Voting in the Limelight*

Ronen Gradwohl†

Abstract

When committees make decisions, voting rules are coupled with one of three disclosure rules: open voting, in which each committee member's individual vote is revealed; anonymous voting, in which only an anonymized tally is publicized; and secret voting, in which only the outcome is disclosed. I focus on strategic voters who have a preference for strategic ambiguity, and show that the amount of disclosure may have a non-monotonic effect on both the accuracy of the decision and the welfare of the voters. In particular, anonymous voting can yield both lower accuracy and higher welfare than both open and secret voting.

Keywords: Committees, voting, transparency, privacy

JEL Classification: C72, D71

*I gratefully acknowledge NSF award #1216006. I would like to thank David Austen-Smith, Tim Feddersen, Nicola Persico, and Yuval Salant for helpful conversations about this research. I would also like to thank seminar participants at Hebrew University, Northwestern, Technion, Tel Aviv University, and the Econometric Society Meeting in Minneapolis, MN.

†Kellogg School of Management, Northwestern University, Evanston, IL 60208, USA. Email: r-gradwohl@kellogg.northwestern.edu.

1 Introduction

In many economic and political settings, decisions are made collectively by committees. The committee members who participate in these decision-making processes are partly motivated by the quality of the decisions they reach, but they may additionally be concerned about the ex post consequences of the way their votes are perceived. For example, policymakers wish to reach the decision that is best given the true state of affairs, but they may also be disinclined to publicly vote against their constituents' desires. Corporate board members aim to serve their organization, but they may be concerned about the way their votes are perceived by shareholders and the company's CEO. Faculty members electing a department chair want to choose the right person for the job, but they may be hesitant to reveal their votes to the candidates and fellow faculty members.

Moreover, in some of these scenarios the committee members would not like to be seen as voting in *any* particular way, and instead prefer to maintain an ambiguous perception of their vote. For example, Weaver (1986) argues that policymakers may face situations in which "all possible alternatives have strong negative consequences for at least some of the policymakers' constituents..." Regardless of the votes they cast, these policymakers risk alienating some of their constituents, and so they "can only hope to limit their exposure to blame."[1] Similarly, board members of a public company would like to prevent angering both the CEO and activist shareholders, even if they have conflicting views on an issue. And finally, faculty members would not like to be seen as voting against either of the candidates, for fear of requital by that candidate. The policymakers, board members, and faculty members in these examples all have a preference for strategic ambiguity, and prefer that the votes they cast remain private.[2]

One might conjecture that for committees with such members, it would be desirable to institute voting procedures that hide some or all of the information about how the votes were cast. For instance, anonymous voting, in which only an anony-

[1]Or in the words of Shepsle (1972), citing Downs (1957): "On the 'critical issues' parties perceive incentives to equivocate, to 'becloud their policies in a sea of ambiguity.'"

[2]In Appendix A I formalize the micro-foundations for the desire for strategic ambiguity, as motivated by these examples.

mous tally of the votes is publicized, would be preferable to open voting, in which all individual votes are publicly disclosed. And secret voting, in which nothing beyond the final decision is revealed, would be best. In this paper I examine the validity of this conjecture by analyzing these three common disclosure rules—open, anonymous, and secret—when voters have a preference for strategic ambiguity. The main result is that the conjecture is false, and that restricting the amount of information disclosed about the votes may actually be harmful.

More specifically, I study a common-value setting, in which committee members receive signals about the state of the world, and in each state of the world there is a corresponding correct outcome that all members prefer most. In this setting, I compare the three disclosure rules along two dimensions: the probability that the committee decides on the correct outcome, and the welfare of the committee members. In standard common-value voting models, in which voters do not have preferences over how their votes are perceived by others, the welfare of voters is maximized when the probability of correctness is maximized. In this paper, however, the two dimensions are not perfectly aligned, as welfare is impacted not only by the outcome, but also by the inferences that can be drawn by outsiders about committee members' votes.

I show that the amount of information disclosed may have a non-monotonic effect on both the probability of correctness and on the welfare of the committee members. In particular, the first-best probability of correctness is often attained at the extremes—in open voting, when all information is disclosed, and in secret voting, when no information is disclosed—but is not attained in anonymous voting, when some but not all information is disclosed. Furthermore, the welfare of the committee members, while always minimal in open voting, is sometimes maximal in anonymous rather than secret voting.

To see the intuition for the tradeoffs between open, anonymous, and secret voting, and the non-monotonic effect of information disclosure on correctness and welfare, consider first the case of sincere voting. Under sincere voting, committee members always vote for the outcome that is most likely correct, given their respective signals. In this case, the probability of correctness is always the same, and the welfare of committee members decreases with the amount of information disclosed—it is minimal in open voting and maximal in secret voting.

In order to isolate the effects of the preference for strategic ambiguity, in this paper I focus on settings in which there are no other strategic distortions—settings in which, absent concerns for ambiguity, sincere voting is an equilibrium.[3] In this setting, even when committee members have a preference for strategic ambiguity, sincere voting is the unique equilibrium in open voting and often the unique equilibrium in secret voting. However, it is often *not* an equilibrium in anonymous voting. The intuition for this last point is the following: When a committee member obtains a signal, voting sincerely will increase the probability that the more-likely-correct outcome is chosen. However, the probability that one committee member's vote affects the outcome might be small, leading to a possible benefit to voting *non*-sincerely. In particular, if such a deviation does not change the outcome, its effect is to increase the uncertainty about the committee member's vote. In the extreme case, for example, if all members vote for the same outcome then the tally of votes, despite being anonymous, fully reveals everyone's vote. However, a deviation will induce some uncertainty, since the identity of the deviator will remain unknown. Such uncertainty is beneficial to the committee member due to her predilection for strategic ambiguity. When the possible benefit from this induced uncertainty outweighs the risk of obtaining the less-likely-correct outcome such deviations are profitable. Thus, in these cases sincere voting is not an equilibrium, and so the probability that the outcome is correct will be less than under the sincere equilibria of open and secret voting.

In fact, the unique equilibrium here under anonymous voting will be one in which committee members randomize, sometimes voting for the outcome that is most likely correct given their respective signals, but sometimes voting for a different outcome. By adding noise to the outcome of the decision-making process this randomization increases the ambiguity about committee members' votes, leading to an increase in utility. If in equilibrium the utility gain from increased ambiguity outweighs the loss from a lower probability of correctness, the welfare under anonymous voting will be higher than under secret voting. In that case, the equilibrium in anonymous voting will achieve both lower probability of correctness and higher welfare than the equilibria of open and secret voting.

[3] In particular, there is no strategic voting à la Austen-Smith and Banks (1996) and Feddersen and Pesendorfer (1998).

Determining whether the net gain from randomization is positive or negative *in equilibrium* requires finding the equilibrium. This is a notoriously challenging problem in general voting settings, and so in this paper I focus on two tractable settings: a setting with only two players and a setting with many players. In the first I am able to explicitly compute equilibria, and then show that non-monotonicity in welfare holds when the preference for ambiguity is strong, when signals are accurate, and when utility functions are not too convex. In the second setting I prove asymptotic results, ones that hold when the number of players is large enough. The general intuition driving the results is that as players begin to mix more, the gain from greater ambiguity about votes increases linearly with the amount of mixing. At the same time, the loss due to lower probability of correctness increases at a lower rate: In the asymptotic case, for example, even a fairly large amount of mixing will nonetheless lead to the correct outcome with high probability, and so such mixing will yield a net welfare gain.

Organization Immediately following is a review of the related literature. Section 2 contains the 2-player model and the various non-monotonicity results. Section 3 presents the many-player model as an extension of the 2-player model, and contains the relevant results. Section 4 concludes. Additionally, Appendix A formalizes micro-foundations for the desire for strategic ambiguity inspired by the examples from the introduction, and Appendix B contains various extensions of and variations on the model.

1.1 Related Literature

Absent a preference for strategic ambiguity, the models analyzed in this paper fall within the framework studied by Austen-Smith and Banks (1996) and Feddersen and Pesendorfer (1998), who identify a conformity effect in strategic voting—namely, that in equilibrium voters condition on being pivotal and thus may disregard their own information. In this paper I focus on settings in which this strategic effect is non-existent, so as to isolate the effects of committee members' preference for strategic ambiguity.

This paper is related to the literatures on position taking (c.f. Mayhew, 1974) and vote buying, in which policymakers are rewarded by outsiders, such as special-interest groups, for voting a particular way. Such policymakers, in addition to being concerned about the outcome of a vote, are thus also concerned about how their individual votes are perceived. Papers such as those of Snyder and Ting (2005), Dal Bó (2007), Felgenhauer and Grüner (2008), and Seidmann (2011) analyze decision-making in committees when members are influenced by outsiders in this way. A main difference between this literature and the current paper is that in the former, committee members would like to publicly favor a *particular* outcome, namely the one advocated by their constituency or special-interest group. In the current paper, however, I consider situations in which members prefer ambiguity and do not want to be seen as taking a position on *any* particular outcome. This addresses one critique of position taking, due to Hurley (2001), about the possibility that committee members are influenced by heterogenous special-interest groups or constituents. It is also related to the notion of position *avoidance* (Jones, 2003), issue avoidance (Thomas, 1991), and strategic ambiguity in politics (Shepsle, 1972), in which legislators do not wish to take a position on any outcome.

The tradeoff faced by committee members who desire strategic ambiguity is similar to the tradeoff faced by voters in Razin (2003). In that paper, voters have a desire to elect a candidate with policies closer to their own, which is analogous to committee members in the current paper wanting to choose the correct outcome. Additionally, voters have a signaling motivation, as the tally of votes affects the policy of the elected candidate.[4] In fact, the latter motivation is analogous to a desire for privacy, in that voters wish the tally to be as close to a tie as possible. Razin (2003) considers only the case of anonymous voting, and shows that the conflicting motivations lead to inefficient equilibria.

