for reasons of profit and out of civic duty, wanting to maintain the integrity of an election.

Decoy ballots have been suggested by Chaum [4], but we are not aware of any analysis of how decoy ballots should be distributed, and how effective they are against vote buying. We assume that real ballots impose a very high cost on society, for the reason that it takes effort for members of society to become informed about an issue and vote appropriately, thus representing their considered opinion on an issue. We model decoy ballots as costly but not so costly that the number of decoys to distribute cannot be considered as a design decision of the Election Authority. The cost of decoys comes about because, to be effective, voters need to be willing to go to the effort to sell the ballot.

Although we situate our discussion in a societal context, similar themes can be easily imagined for economies of AIs [12], where it is desired to elicit and fairly aggregate multiple opinions, but would not be scalable to request input from every agent all the time.

Our Contributions

In this work, we present the first game-theoretic study of the power of decoy ballots in thwarting vote buyers. We derive a characterization of the form of an optimal defense, and compare its power to those of neutral defenses that could be enabled through leveraging simple societal processes to distribute decoys. Our results are positive: decoy ballots are effective in thwarting the power of a vote buyer.

In more detail, we first provide a formal model of vote buying, including a complete characterization of the vote buyer's behavior and an optimal policy for distributing decoy ballots by the Election Authority (EA). In addition, we model two societal processes by which decoys could be distributed—these approaches releasing the EA from any concern that it be seen to be biasing the outcome of an election when distributing decoys.

We show in simulation that the EA can make effective use of decoy ballots to maintain election integrity (e.g., reducing the probability that the buyer changes the outcome to less than 1%). For the optimal defense, we are able to achieve this by adding a small number of decoys that are proportional in quantity to the number of ballots the buyer can afford to buy. We also show that a "civic duty defense," which allocates decoys to a random subset of those who request a ballot, is almost as effective as the optimal defense.

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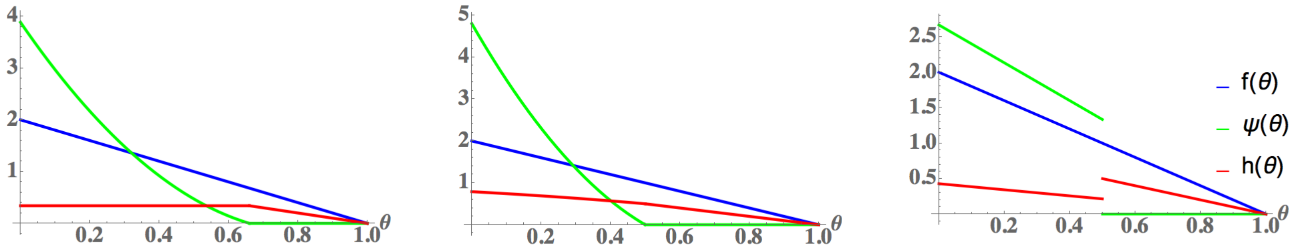
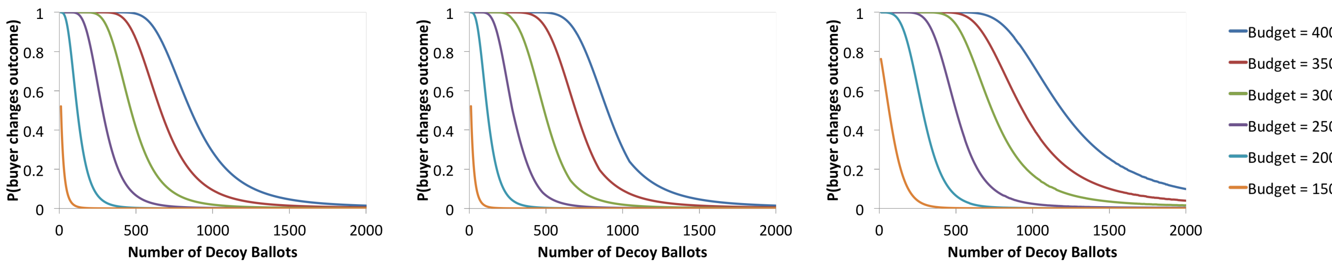


(a) optimal defense (b) civic duty defense (c) auction-based defense

Figure 1: Examples of type distribution $f(\theta)$, decoy distribution $\psi(\theta)$, and desirability to buyer $h(\theta)$ for (a) an optimal defense, (b) a civic duty defense with max type requesting a decoy $x_{\text{C}} = 0.5$ and 10% decoy ballots, (c) an auction-based defense with max type assigned a decoy $x_{\text{A}} = 0.5$ and 50% decoy ballots. Here $f = \text{Beta}(1, 2)$.



(a) optimal defense (b) civic duty defense (c) auction-based defense

Figure 2: Using decoys to thwart vote buying, for different buyer budgets (the number of ballots the buyer can buy). Number of real ballots is 750, the voter type distribution is f = Beta(2,4). The results are qualitatively unchanged for other decoy distributions.

Related Work

There are numerous studies on vote buying, e.g. [8,13,14,17]. These include game-theoretic models of vote buying [6, 10, 16], but none that consider the role of decoy ballots. This work also relates to studies of control and bribery as studied in computational social choice, in particular the problem of *lobbying* [1–3, 5, 7]. There is also a conceptual connection with work on *security games* [15].

2. RESULTS

We model each voter i as having an immutable, publicly observable voter type θ_i, which indicates the probability of voting YES, drawn IID from the distribution f. Without loss of generality, we assume that the election outcome without any interference by a buyer is NO, and that there is a budget-limited buyer, trying to make the election outcome YES. We assume that the buyer knows the decoy distribution ψ, and uses his knowledge of f and ψ to compute $h(\theta) \stackrel{\text{def}}{=} P(\text{real} \wedge \text{NO}|\theta)$, which corresponds to the desirability of a voter's ballot to the buyer.