The concerns for strategic ambiguity in this paper are also related to career concerns, first modeled by Holmström (1999). Careerist committee members care about signaling a particular trait of their type, for example that they are well-informed, that they are unbiased, that they are hawks or doves with respect to a particular policy, or that they are skilled bargainers. Various papers, including those of Sibert (2003), Fingleton and Raith (2005), Visser and Swank (2007), Levy (2007a,b), Stasavage (2007),

[4]See also **?**.

and Gersbach and Hahn (2008), study the effects of such careerist concerns on decision making in committees, and some consider the question of whether transparency—i.e., open voting—is better than secret voting.[5] With career concerns, different disclosure rules may lead to different inferences about committee members' types, and so affect behavior. There are two main differences between these papers and the current one. First, in this paper, committee members are concerned about the direct, ex post consequences of their votes, as in the position taking and vote buying literatures. This is in contrast with the literature on career concerns, in which the committee members are concerned about how their vote leads to various perceptions about their type. The second difference is that this literature focuses mostly on the comparison between open and secret voting, sometimes arguing for the optimality of the former and sometimes the latter. The current paper, in contrast, highlights the non-monotonicity that manifests itself in the important intermediate case of anonymous voting.[6]

Finally, this paper is part of a recent literature that strives to understand the effects of privacy concerns in various decision-making contexts (**?**Kearns et al., 2012; Nissim et al., 2012; Chen et al., 2013; Gradwohl and Smorodinsky, 2014; Dziuda and Gradwohl, 2015). One significant conceptual difference between those papers and the current one is that in the former, individuals would like to maintain the privacy of their *types*, whereas in the latter individuals are concerned about strategic ambiguity—or, in other words, the privacy of their *actions*.[7]

[5]Empirical studies of the same question include Meade and Stasavage (2008) and Swank et al. (2008).

[6]One notable exception is Levy (2007a) who, in a setting with career concerns, also observes that a non-monotonicity may arise in terms of the probability of correctness, and in particular that anonymous voting might be strictly worse than both open and secret voting. The widespread prevalence of anonymous voting in some settings (e.g. Robbins, 2007) is, however, somewhat incongruous with this finding. The current paper provides one justification for anonymous voting by showing that it may actually dominate open and secret voting in terms of welfare.

[7]However, in Section B.5 I show that some of the qualitative results of this paper hold also when individuals are concerned about the privacy of their signals, rather than their actions.

2 The 2-Player Model

In this section I describe the 2-player model, which will serve also as a foundation for the many-player model of Section 3. As noted above, in order to isolate the effects of disclosure and privacy concerns I focus on a setting in which there are no strategic effects caused by other considerations (such as those in Austen-Smith and Banks (1996) and Feddersen and Pesendorfer (1998)).

To this end, suppose that there are two possible states of the world, $\Theta = \{A, B\}$, that are equally likely. The committee must vote to decide between two possible outcomes, $\{A, B\}$, where each state corresponds to a *correct* outcome, namely A in state A and B in state B. Each member of the committee, called a player, receives a conditionally-independent, identically-distributed signal $s_i \in \{a, b\}$ satisfying

$$\Pr [s_i = a | \text{state } A] = \Pr [s_i = b | \text{state } B] = p,$$

where $p \in (1/2, 1)$ is the *accuracy* of the signal. After receiving her signal, each player submits a vote $m_i \in \{a, b\}$. The result is determined by a *voting procedure*, namely a voting rule coupled with a *disclosure rule*. In this section I will focus on the voting rule in which the outcome is A if $m_1 = m_2 = a$, and B otherwise, and so B may be viewed as the status quo that requires unanimity in order to be overturned.[8] The disclosure rule determines what information, in addition to the outcome, is revealed following the vote. We will focus on three important disclosure rules: open voting, in which both players' votes are revealed; anonymous voting, in which only the tally of the votes is revealed; and secret voting, in which nothing beyond the outcome is revealed. Now, part of the players' utilities comes from the correctness of the outcome: Namely, they get a utility of 1 if the outcome is the correct one, and 0 otherwise. However, there is another element to players' utilities that depends on the information disclosed, which I now describe.

In addition to the two voting players, there is a third participant called the *observer*. The observer has no utility function, does not receive a signal, and takes no actions. His sole purpose is to draw inferences about the players' votes. The observer observes the information disclosed by the voting procedure—the full voting profile under open voting, the tally of the votes under anonymous voting, or just the

[8] In Section 3 we will consider the case of majority rule.

outcome under secret voting—and then draws inferences, via Bayes' rule, about each player's vote.

For example, under open voting, the observer can completely infer a player's vote, since he observes the entire voting profile. Under anonymous voting, however, this is only sometimes the case. If the tally is 2:0 (respectively, 0:2), then the observer can infer that each player voted for A (respectively, B). However, if the tally is 1:1, then the inference drawn by the observer about a particular player's vote is $1/2$: that is, there is a chance of $1/2$ that a particular player voted for B (or A).[9] In this model, a player's utility will depend both on the correctness of the outcome and on the observer's inferences about her vote.

For each player i there is a continuous privacy cost function $C_i : [0, 1] \mapsto \mathbb{R}_+$, where the domain of the function represents the probability that the observer assigns to the event that player i voted b. This C_i is a reduced-form representation of players' concerns for strategic ambiguity, and captures the costs incurred by a player as a consequence of the information disclosed about her vote. In Appendix A I formalize micro-foundations for this privacy cost function, motivated by the examples from the introduction.

The utility of player i given state θ, outcome $o \in \{A, B\}$, and inference I is then

$$u_i(\theta, o, I) = \mathbf{1}_{(o=\theta)} - C_i(I),$$

where the symbol $\mathbf{1}_{(\cdot)}$ denotes the indicator function.

I make some assumptions about the cost function in order to capture the players' predilection for strategic ambiguity. First, the cost function satisfies $C_i(1/2) = 0$: This corresponds to no loss when the observer can infer nothing about the player's vote, and nonnegative loss when the observer can draw an inference (since the range of C_i is $\mathbb{R}_+$). I also assume that C_i is strictly decreasing on $[0, 1/2]$ and strictly increasing on $[1/2, 1]$. Furthermore, sometimes I will make the stronger assumption that C_i is convex, in order to capture the idea that the privacy cost is larger when the inference is more precise, but the loss may be very small when the inference is weak (i.e. close to the no inference, $I = 1/2$, case).

[9] The inference of $1/2$ is derived by Bayes' rule, under the symmetry assumption about the players' strategies to be discussed.

For tractability I make two additional, simplifying assumptions on C_i that do not change the qualitative results of the paper. First, I assume that $C_1 \equiv C_2 \equiv C$. Second, I assume that $C(0) = C(1)$, and sometimes use $c \stackrel{\text{def}}{=} C(1)$.

Voting Voting is *sincere* if each player votes according to her signal. It is *responsive* if players vote differently depending on the signal they obtain (this rules out equilibria where players ignore their signals).[10] While sometimes we will consider the case in which players are assumed to vote sincerely, the more interesting case is when players vote strategically. We will use an appropriate variant of responsive, symmetric Nash equilibria as the solution concept, where each player's strategy σ is a function of her signal. More formally, an equilibrium consists of a symmetric, responsive strategy profile and inferences made by the observer, where those inferences depend on the outcome as well as information revealed (i.e., the voting profile in open voting and the tally of votes in anonymous voting). The strategy profile must be a symmetric Nash equilibrium subject to the inferences of the observer, and the observer's inferences must be correct in equilibrium – they are determined by p, the strategy profile, and the revealed information via Bayes' rule.[11]

We will be interested in two dimensions when comparing various information disclosure policies. First, we will consider the probability of getting the correct outcome, $\Pr[o = \theta]$. Second, we will consider the welfare of a player i, namely $\mathcal{E}[u_i(\theta, o, I)]$.[12] Both the probability and the expectation are over the realizations of the state, the players' signals, and the possible randomization in the players' strategies.

2.1 Sincere Voting

In this section I perform a preliminary analysis of the three disclosure rules while maintaining the assumption that players vote sincerely. As will be described in the following sections, sincere voting is not always an equilibrium, and thus the results

[10] For the symmetric, two player case, assuming that players do not play weakly dominated strategies suffices to rule out such equilibria. This is not true for more general cases (see Feddersen and Pesendorfer, 1998).

[11] There will be no "off-equilibrium" inferences, as all outcomes will occur with positive probability.

[12] Recall that players are symmetric, so in a symmetric equilibrium they obtain the same expected utilities.

of Propositions 1 and 2 below will not hold under strategic voting.

We begin with the following simple proposition:

Proposition 1 *Under sincere voting and any disclosure rule,* $\Pr[o = \theta] = p$.

Next, denote by $U^O(p)$, $U^A(p)$, and $U^S(p)$ the expected utilities of a player in open, anonymous, and secret voting, respectively, when the accuracy of signals is p and assuming that players vote sincerely.

Proposition 2 *If C is convex then $U^O(p) < U^A(p) \leq U^S(p)$ for every $p \in (1/2, 1)$, with a strict inequality under strict convexity.*

The proof of this proposition appears in the appendix, but the intuition is quite straightforward. Observe first that if the outcome is A, then regardless of the disclosure rule, players' votes are fully revealed. This is because the only way to obtain outcome A is when both players vote a. The differences in a player's utilities must therefore arise from inferences when the outcome is B.

Consider first a comparison between open and anonymous voting. In the former, the vote of a player is always revealed, and so she always suffers the disutility $C(1)$ or $C(0)$. In the latter, however, this is only true when the revealed tally is 0:2, which means both players voted for b. If the tally is 1:1, however, the incurred disutility is $C(1/2) = 0 < C(1)$, so the privacy cost is lower and hence the expected utility higher than in open voting.

Consider now a comparison between anonymous and secret voting. In the latter, the disutility incurred is $C(I)$, where I is the observer's inference about the probability a player voted b given outcome B. If $C(I)$ were linear in I, then the privacy cost here would be the same as the expected privacy cost in anonymous voting (given outcome B), by linearity of expectation. However, since C is strictly convex, the incurred privacy cost in secret voting is smaller than the expected privacy cost in anonymous voting, leading to a higher expected utility.

2.2 Strategic Voting

In this section I analyze the equilibria of the three voting procedures. Let us begin with open voting: Since the observer observes who voted for what, he will draw an inference of $I = 1$ if the player voted b or $I = 0$ if the player voted a. Thus, each player will always incur a cost $C(1)$ or $C(0)$, leading to the following proposition:

Proposition 3 *In open voting, sincerity is the unique equilibrium.*

If there were no privacy concerns and players were motivated solely by the probability of correctness, then sincerity would be an equilibrium. In open voting players always incur the full privacy cost, and so here this dimension of players' utilities is neutralized and sincerity remains an equilibrium.

In anonymous voting, the observer observes a tally of either 2:0, 0:2, or 1:1. In the first two cases he will draw an inference of $I = 0$ or $I = 1$, leading to a maximal privacy cost. However, if the tally is 1:1, the observer's inference will be $I = 1/2$, for which the privacy cost is 0. Now, while sincere voting is always an equilibrium in open voting, this is never the case in anonymous voting.

Proposition 4 *In anonymous voting, sincerity is never an equilibrium.*

Consider the following intuition. Suppose players vote sincerely. When a player receives signal b it is likely that the other player received the same signal. In that case, the player would want to deviate, since a deviation to a will not change the outcome, but will yield a lower privacy cost (namely, $C(1/2) = 0$ rather than $C(1) = c$). There is a cost, however—if the other player voted a, then a deviation *will* change the outcome to A. However, note that if the other player voted a then she must have received signal a. But then the players received different signals, and so the posterior on the state is the same as the prior. In this case, the players are actually indifferent between the two outcomes. Thus, the benefit derived from a deviation always outweighs the cost of changing the outcome to A, and so it is profitable. This implies that sincerity is not an equilibrium.

Sincerity is not an equilibrium in anonymous voting, but there always exists an equilibrium in which voters play mixed strategies.

Proposition 5 *For each p there exists a threshold $c^*(p) < 1$ such that the following holds:*

- *if $c \leq c^*(p)$ then the unique equilibrium in anonymous voting with signal accuracy p is one in which players vote sincerely on signal a, but mix on signal b, and*

- *if $c > c^*(p)$ then in the unique equilibrium players mix on both signals.*

For some intuition, recall that by Proposition 4 sincere voting is not an equilibrium, and clearly always voting against one's signal cannot be part of an equilibrium. Thus, there must be some mixing in equilibrium. When a player mixes, the possible benefit is a reduction in privacy costs, but the harm is that the outcome may be incorrect. While mixing on either signal confers the same benefit, the harm is lower when mixing on signal b, since in that case the outcome changes only if the other player also votes a. Thus, for small c there will only be mixing on signal b. For large c the benefit of mixing on either signal outweighs the harm, and so players will also mix on signal a.

In secret voting, the observer's inference is based solely on the outcome. If the outcome is A, then he can infer that both players voted a, leading to the inference $I = 0$ and maximal privacy cost c. However, if the outcome is B, the inference is a bit more involved, as it depends on the strategy profile employed by the players. But given a strategy profile σ, the inference on outcome B is straightforward to calculate with Bayes' rule.

Now, depending on the privacy cost C and the accuracy p of the signal, sincerity may or may not be an equilibrium under secret voting. In particular, sincerity is an equilibrium if and only if c is less than a threshold $\overline{c}(p)$, where

$$\overline{c}(p) = \frac{(p^2 + (1-p)^2) \cdot C\left(\frac{1}{1+2p(1-p)}\right) + 2p - 1}{p^2 + (1-p)^2}.$$

Proposition 6 *In secret voting, sincerity is an equilibrium if and only if $c \leq \overline{c}(p)$. For $c > \overline{c}(p)$, the unique responsive equilibrium involves players voting sincerely on signal b, but mixing on signal a.*

The intuition is the following. Since players only affect the outcome (and thus the information disclosed) when they are pivotal, they condition on being pivotal. Pivotality here means that the other player voted for a. A pivotal player must choose between voting a, obtaining outcome A, but losing all privacy (since then the outcome will be A, leading to an inference of $I = 0$), or voting b, obtaining outcome B, and obtaining an inference $I < 1$. So voting b dominates voting a in terms of the privacy cost. Now, on signal b, a pivotal player can also infer that state B is at least as likely as A, and so voting b is always optimal. On signal a, a pivotal player can infer that A is more likely. If she values the more-likely-correct outcome but higher privacy cost (voting a) more than the less-likely-correct outcome but lower privacy cost (voting b), then she will vote a, leading to sincere voting.

If, however, a pivotal player does not value the outcome enough relative to her privacy concerns (that is, c is large), then in equilibrium she mixes on signal a. A strategy profile in which players mix on signal a means that the inference I on outcome B will be closer to 1. Thus, the privacy cost of voting b will be higher. At some level of mixing, the privacy cost of outcome B will be sufficiently high so that a pivotal player receiving signal a is indifferent between the more-likely-correct outcome A and maximal privacy cost, and the less-likely-correct outcome B and somewhat lower privacy cost.

2.3 A Comparison of Disclosure Rules

We will compare the three disclosure rules along two dimensions: the probability of obtaining the correct outcome, and the welfare of the players.

2.3.1 Probability of Correctness

Absent any privacy concerns, the probability of obtaining the correct outcome is p. By Proposition 1, this first-best is also obtained whenever voting is sincere. It is thus obtained under strategic voting whenever sincere voting is an equilibrium: namely, in open voting and in secret voting with $c \leq \bar{c}(p)$. Notice further that the probability of correctness approaches 1 as the signal increases in accuracy, i.e. $\lim_{p \to 1} \Pr[o = \theta] = 1$.

However, an implication of proposition 4 is that when voting is anonymous, strategic voting is harmful in terms of the probability of obtaining the correct outcome.

Proposition 7 *For any equilibrium in anonymous voting it holds that* $\Pr[o = \theta] < p$. *Furthermore,* $\lim_{p \to 1} \Pr[o = \theta] < 1$.

Thus, in terms of the probability of correctness, anonymous voting is always worse than open voting, and sometimes worse than secret voting. In particular, the amount of information disclosed has a non-monotonic effect on the probability of correctness.

An additional, minor note in the comparison between anonymous and secret voting is that when sincerity is not an equilibrium under secret voting, the bias in the outcome goes in the opposite direction of the bias produced by anonymous voting: In anonymous voting players vote sincerely on signal a and mix on signal b, whereas in secret voting players mix on signal a and vote sincerely on signal b.

2.3.2 Voter Welfare

Proposition 2 states that under sincere voting, disclosing less information improves the expected utilities of the players. In this section we show that this monotonicity may break down under strategic voting. More specifically, the welfare obtained under open voting is always the lowest of the three. However, there are some cases in which the welfare in anonymous voting is higher than in secret voting. The three propositions in this section identify distinct conditions under which this is true.

Denote by $U^A(\sigma, p)$ and $U^S(\sigma, p)$ the expected utilities of a player under anonymous and secret voting, respectively, when the strategy profile is σ and the accuracy of signals is p. Consider first a setting in which privacy concerns are very large relative to committee members' utilities from the outcome. One might expect that in this case, secret voting will surely dominate anonymous voting in terms of welfare. The first proposition below, however, shows that this is not the case.

Fix any cost function C, and for any $\alpha > 0$ define the cost function $C_\alpha : [0,1] \mapsto \mathbb{R}$ as the cost function that satisfies $C_\alpha(I) = \alpha \cdot C(I)$ for all $I \in [0,1]$. Denote by $U^A_\alpha(\sigma, p)$ and $U^S_\alpha(\sigma, p)$ the expected utilities of a player in the game with cost function C_α under anonymous and secret voting, respectively, when the strategy profile is σ and the accuracy of signals is p.

Proposition 8 *For every α let σ^A_α be the equilibrium in anonymous voting and σ^S_α the equilibrium in secret voting, when the cost function is C_α. Then there exists an α_0 such that $U^A_\alpha(\sigma^A_\alpha, p) > U^S_\alpha(\sigma^S_\alpha, p)$ for all $\alpha \geq \alpha_0$.*

The intuition underlying this proposition is the following. When privacy costs are large, the equilibrium in anonymous voting involves mixing on both signals. As α grows, the amount of mixing approaches $1/2$, since players wish to maximize the probability of a 1:1 tally. In the limit, the privacy costs of the players approach

$C_\alpha(1)/2$: With probability approaching 1/2, the players vote for the same outcome and incur maximal privacy costs, and with probability approaching 1/2 they vote for different outcomes and incur no privacy costs. However, in secret voting the equilibrium involves mixing only on signal a. In fact, as α grows, the amount of mixing on signal a approaches 1, and so in the limit both players vote b. Thus, as α gets large, the privacy cost approaches the maximal $C_\alpha(1)$. Finally, when α is large the utilities of the players are dominated by the privacy costs, and so for such α the welfare under anonymous voting is larger than under secret voting.

What happens when privacy costs are small relative to the utilities derived from the outcome? The following proposition shows that a similar result sometimes holds: anonymous voting yields higher welfare in equilibrium than secret voting when p is large enough.

Proposition 9 *For every $c_0 < 1$ there exists $p_0 < 1$ for which the following holds: If $c \leq c_0$ then for all $p \geq p_0$, the equilibria σ^A in anonymous voting and σ^S in secret voting satisfy $U^A(\sigma^A, p) > U^S(\sigma^S, p)$.*

The intuition for this result is the following. The bound on c guarantees that sincere voting will be an equilibrium in secret voting, and suppose the outcome is B. When p approaches 1 then the state is B with increasingly high probability, and the inference made by the observer approaches 1. Thus, with high probability the players will incur nearly maximal privacy cost, and the welfare in secret voting will approach that of open voting. Now, while the welfare in anonymous voting will also approach that of open voting, at some point this convergence will halt due to strategic voting. For increasingly large values of p, the welfare of secret voting will keep dropping, whereas that of anonymous voting will not, and so eventually the latter will dominate the former.