We prove that the optimal buyer behavior in the subgame equilibrium of the induced game is to buy in order of decreasing $h(\theta)$ until the budget is exhausted. We also derive an expression that, given the buyer's behavior, allows us to compute the probability that the buyer changes the election outcome. This is determined by the fraction of real ballots that can be bought for a given defense.

We prove the following theorem, characterizing an optimal defense:

THEOREM 1. *Defense ψ is the best response of the EA in a subgame perfect equilibrium of the vote buying game if there is some x_{o}, $0 \le x_{\text{o}} \le 1$, s.t. $h(\theta) = \min(1 - x_{\text{o}}, 1 - \theta)$.*

We also prove the functional form of an optimal defense:

THEOREM 2. *For any given n_r real ballots and n_d decoy ballots, the best response of the EA in a subgame perfect equilibrium of the vote buying game is given by a decoy ballot distribution with density function*

$$\psi(\theta) = \begin{cases} \frac{n_r}{n_d} \frac{(x_{\text{o}} - \theta) f(\theta)}{1 - x_{\text{o}}} & \text{for } \theta \in [0, x_{\text{o}}] \\ 0 & \text{for } \theta \in (x_{\text{o}}, 1] \end{cases},$$

where the threshold x_{o} is determined by the following equation: $\frac{1}{1 - x_{\text{o}}} \int_0^{x_{\text{o}}} F(\theta) d\theta = \frac{n_d}{n_r}$ and $F(\theta)$ is the CDF of f.

In addition to the optimal defense, we consider defenses where the EA does not design ψ. These have the advantage that the EA does not play too active a role in, and in that they do not rely on knowledge of the EA. In particular, we consider a *civic duty defense*, where the EA makes decoys available to a random subset of voters who make an explicit request for a decoy, and an *auction-based defense*, where the EA makes decoys available to voters via a simple auction. Example defenses are illustrated in Figure 1.

For an illustration of our main simulation results, Figure 2 fixes the number of real ballots, and shows that vote buying can be successfully thwarted by issuing sufficiently many decoy ballots. The optimal and civic duty defenses are most effective, but even issuing decoys according to the auction-based defense substantially reduces the probability of a vote buyer's success. Even a small number of decoys, relative to the number of real ballots, can be effective.

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REFERENCES

[1] D. Binkele-Raible, G. Erdélyi, H. Fernau, J. Goldsmith, N. Mattei, and J. Rothe. The Complexity of Probabilistic Lobbying. *Discret. Optim.*, 11, Feb. 2014.

[2] F. Brandt, V. Conitzer, U. Endriss, J. Lang, and A. D. Procaccia, editors. *Handbook of Computational Social Choice*. Cambridge University Press, 2016.

[3] R. Bredereck, J. Chen, S. Hartung, S. Kratsch, R. Niedermeier, O. Suchý, and G. J. Woeginger. A Multivariate Complexity Analysis of Lobbying in Multiple Referenda. *J. Artif. Intell. Res. (JAIR)*, 50:409–446, 2014.

[4] D. Chaum. Random-Sample Voting. `http://rsvoting.org/whitepaper/white_paper.pdf`, 2016.

[5] R. Christian, M. Fellows, F. Rosamond, and A. Slinko. On complexity of lobbying in multiple referenda. *Review of Economic Design*, 11(3):217–224, 2007.

[6] E. Dekel, M. O. Jackson, and A. Wolinsky. Vote Buying: General Elections. *Journal of Political Economy*, 116(2):351–381, 2008.

[7] P. Faliszewski and J. Rothe. Control and bribery in voting. In *Handbook of Computational Social Choice*, chapter 7. Cambridge University Press, 2016.

[8] F. Finan and L. Schechter. Vote-Buying and Reciprocity. *Econometrica*, 80(2):863–881, 2012.

[9] A. Goel and D. T. Lee. Towards large-scale deliberative decision-making: Small groups and the importance of triads. In *Proceedings of the 2016 ACM Conf. on Econ. and Comp., EC '16, Maastricht, The Netherlands, July 24-28, 2016*, pages 287–303, 2016.

[10] T. Groseclose and J. M. Snyder. Buying supermajorities. *The American Political Science Review*, 90(2):303–315, 1996.

[11] D. T. Lee, A. Goel, T. Aitamurto, and H. Landemore. Crowdsourcing for participatory democracies: Efficient elicitation of social choice functions. In *Proceedings of the Second AAAI Conference on Human Computation and Crowdsourcing, HCOMP 2014, November 2-4, 2014, Pittsburgh, Pennsylvania, USA*, 2014.

[12] D. C. Parkes and M. P. Wellman. Economic Reasoning and Artificial Intelligence. *Science*, 349(6245):267–272, 2015.

[13] F. C. Schaffer. Why Study Vote Buying? In *Elections for Sale: The Causes And Consequences of Vote Buying*, chapter 1, pages 1–16. Lynne Rienner Pub, 2007.

[14] S. C. Stokes, T. Dunning, M. Nazareno, and V. Brusco. *Brokers, Voters, and Clientelism*, chapter 8. What Killed Vote Buying in Britain and the United States? Cambridge University Press, 2013.

[15] M. Tambe. *Security and Game Theory: Algorithms, Deployed Systems, Lessons Learned*. Cambridge University Press, 2011.

[16] P. C. Vicente. A Model of Vote-buying with an Incumbency Advantage. `http://www.pedrovicente.org/vb.pdf`, 2013.

[17] P. C. Vicente. Is Vote Buying Effective? Evidence from a Field Experiment in West Africa. *The Economic Journal*, 124(574):F356–F387, 2014.