Proposition 9 shows that for any cost function C with small enough c, anonymous voting yields higher welfare in equilibrium than secret voting when p is large enough. The following proposition shows that if C is not too convex, then this welfare ordering holds for nearly all $p > 1/2$. In the following proposition, "not too convex" means that the distance between $C(p)$ and $\ell(p) = 2cp - c$ (where the latter is the linear cost function) is small.

In the following, denote by p_0 the smallest number for which $c \leq \frac{2p_0-1}{p_0^2+(1-p_0)^2}$, and by $d_\ell \stackrel{\text{def}}{=} \max_{p_0<p<1}\{2cp - c - C(p)\}$ the distance of $C(p)$ from linearity.

Proposition 10 *Let σ^A be an equilibrium in anonymous voting and σ^S an equilibrium in secret voting. Then there exists an $\varepsilon > 0$ such that if $d_\ell < \varepsilon$ then $U^S(\sigma^S, p) < U^A(\sigma^A, p)$ for all $p \geq p_0$.*

Note that $p_0 \to 1/2$ as $c \to 0$, so when c is small it is indeed true that the welfare in anonymous voting is higher than in secret voting for nearly all $p > 1/2$.

A simple corollary applies to the case in which C is linear on $[1/2, 1]$:

Corollary 1 *If $C(p) = 2cp - c$ for all $p \in [1/2, 1]$ then $U^S(\sigma^S, p) < U^A(\sigma^A, p)$ for all $p \in (1/2, 1)$.*

The intuition for these results is the following. If C is linear, then the welfare from sincere, anonymous voting and sincere, secret voting is the same (due to linearity of expectation and linearity of C). Under secret voting, sincerity is an equilibrium, but under anonymous voting it is not. However, the equilibrium in anonymous voting strictly increases the welfare of players: as players mix more, the gain from lower privacy costs increases linearly with the amount of mixing, whereas the loss due to lower probability of correctness increases quadratically with the amount of mixing (since both players need to vote a to upend the status quo). The result of Proposition 10 then follows whenever C is in actuality not far from linear, so that the welfare increase due to strategic voting in anonymous voting surpasses the "non-linearity" of C.

3 The Many-Player Model

In this section I consider a setting with many players, and find asymptotic results. I will assume that the number of players n is odd, and that the outcome is determined by simple majority rule. Additional simplifying assumptions on the cost function C are that it is differentiable on $(0, 1/2) \cup (1/2, 1)$, and that it is symmetric, with $C(I) = C(1 - I)$ for all $I \in [0, 1]$.[13]

[13]This second assumption is mainly for simplicity. A weaker assumption guaranteeing that sincerity is an equilibrium under secret voting would suffice.

3.1 Probability of Correctness

In this setting it is straightforward to see that under open voting sincerity is an equilibrium, just as in Proposition 3. It is also clear that sincere voting is always an equilibrium under secret voting: This is because the inference I_A on outcome A is equal to $1 - I_B$, where I_B is the inference on outcome B. So on signal a, if a player is pivotal then A is more likely to be the realized state, and so she contemplates the more likely outcome with a loss of $C(I_A)$ and the less likely outcome with a loss of $C(I_B) = C(1 - I_A) = C(I_A)$. She will choose the former and vote a sincerely.

The following theorem states that, for large enough n, sincere voting is not an equilibrium under anonymous voting.

Proposition 11 *There exists an n_0 such that if $n > n_0$ then sincerity is not an equilibrium under anonymous voting.*

The intuition is that for large enough n, the probability of an individual vote mattering is negligible, but the gain from a deviation from sincerity is substantial. In particular, while the probability of an individual vote mattering—that is, that a particular player is pivotal—is exponentially small in n, deviating from sincerity will lead the inference about the vote to get closer to $1/2$ by roughly $1/n$. The latter is asymptotically much larger than the former, and so a deviation will be profitable.

3.2 Voter Welfare

In this section I show that the welfare in anonymous voting is higher than in secret voting. I will place a restriction on equilibria, and only consider ones that are symmetric not only across players but also across signals. That is, for any player i the probability he votes $m_i = s_i$ is independent of whether $s_i = a$ or $s_i = b$. Because of the symmetric nature of the voting rule and the payoffs such equilibria always exist.

Proposition 12 *Let C be convex. Fix $p \in (1/2, 1)$, and for every n let σ_n^S and σ_n^A be the symmetric equilibrium profiles when there are n players under secret and anonymous voting, respectively. Then there exists an n_0 such that if $n > n_0$ then $U^S(\sigma_n^S, p) < U^A(\sigma_n^A, p)$.*

Proposition 11 showed that sincerity is not an equilibrium under anonymous voting, for large enough n. But why is mixing beneficial to the players? By mixing, they decrease the probability of correctness, but also the privacy cost. The latter holds because mixing leads to a "noisier" distribution, and so more voting profiles that are closer to 50:50 (with full mixing—voting uniformly for both signals—the privacy cost is minimal). The question is then whether the gain from lower privacy costs compensates the players for the loss due to lower probability of correctness. Under sincere, secret voting, the privacy cost will be roughly $C(p)$. Under anonymous voting, however, it will be substantially lower: If players mix so that they vote according to their signal with probability $q < p$, the expected privacy cost will be close to $C(q)$, where $C(q) < C(p)$. However, even with such mixing the probability of correctness will be close to 1 (for large n), since $q > 1/2$. This amounts to a net welfare gain.

4 Conclusion

In this paper I analyzed a simple common-value voting framework, and showed that restricting the amount of information disclosed about votes can lead to unexpected distortions when players have a preference for strategic ambiguity. In particular, the amount of information disclosed has a non-monotonic effect on both the probability of correctness and on the welfare of players.

There are many extensions and variations on the model that seem interesting. Below I consider a few of them and, in the appendix, briefly argue that the non-monotonicity results of the paper sometimes generalize. More in-depth analyses are deferred to future work.

Throughout this paper I have assumed that players cannot abstain from voting. Essentially, this amounts to assuming that the voting rule is a threshold rule—that is, in order to decide on outcome A at least 2 votes are necessary (irrespective of the number of voters not abstaining). Thus, an abstention is implicitly equivalent to a vote for B. While such a view is sometimes reasonable, there is an opposing contention that abstention is an explicit response to privacy concerns (see for example Thomas, 1991). Under this view, the privacy cost associated with an explicit vote for B is higher than the privacy cost associated with an implicit vote for B via abstention.

In Appendix B.1 I show that, in some cases, the non-monotonicity results hold even with the possibility of abstention.

Another important assumption made in this paper is that players do not communicate before voting. Intuitively, this seems crucial for the result on anonymous voting—if players could share their signals with one another, then in the 2-player model the tally on an anonymous vote for B would always be 1:1, and the probability of correctness would be maximal. Nonetheless, in Appendix B.2 I argue that this intuition is somewhat inaccurate, and that in some settings the non-monotonicity could hold also with pre-vote communication.

I also assumed the setting to be one in which, absent a preference for strategic ambiguity, sincerity is an equilibrium. Of course, this need not be the case more generally. If sincere voting is not an equilibrium, then an appropriate choice of disclosure rule could make voting "more sincere". In fact, for some settings of the parameters (described in Appendix B.3) there could be a non-monotonicity in the probability of correctness in which anonymous voting is *maximal*.

Two other modifications are interesting: First is the case in which the observer is also a player who participates in the vote, and I argue in Appendix B.4 that this is a straightforward extension of this model in which all qualitative results still hold. The second is the case in which individuals are concerned about the privacy of their signals, rather than their actions. In Appenix B.5 I argue that the non-monotonicity results about the probability of correctness hold also when individuals are concerned about the privacy of their signals, rather than their actions.

Appendix

A Micro-Foundations

In this section I formalize micro-foundations for the desire for strategic ambiguity, motivated by the examples in the introduction. Suppose there are two states of the world, $\Theta = \{A, B\}$, and two outcomes $O = \{A, B\}$. The outcomes can correspond to two alternatives facing a policymaker, or to two candidates vying to be department chairs. Outcome $o \in \{A, B\}$ is the better outcome in state $\theta = o$. One of the outcomes will be chosen. Additionally, there are two observers $V = \{V_A, V_B\}$, representing the two constituencies of the policymaker, or the two candidates for department chair. The utility of observer V_o, denoted $u_o : O \times \Theta \mapsto \mathbb{R}$, depends on which outcome o is chosen and on the state of the world θ, and satisfies

$$u_o(o, o) > u_o(o, o') > u_o(o', o') > u_o(o', o),$$

where $o' \in O$, $o' \neq o$. That is, observer V_o lexicographically prefers outcome o to the other outcome. However, fixing the outcome, he prefers that the chosen outcome be the better outcome in the realized state. Note that in the policymaker example, these utilities imply that maximizing the probability of correctness is equivalent to maximizing the total welfare of the constituencies (assuming their respective utilities are symmetric).

Next, there is a committee that votes on the outcomes. After observing the result of the voting rule and the disclosure rule, each observer infers the vote cast by each committee member. Observers reward those voters whom they believe voted for their preferred outcome, and punish those whom they believe voted for the other outcome. That is, constituencies reward policymakers who voted for their preferred outcome, and punish the others. Candidates for department chair reward faculty members who voted for them, and punish those who voted against them.

More specifically, given an inference $I \in [0, 1]$ (denoting the inferred probability that a particular committee member i voted for outcome B):

- if $I > 1/2$, observer V_B rewards i by $\mathrm{re}_i^B(I) > 0$ and observer V_A punishes i by $\mathrm{pu}_i^A(I) > 0$;
- if $I < 1/2$, observer V_A rewards i by $\mathrm{re}_i^A(I) > 0$ and observer V_B punishes i by $\mathrm{pu}_i^B(I) > 0$;
- if $I \geq 1/2$ observer V_B does not punish and observer V_A does not reward: $\mathrm{pu}_i^B(I) = \mathrm{re}_i^A(I) = 0$; and
- if $I \leq 1/2$ observer V_A does not punish and observer V_B does not reward: $\mathrm{pu}_i^A(I) = \mathrm{re}_i^B(I) = 0$.

The utility of committee member i given state θ, chosen outcome $o \in \{A, B\}$, and inference I of the observers is

$$u_i(\theta, o, I) = \mathbf{1}_{(o=\theta)} + \mathrm{re}_i^A(I) + \mathrm{re}_i^B(I) - \mathrm{pu}_i^A(I) - \mathrm{pu}_i^B(I).$$

Fixing $\widetilde{C}_i(I) \stackrel{\text{def}}{=} -(\mathrm{re}_i^A(I) + \mathrm{re}_i^B(I) - \mathrm{pu}_i^A(I) - \mathrm{pu}_i^B(I))$, we get that the utility of a committee member is

$$u_i(\theta, o, I) = \mathbf{1}_{(o=\theta)} - \widetilde{C}_i(I).$$

Now, Lau (1985) provides evidence for "negativity bias," which is the "tendency [of voters] to be more sensitive to real or potential losses than they are to gains," (Weaver, 1986). This negativity bias translates into greater punishments than rewards, for example by constituents to policymakers, leading to the blame-avoidance behavior described by Weaver (1986). The following claim states that in the presence of such negativity bias, the committee members optimally prefer to maintain the privacy of their vote:

Claim 1 *If for all $I \in [0, 1]$ it holds that $\mathrm{pu}_i^A(I) \geq \mathrm{re}_i^B(I)$ and $\mathrm{pu}_i^B(I) \geq \mathrm{re}_i^A(I)$, then for any $o \in O$ and $\theta \in \Theta$*

$$\frac{1}{2} \in \arg\max_{I \in [0,1]} u_i(\theta, o, I).$$

The proof is straightforward, as $\widetilde{C}_i(1/2) = 0$ whereas $\widetilde{C}_i(I) \geq 0$ elsewhere.

For a simple example, consider the symmetric, linear case in which $\mathrm{re}_i^B(I) = \mathrm{re}_i^A(1 - I) = r(I - 1/2)$ for $I \geq 1/2$, and $\mathrm{pu}_i^B(I) = \mathrm{pu}_i^A(1 - I) = p \cdot (1/2 - I)$ for $I \leq 1/2$, where $r, p \in \mathbb{R}_+$. The following is a corollary of the claim above:

Corollary 2 *If $p > r$ then $\arg\max_{I \in [0,1]} u_i(\theta, o, I) = \{1/2\}$ for all $o \in O$ and $\theta \in \Theta$. Furthermore, in this case $\widetilde{C}$ is convex and strictly increasing on $[1/2, 1]$.*

B Variations and Extensions

In Section 2.3 I have shown that the amount of information disclosed has a non-monotonic effect on the probability of correctness and on the welfare of players. In this section I discuss some of the simplifying assumptions made in the analysis, and argue that relaxing them mostly leaves the qualitative results unchanged. I also describe various extensions of and variations on the model.

B.1 Abstention

Throughout this paper I have assumed that players cannot abstain from voting. Essentially, this amounts to assuming that the voting rule is a threshold rule—that is, in order to decide on outcome A at least 2 votes are necessary (irrespective of the number of voters not abstaining). Thus, an abstention is implicitly equivalent to a vote for B.

While such a view is sometimes reasonable, there is an opposing contention that abstention is an explicit response to privacy concerns (see for example Thomas, 1991). Under this view, the privacy cost associated with an explicit vote for B is higher than the privacy cost associated with an implicit vote for B via abstention. So how does the possibility of abstention affect the results of this paper?

In this section I will show that in some settings, the results are robust to the possibility of abstention. Suppose that players have cost function $C : [0,1]^2 \mapsto \mathbb{R}_+$, where the first element of the domain of the function represents the probability that the observer assigns to the event that a player abstained, and the second element is the probability that the player voted b (and of course, the sum of the two is bounded above by 1). Assume as before that $C(0, 1/2) = 0$, that $C(0, 1) = C(0, 0) = c$, and that $C(0, \cdot)$ is strictly decreasing on $[0, 1/2]$ and strictly increasing on $[1/2, 1]$.

What should the cost function be when players are believed to abstain with some positive probability? For the analysis in this section, I will assume that $C(1, 0) > 0$, and define $\bar{c} \stackrel{\text{def}}{=} C(1, 0)$. That is, a player who is known to abstain also suffers some cost. This assumption is sometimes justified by evidence that constituents view vote participation rates by policymakers as legislator effort, and so non-participation (termed *participatory shirking*) is costly (c.f. Bender and Lott, 1996). Naturally, I assume that $\bar{c} < c$: While there may be a cost to abstention, this cost is smaller than the maximal privacy cost (otherwise players would never abstain). Finally, I leave all other values of $C(\cdot, \cdot)$ unspecified – they do not play a role in the analysis of this section.

Consider the case of three players in which the outcome is determined by the majority of votes, and such that the outcome is A with probability $1/2$ if votes are tied or all three players abstain.

Consider first the case of secret voting. Observe that, under the symmetry assumption $C(0, I) = C(0, 1 - I)$ for $I \in [0, 1]$ (see Section 3), sincerity is an equilibrium here. To see this, suppose players are sincere, and a player receives signal a. She conditions on being pivotal – that is, one of the other players is voting a and the other b. Voting a yields expected utility $p - C(0, 1/4)$, voting b yields expected utility $1-p-C(0, 3/4)$, and abstaining yields expected utility $1/2-(C(0, 1/4)+C(0, 3/4))/2$. By the symmetry assumption, voting a is strictly optimal.

Now, the situation may be different under open voting. Since players here always incur the privacy cost c, this is analogous to a model of costly voting in which players incur a cost of c for voting and $\bar{c} < c$ for abstaining. If the privacy cost c is much larger than the cost of abstention $\bar{c}$, then clearly no player will want to vote. In fact, Battaglini et al. (2007) show that all players will abstain whenever $c - \bar{c} > p - 1/2$.[14] For such large values of $c - \bar{c}$, then, restricting the amount of information will surely be beneficial, and there is no non-monotonicity in terms of the probability of correctness. However, if $c - \bar{c}$ is relatively small, then the qualitative result of this paper may still go through. In particular, Battaglini et al. (2007) also show that, even with abstention, sincerity is an equilibrium whenever $c - \bar{c} \in [0, p(1 - p)(2p - 1)]$ – that is, for such values of c and $\bar{c}$ players do not abstain, and in fact vote according to their signals.[15]

What about anonymous voting? Clearly, sincerity is not an equilibrium under anonymous voting with possibility of abstention whenever it is not an equilibrium without the possibility of abstention, since profitable deviations in the latter case remain profitable also in the former. Thus, the non-monotonicity in the probability of correctness sometimes holds also when there is a possibility of abstaining.

A more in-depth analysis of the interesting interplay between abstention and privacy concerns, including a welfare analysis, is left for future work.[16]

[14] Battaglini et al. (2007) analyze the case $\bar{c} = 0$, but their proof easily extends to the case $\bar{c} > 0$.

[15] In the middle range of parameters $(p(1-p)(2p-1), p-1/2)$ there is a unique mixed equilibrium in which players abstain with positive probability.

[16] At the very least, this requires specifying values for C not defined in this section. One approach would be to have the privacy cost $C(J, I)$ be a function of $|I-(1-J)|$, the difference in the probability a player voted a and the probability she voted b. Such an approach could be consistent with the micro-foundations formalized in Appendix A.

B.2 Deliberation

An important assumption made in this paper is that players do not communicate before voting. Intuitively, this seems crucial for the result on anonymous voting—if players could share their signals with one another, then in the 2-player model the tally on an anonymous vote for B would always be 1:1, and the probability of correctness would be maximal. In this section I argue that this intuition is somewhat inaccurate, and that in some settings the non-monotonicity could hold also with pre-vote communication.

Communication within committees is difficult to analyze, and so one case that has been widely studied (due to its relevance but also largely due to its tractability) is that in which communication takes the form of a straw poll (Coughlan, 2000).[17] In this model, players first take a poll by voting non-bindingly for a or b, then they observe the outcome, and finally they take a binding vote. The result of the binding vote will then be either open, anonymous, or secret.[18]

Consider first the case in which the equilibrium strategies of players in the poll and vote are symmetric, and suppose the outcome of the vote is anonymous. Suppose for simplicity that players vote truthfully in the straw poll. In this case, what will happen if the poll's tally is 0:2? The players are fairly confident that the state is B, but the profile in which both vote b is not an equilibrium, for the same reason as in Proposition 4. Thus, in the unique symmetric equilibrium players will mix, which will yield a lower probability of correctness and possibly higher welfare, as in the case without communication.

Of course, this highlights the possible benefit from further communication beyond a straw poll. For example, the players might take a straw poll, then on tally 0:2 they could flip a coin to determine which player will vote a and which will vote b. This yields optimal probability of correctness and minimal privacy loss. The following two observations are notable:

First, observe that such random coordination on tally 1:1 requires that communication (the straw poll and coin flip in the example) not be observed by the outside

[17] But see **?** for an analysis of advisory committees with arbitrary communication.

[18] One might consider other alternatives as well, in which the outcome of the straw poll could be transparent, either open, anonymous, or secret. Fehrler and Hughes (2014) study a variant of this form.

observer. In particular, deliberation cannot be transparent. With transparency such random coordination is not possible—either the strategy profile is asymmetric (and thus known to the observer) or players coordinate during deliberations, in which case the observer also learns which player will vote a and which b. Thus, it seems that optimal probability of correctness and minimal privacy loss is obtainable only with non-transparent deliberation.[19]

Second, observe that even if deliberations are not transparent, there is still a non-monotonicity in the amount of privacy loss of the players. In particular, under open voting privacy loss is maximal, under anonymous voting (with non-transparent deliberations) it is minimal, and under secret voting it may be somewhere in between. To see the last point, observe that under secret voting, there is always an equilibrium in which voting is sincere, regardless of behavior during the communication phase. This holds because under secret voting, a deviation does not affect the observer's inference without affecting the outcome. Thus, while the probability of correctness is maximal for both anonymous and secret voting, the non-monotonicity in welfare persists.

B.3 What if Sincerity is Not an Equilibrium?

The setting analyzed in this paper contains enough symmetry so that sincere voting is an equilibrium in open and often secret voting. Of course, this need not be the case more generally. If sincere voting is not an equilibrium, then an appropriate choice of disclosure rule could make voting "more sincere". In fact, for some settings of the parameters there could be a non-monotonicity in the probability of correctness in which anonymous voting is maximal. Consider the example of a three-player committee, and suppose the voting rule is unanimity. Sincere voting is not an equilibrium under open voting (Feddersen and Pesendorfer, 1998), and in the unique symmetric equilibrium players mix on signal b. Mixing is such that players are indifferent between the two outcomes on signal b, conditional on the other two players voting a. Under secret voting sincerity is still not an equilibrium, but there is less mixing in equilibrium. This follows from the fact that under the equilibrium profile in open voting, a pivotal player who observed signal b would still prefer B over A since B is

[19] See Fehrler and Hughes (2014) for an analysis of transparency in deliberation.

associated with lower privacy cost (under outcome A the privacy loss is maximal). Thus, in equilibrium there will be less mixing on signal b with secret voting than in open voting.

The analysis of anonymous voting in this setting is a bit more involved. In general, however, whether equilibrium voting is more or less sincere here than in secret voting depends on the privacy cost function, and that both directions are possible.

B.4 The Observer as a Voting Player

In this paper I assumed that the observer does not participate in the voting game. However, I now argue that the qualitative results of this paper hold even if the observer is a voting player. Suppose there are three players, and the voting rule is simple majority. Suppose each player has privacy concerns, but where the observer is one of the other players. Note that this is similar to the two player case with an outside observer. Let us analyze the interaction from the point of view of a particular player, say player 1, and suppose her observer is player 2. Then the inferences that player 2 draws about player 1 may depend on her own vote: For example, in anonymous voting, if the tally is 2:1 but player 2 voted b, then she can infer that the other players both voted a. Now, under open voting sincerity is still an equilibrium, as in Section 3. Furthermore, we claim that sincerity is often an equilibrium in secret voting as well. If the outcome is A (respectively, B), and player 2 voted a (respectively, b), then she draws some inference $0 < I < 1$ about player 1's vote. However, if the outcome is A (respectively, B), and player 2 voted b (respectively, a) then she can completely infer player 1's vote. Now, player 1, on obtaining signal a, conditions on being pivotal. In this case, there is a 50% chance that player 2 votes against her signal. Thus, player 1 contemplates voting a and obtaining the more-likely-correct outcome, a 50% chance of having her vote found out, and a 50% chance of player 2 inferring some I, versus voting b and obtaining the less-likely-correct outcome, a 50% chance of having her vote found out, and a 50% chance of player 2 inferring $1-I$. If $C(I) = C(1-I)$ then she will choose the former and vote a sincerely.

Finally, we argue that in anonymous voting sincerity is not always an equilibrium. Suppose that p is large. In this case, on signal a player 1 infers that it is likely that players 2 and 3 also received signal a, and so a deviation is unlikely to change the outcome. However, a deviation will change player 2's inference from a certainty that player 1 voted a to an inference of $I = 1/2$. Thus, the deviation will be profitable, and sincerity is not an equilibrium. Hence, when a player is concerned about inferences drawn by another player, the qualitative results about the non-monotonic effect of information disclosure on the probability of correctness go through. Similarly, the non-monotonic effect on welfare also goes through.

Of course, a player may be concerned about the inferences of more than one player, and then the question is how does she aggregate these concerns. One interesting case is when the privacy cost of a player is the worse of the inferences drawn by either of the other two players. In this case again the qualitative results of the paper go through: Under secret voting, if a player is pivotal she will always reveal her vote to one of the two players, and so sincerity will be an equilibrium. In anonymous voting, when p or c are large the benefit of additional uncertainty from a deviation will again be higher than that of increased probability of correctness from sincerity.

B.5 Concern for the Privacy of the *Signal*

In this paper, players are concerned about the privacy of their actions. A related but different concern might be for the privacy of their *signals*:[20] That is, a player might be hesitant to reveal whether her signal was $s_i = a$ or $s_i = b$. For example, faculty members voting on a hiring decision might not wish others to know whether their signal (which arises from their impression of the candidate) was positive or negative. It turns out that the insights of this paper are applicable in this modified setting as well. In particular, note that under sincere voting, the inference about a player's action is the same as the inference about her signal, and so when sincere voting is an equilibrium under this paper's privacy concerns, it is also an equilibrium when players are concerned about the privacy of their signals. Thus, in this variant sincere voting will be an equilibrium in open and secret voting. However, in anonymous voting sincerity will not be an equilibrium, essentially for the same reasons as in this paper.

While the insights about sincere and strategic voting in this variant of the model are similar to the ones in the paper's main model, there are some notable differences.

[20] I thank Yair Antler for pointing out this variant.

In particular, the inferences made by the observer when voting is not sincere are not the same, leading to different kinds of equilibria. To see this, consider some non-sincere strategy profile, in which the players mix on signal a. Then if the tally is 0:2, the inference is that both players *voted* b, but it not true that both players received the *signal* b. Thus, the payoff associated with a particular mixed strategy would be different in this variant than from the main model of this paper. For another simple example, consider an unresponsive strategy profile in which both players vote b. In the main model of the paper, players would incur a privacy loss of $C(1) = c$, since the observer infers that each voted b with probability 1. However, in this proposed variant in which concerns are about the privacy of the *signals*, the privacy loss would be 0: Since both players always vote b regardless of their signals, no inference can be made about the signals from the outcome B. Thus, since each player is equally likely to obtain signal a as b, the privacy loss is 0.

These examples show that the equilibria under anonymous voting would be different from the ones in this paper, and so some of the results would need to be modified accordingly. I leave a more detailed analysis of this variant to future work.

C Proof from Section 2.1

Proof of Proposition 2: First observe that for each player i, $\Pr[s_i = a] = \Pr[s_i = b] = 1/2$. Furthermore, $\Pr[\theta = A | s_i = a] = \Pr[\theta = B | s_i = b] = p$. We now compute the expected utilities given each signal, assuming that players vote with the signal, $m_i = s_i$.

Consider first the case of open voting. On signal a, the outcome is correct if $\theta = A$ and the other player also voted a, which happens with probability p^2, and if $\theta = B$ and the other player voted b, which happens with probability $(1-p)p$. On signal b, the outcome is correct with probability p. For both signals, the disutility due to C is 1. Thus,

$$U_i^O(p) = \frac{(p^2 + p(1-p)) - c}{2} + \frac{p - c}{2} = p - c.$$

A similar analysis for anonymous voting yields:

$$U_i^A(p) = \frac{p - p^2 c - (1-p)^2 c}{2} + \frac{p - p^2 c - (1-p)^2 c}{2} = p - c + 2p(1-p)c.$$

For secret voting, we first derive the inference made by the observer on outcome B:

$$
\begin{aligned}
I &= \Pr\left[m_i = b | o = B\right] = \frac{\Pr\left[m_i = b \cap o = B\right]}{\Pr\left[o = B\right]} \\
&= \frac{\Pr\left[m_i = b \cap o = B | \theta = A\right] \cdot \Pr\left[\theta = A\right] + \Pr\left[m_i = b \cap o = B | \theta = B\right] \cdot \Pr\left[\theta = B\right]}{\Pr\left[o = B | \theta = A\right] \cdot \Pr\left[\theta = A\right] + \Pr\left[o = B | \theta = B\right] \cdot \Pr\left[\theta = B\right]} \\
&= \frac{(1-p)^2 + p(1-p) + p^2 + p(1-p)}{(1-p)^2 + 2p(1-p) + p^2 + 2p(1-p)} \\
&= \frac{(p + (1-p))^2}{(p + (1-p))^2 + 2p(1-p)} \\
&= \frac{1}{1 + 2p(1-p)}
\end{aligned}
$$

Denote by $c_S \stackrel{\text{def}}{=} C(I)$. Now, consider the linear function $\ell : \mathbb{R} \mapsto \mathbb{R}$ for which $\ell(1/2) = 0$ and $\ell(1) = c$, namely $\ell(x) = 2c(x - 1/2)$. This function also satisfies

$$
\ell(I) = 2c\left(\frac{1}{1 + 2p(1-p)} - \frac{1}{2}\right) = \frac{c(1 - 2p(1-p))}{1 + 2p(1-p)}.
$$

Since C is convex,

$$
c_S = C(I) \leq \ell(I) = \frac{c(1 - 2p(1-p))}{1 + 2p(1-p)}.
$$

We can now compute the expected utility of a player in secret voting:

$$
\begin{aligned}
U_i^S(p) &= \frac{p - p^2c - (1-p)^2c - 2p(1-p)c_S}{2} + \frac{p - c_S}{2} \\
&= p - \frac{1}{2}\left(p^2c + (1-p)^2c + (1 + 2p(1-p))c_S\right) \\
&\geq p - \frac{1}{2}\left(p^2 + (1-p)^2 + (1 - 2p(1-p))\right)c \\
&= p - c + 2p(1-p)c \\
&= U_i^A(p).
\end{aligned}
$$

Thus, $U_i^O(p) < U_i^A(p) \leq U_i^S(p)$, as claimed. Note that the inequalities are strict under strict convexity. ■

D Proofs from Section 2.2

The proofs for determining whether a given strategy profile is an equilibrium under the different disclosure rules all take the same form of checking whether the incentive compatibility constraints are satisfied. In particular, given a fixed strategy profile, they compare the expected utilities of a player given signal a and voting a and b, and given signal b and voting a and b. If the strategy profile calls for, say, voting a whenever the signal is a, then it must be the case that on signal a the expected utility of voting a is at least as high as that of voting b. If the strategy profile on a particular signal calls for mixing between a and b then the expected utilities of the respective votes must be equal.

Proof of Proposition 3:

- On signal a, contemplate a vs. b, yielding $(p^2 + (1-p)p) - pc - (1-p)c$ vs. $(1-p) - (1-p)c - pc$, so vote with signal since the former is always greater.
- On signal b, contemplate b vs. a, yielding $p - pc - (1-p)c$ vs. $p - (1-p)c - pc$, so again vote with signal.

Thus, sincerity is always an equilibrium.

We now show that there are no other responsive pure equilibria. First, note that there is an unresponsive equilibrium in which both players always vote for b. The profile in which both players always vote for a is not an equilibrium: On signal b, an player will deviate to b to yield outcome B, which on signal b she views as more likely. Finally, the profile in which players vote a on signal b and b on signal a is also not an equilibrium: On signal b, player i is pivotal (changes the outcome, and hence her utility) only if the other player voted a, which means the other player also got signal b. Thus, in this case B is the more likely state, and so player i will deviate to b.

We now show that there are no mixed equilibria. First, we argue that players will not mix on signal b. For suppose players do, and so they are indifferent between voting a and b. They only affect the outcome when they are pivotal, which occurs when the other player voted a. However, in that case, B is the more likely state (since the player got signal b and the other player got signal b with probability greater than 0), and so the strictly better action is a vote for b. Thus, a player will not mix on signal b. Formally, assuming players vote for a on signal a with probability r, and for b on signal b with probability $q < 1$. On signal b,

- Vote a: utility is $(1-p)(pr+(1-p)(1-q))+p^2q+p(1-p)(1-r)-c$
  $= 1-p+(2p-1)q.$

- Vote b: utility is $p+(1-p)(pq+(1-p)(1-r))-c$
  $= 1-p+(2p-1)r+p^2(1-r)+pq(1-p).$

Since $p^2 > 2p-1$ for all $p \in (1/2,1)$, it holds that $(2p-1)r+p^2(1-r) \geq 2p-1 > q(2p-1)$, and so voting b is strictly preferred to voting a.

Now, we show that players will not mix on signal a either. Suppose players do mix, and vote a with probability $0 < r < 1$.

- Vote a: utility is $p^2r+(1-p)(p+(1-p)(1-r))-c$
  $= 1-p+(2p-1)r-c.$

- Vote b: utility is $1-p-c$.

Since $r > 0$ and $p > 1/2$, voting a is strictly better than voting b. Thus, there is no mixing on signal a in equilibrium either. ■

Proof of Proposition 4: Consider the sincere strategy profile, in which players vote a on signal a and b on signal b. On signal b,

- Vote b: utility is $p-p^2c-(1-p)^2c$.
- Vote a: utility is $(p^2+(1-p)p)-(1-p)pc-p(1-p)c$.
- In equilibrium, the former must be $\geq$ the latter. This is never true, since $p^2+(1-p)^2 > 2p(1-p)$ for all $p \in (1/2,1)$.

Thus, sincere voting is not an equilibrium. ■

Proof of Proposition 5: Proposition 4 showed that sincere voting is not an equilibrium in anonymous voting. We first show that there are no other pure equilibria in anonymous voting.

The strategy profile in which players always vote for a is not an equilibrium, because on signal b a player believes state B is more likely, and a deviation to b not only gives outcome B but also lower privacy costs. The strategy profile in which players always vote for b is not an equilibrium because a deviation to a does not change the outcome, but lowers the privacy costs from $C(1) = c$ to $C(1/2) = 0$. Finally, the profile in which players vote b on signal a and a on signal b is also not an equilibrium: On signal a,

- Vote a: utility is $p(1-p) + (1-p)(1-p) - (p(1-p) + (1-p)p)c$
  $= 1 - p - 2p(1-p)c$.
- Vote b: utility is $1 - p - (p^2 + (1-p)^2)c$.
- In this equilibrium, the latter needs to be greater than the former, and so:

$$\begin{aligned}
&1 - p - 2p(1-p)c \leq 1 - p - (p^2 + (1-p)^2)c \\
&\Leftrightarrow 2p(1-p)c \geq (p^2 + (1-p)^2)c \\
&\Leftrightarrow \left(p^2 + (1-p)^2 - 2p(1-p)\right) c \leq 0 \\
&\Leftrightarrow (2p-1)^2 c \leq 0.
\end{aligned}$$

  However, this last inequality never holds, since $c > 0$ and $p > 1/2$.

Thus, in anonymous voting there are no pure equilibria. We now consider mixed equilibria.

To this end, consider the strategy profile in which, on signal a, players vote a with probability $r \in [0,1]$, and on signal b they vote b with probability $q \in [0,1]$. By the previous analysis, at least one of r, q is in $(0,1)$.

- On signal a:
  - Vote a: utility is

$$\begin{aligned}
&(p^2 r + p(1-p)(1-q) + (1-p)pq + (1-p)^2(1-r)) \\
&\quad - (p^2 r + p(1-p)(1-q) + (1-p)^2 r + (1-p)p(1-q))c \\
&= (2pr - p - r + 1) - (2(1-p)p(1-q) + (1-p)^2 r + p^2 r)c.
\end{aligned}$$

  - Vote b: utility is

$$\begin{aligned}
&(1-p) - ((1-p)pq + (1-p)^2(1-r) + p(1-p)q + p^2(1-r))c \\
&= (1-p) - (2(1-p)pq + (1-p)^2(1-r) + p^2(1-r))c.
\end{aligned}$$

- On signal b:
  - Vote b: utility is

$$\begin{aligned}&p-(p^2q+p(1-p)(1-r)+(1-p)^2q+(1-p)p(1-r))c\\&=p-((1-p)^2q+p^2q+2(1-p)p(1-r))c\end{aligned}$$

  - Vote a: utility is

$$\begin{aligned}&(p^2q+p(1-p)(1-r)+(1-p)pr+(1-p)^2(1-q))\\&\quad-((1-p)pr+(1-p)^2(1-q)+p^2(1-q)+p(1-p)r)c\\&=(2pq-p-q+1)-((1-p)^2(1-q)+p^2(1-q)+2(1-p)pr)c\end{aligned}$$

We now consider different kinds of profiles, and check under what conditions they are equilibria:

- $r=1$**:** On signal a, compare a vote for a that yields $p-(1-2pq+2p^2q)c$ with a vote for b that yields $(1-p)-(2(1-p)pq)c$. Will always vote for a (necessary for this kind of equilibrium) iff

$$q\geq\frac{c-(2p-1)}{4p(1-p)c}.\tag{1}$$

  On signal b, compare a vote for b yielding $p-(1-2p+2p^2)qc$ with a vote for a yielding $(2pq-p-q+1)-(1-q+2pq-2p^2q)c$. Since we need $q\in(0,1)$, these must be equal in equilibrium, yielding

$$q=\frac{c+(2p-1)}{c(4p^2-4p+2)+2p-1}.$$

  This q also satisfies (1) whenever

$$c\leq\frac{1}{4}\sqrt{\frac{32p^2-32p+9}{(2p-1)^2}}+\frac{1}{4(2p-1)},\tag{2}$$

  (which is always satisfied if $c\leq 1$), and is bounded above by 1 and below by 0 whenever $c>0$.

- $q=1$: In this kind of profile, on signal b agents must prefer to vote for b over a:

– Vote b: utility is

$$\begin{aligned}&p-(p^2+p(1-p)(1-r)+(1-p)^2+(1-p)p(1-r))c\\&=p-((1-p)^2+p^2+2(1-p)p(1-r))c\end{aligned}$$

– Vote a: utility is

$$\begin{aligned}&(p^2+p(1-p)(1-r)+(1-p)pr)\\&\quad-((1-p)pr+p(1-p)r)c\\&=p-2(1-p)prc.\end{aligned}$$

However, for all $p \in (1/2, 1)$ and $c > 0$ it holds that $p - 2(1-p)prc > p - ((1-p)^2 + p^2 + 2(1-p)p(1-r))c$, so no such equilibrium exists.

- $r = 0$: In this kind of profile, players vote a only on signal b, and then they do so with probability $1 - q$. On signal a, a player contemplates:

  – Vote a: utility is

$$\begin{aligned}&(p(1-p)(1-q)+(1-p)pq+(1-p)^2)\\&\quad-(p(1-p)(1-q)+(1-p)p(1-q))c\\&=(1-p)-(2(1-p)p(1-q))c.\end{aligned}$$

  – Vote b: utility is

$$\begin{aligned}&(1-p)-((1-p)pq+(1-p)^2+p(1-p)q+p^2)c\\&=(1-p)-(2(1-p)pq+(1-p)^2+p^2)c.\end{aligned}$$

  For this kind of equilibrium, need the latter to be weakly greater than the former, i.e. $(1-p)-(2(1-p)pq+(1-p)^2+p^2)c \geq (1-p)-(2(1-p)p(1-q))c$, and so

$$2(1-p)pq+(1-p)^2+p^2 \leq 2(1-p)p(1-q).$$

  However, this inequality is always false, since $p^2 + (1-p)^2 \geq 2(1-p)p$, and so there is no equilibrium with $r = 0$.

- $q = 0$: In this kind of profile, players vote b only on signal a, and then they do so with probability $1 - r$. On signal b, a player contemplates:

  - Vote b: utility is

$$\begin{aligned} &p - (p(1-p)(1-r) + (1-p)p(1-r))c \\ &= p - (2(1-p)p(1-r))c \end{aligned}$$

  - Vote a: utility is

$$\begin{aligned} &(p(1-p)(1-r) + (1-p)pr + (1-p)^2) \\ &\quad - ((1-p)pr + (1-p)^2 + p^2 + p(1-p)r)c \\ &= 1 - p - ((1-p)^2 + p^2 + 2(1-p)pr)c \end{aligned}$$

  For this kind of equilibrium, need the latter to be weakly greater than the former, i.e. $1 - p - ((1-p)^2 + p^2 + 2(1-p)pr)c \geq p - (2(1-p)p(1-r))c$. A necessary condition for this to hold is

$$(1-p)^2 + p^2 + 2(1-p)pr \leq 2(1-p)p(1-r),$$

  but this is always false due to the same fact as above, that $p^2 + (1-p)^2 \geq 2(1-p)p$.

- $r \in (0, 1)$ **and** $q \in (0, 1)$**:** In an equilibrium with players mixing on both signals, we must have indifference between votes for a and b for each signal. The first equality

$$\begin{aligned} &(2pr - p - r + 1) - (2(1-p)p(1-q) + (1-p)^2 r + p^2 r)c \\ &= (1-p) - (2(1-p)pq + (1-p)^2(1-r) + p^2(1-r))c \end{aligned}$$

  gives

$$r = \frac{c(-4p^2(q-1) + 4p(q-1) + 1)}{c(4p^2 - 4p + 2) - 2p + 1},$$

  and second equality

$$\begin{aligned} &p - ((1-p)^2 q + p^2 q + 2(1-p)p(1-r))c \\ &= (2pq - p - q + 1) - ((1-p)^2(1-q) + p^2(1-q) + 2(1-p)pr)c \end{aligned}$$

gives

$$r = \frac{c(-4p^2(q-1)+4p(q-1)-2q+1)-2p(q-1)+q-1}{4c(p-1)p}.$$

Together they give the solution

$$q = \frac{c^2(4p-2)+c-2p+1}{(4c^2-1)(2p-1)}$$

and

$$r = \frac{c(2c(2p-1)+1)}{(4c^2-1)(2p-1)}.$$

The constraint $r > 0$ implies that $c > 1/2$. This, together with the constraint $r \leq 1$ implies

$$c \geq \frac{1}{4}\sqrt{\frac{32p^2-32p+9}{(2p-1)^2}} + \frac{1}{4(2p-1)},$$

which complements the condition (2) for equilibrium existence in the $r = 1$ case.

Conclusion: This equilibrium exists whenever an $r = 1$ equilibrium does not.

■

Proof of Proposition 6: We first show that in any equilibrium under secret voting, players will always vote sincerely on signal b. Intuitively, this should hold because on signal b, a player will affect the outcome only if she is pivotal. In that case, however, state B is at least as likely as state A to be the correct state, and the choice is between outcome A with no privacy (i.e. privacy cost equal to c) and outcome B with some privacy (privacy cost $\tilde{c}_S < c$). The player will choose to vote for b.

Consider the strategy σ in which on signal a, players vote a with probability $r \in [0,1]$, and on signal b, players vote b with probability $q \in [0,1]$. Let $\tilde{c}_S$ be the cost associated with the observer's inference on outcome B, and note that $c_S \leq c$, with equality only in the case in which players vote b always, regardless of their signal. On signal b, a player faces the following tradeoff:

- Vote b: utility is $p - \tilde{c}_S$.

- Vote a: utility is

$$\begin{aligned}
&(p^2q + p(1-p)(1-r) + (1-p)pr + (1-p)(1-p)(1-q)) \\
&\quad - ((1-p)pr + (1-p)(1-p)(1-q) + p(1-p)r + p^2(1-q))c \\
&\quad - (p^2q + p(1-p)(1-r) + (1-p)^2q + (1-p)p(1-r))\tilde{c}_S \\
&= (2pq - p - q + 1) - (p^2(1-q) + (1-p)^2(1-q) + 2p(1-p)r)c \\
&\quad - (p^2q + p(1-p)(1-r) + (1-p)^2q + (1-p)p(1-r))\tilde{c}_S
\end{aligned}$$

We now show that a player always prefers to vote b over a. We have

$$\begin{aligned}
&\tilde{c}_S \leq (p^2(1-q) + (1-p)^2(1-q) + 2p(1-p)r)c \\
&\qquad + (p^2q + p(1-p)(1-r) + (1-p)^2q + (1-p)p(1-r))\tilde{c}_S \\
&\Leftrightarrow (p^2(1-q) + (1-p)^2(1-q) + 2p(1-p)r)c \\
&\qquad \geq (1 - p^2q + p(1-p)(1-r) - (1-p)^2q - (1-p)p(1-r))\tilde{c}_S \\
&\Leftarrow (p^2 + (1-p)^2 + 2p(1-p))c \geq \tilde{c}_S
\end{aligned}$$

This last inequality always holds, since $\tilde{c}_S \leq c$. Observe also that the inequality is strict whenever $q < 1$ (since then $\tilde{c}_S < c$ due to the assumption that C is strictly increasing on $[1/2, 1]$ and the fact that if there is a chance of voting a, the probability of having voted for b is strictly less than 1), and so we get that in equilibrium, we must have $q = 1$.

Given the fact that players always vote b on signal b, we now analyze equilibrium profiles in secret voting with $q = 1$ and $r \leq 1$. First, we calculate the inference I_r made by the observer when players play this strategy profile and the outcome is B.

$$\begin{aligned}
I_r &= \Pr[m_i = b | o = B] = \frac{\Pr[m_i = b \cap o = B]}{\Pr[o = B]} \\
&= \frac{\Pr[m_i = b \cap o = B | \theta = A] \cdot \Pr[\theta = A] + \Pr[m_i = b \cap o = B | \theta = B] \cdot \Pr[\theta = B]}{\Pr[o = B | \theta = A] \cdot \Pr[\theta = A] + \Pr[o = B | \theta = B] \cdot \Pr[\theta = B]} \\
&= \frac{(1-p)^2(1 + (1-r)^2 + r(1-r)) + 2p(1-p)(2-r) + p^2((1-r)^2 + r(1-r) + 1)}{(1-p)^2(1 + (1-r)^2 + 2r(1-r)) + 4p(1-p) + p^2((1-r)^2 + 2r(1-r) + 1)} \\
&= \frac{(1-p)^2(2-r) + 2p(1-p)(2-r) + p^2(2-r)}{(1-p)^2(2-r^2) + 4p(1-p) + p^2(2-r^2)}.
\end{aligned}$$

Observe that $I_1 = 1/(1 + 2p(1-p))$, the same inference derived in the proof of Proposition 2, and that $I_0 = 1$. This latter inference corresponds to the case in which players always vote b, and so $I_0 = 1$ is the correct inference that any player voted b with probability 1.

Let $\bar{c}_r = C(I_r)$. Consider a player's options on signal a, and the corresponding expected utilities:

- Vote a: Get

$$\begin{aligned}
&(p^2r + (1-p)p + (1-p)(1-p)(1-r)) - (p^2r + (1-p)^2r)c \\
&\qquad - (p(1-p) + p^2(1-r) + (1-p)p + (1-p)(1-p)(1-r))\bar{c}_r \\
&\qquad = (2pr - p - r + 1) - (p^2 + (1-p)^2)rc - (p - p^2r + (1-p)(1 - r + pr))\bar{c}_r
\end{aligned}$$

- Vote b: Get $(1-p) - \bar{c}_r$.

There are now three cases to consider: $r = 0$, $r = 1$, and $r \in (0,1)$. In the first case, players always vote for b, and this is an unresponsive equilibrium that yields inference $I_0 = 1$. The second case is the sincere profile, which requires voting a to be weakly better than voting b on signal a, namely

$$\begin{aligned}
&(2pr - p - r + 1) - (p^2 + (1-p)^2)rc - (p - p^2r + (1-p)(1 - r + pr))\bar{c}_r \geq (1-p) - \bar{c}_r \\
&\Leftrightarrow p - (p^2 + (1-p)^2)c - (p - p^2 + (1-p)p)\bar{c}_1 \geq (1-p) - \bar{c}_1 \\
&\Leftrightarrow c \leq \frac{(p^2 + (1-p)^2)\,\bar{c}_1 + 2p - 1}{p^2 + (1-p)^2}.
\end{aligned}$$

So sincerity is an equilibrium whenever

$$c \leq \frac{(p^2 + (1-p)^2) \cdot C\left(\frac{1}{1 + 2p(1-p)}\right) + 2p - 1}{p^2 + (1-p)^2}, \tag{3}$$

and in particular whenever

$$c \leq \frac{2p - 1}{p^2 + (1-p)^2}.$$

Now consider the case $r \in (0,1)$. Here we need equality between the utility from a vote for A and a vote for B, on signal a. Thus, for this to be an equilibrium we need

$$\begin{aligned}
&(2pr - p - r + 1) - (p^2 + (1-p)^2)rc - (p - p^2r + (1-p)(1 - r + pr))\bar{c}_r = (1-p) - \bar{c}_r \\
&\Leftrightarrow c = \frac{(p - p^2r + (1-p)(1 - r + pr) - 1)\bar{c}_r - 2pr + r}{-(p^2 + (1-p)^2)r} \\
&\Leftrightarrow c = \frac{(p^2 + (1-p)^2)\,\bar{c}_r + 2p - 1}{p^2 + (1-p)^2}.
\end{aligned} \tag{4}$$

Observe that as r decreases from 1 to 0, I_r increases from $1/(1+2p(1-p))$ to 1, and so $\overline{c}_r = C(I_r)$ increases from $C(1/(1+2p(1-p)))$ to $C(1) = c$. Thus, if (3) does not hold, and c is greater than the RHS of (3), then we can decrease r. By continuity of C, at some point (4) will be satisfied at equality (since the inequality goes the other way when $r = 0$).

■

E Proofs from Section 2.3

Proof of Proposition 7: Proposition 4 showed that sincere voting is never an equilibrium in anonymous voting, and Proposition 5 showed that the unique equilibria involve mixing on signal a and possible also on signal b. Suppose on signal a players vote a with probability $r \in (0,1]$, and on signal b they vote b with probability $q \in (0,1)$. Then

$$\begin{aligned}\Pr[o=\theta] &= \frac{p^2r^2 + 2p(1-p)r(1-q) + (1-p)^2(1-q)^2}{2} \\ &\quad + \frac{p^2(q^2+2q(1-q)) + 2p(1-p)(q+(1-q)(1-r)) + (1-p)^2(1-r^2)}{2} \\ &= \frac{2-2q+q^2-r^2-2p(1-2q+q^2-r^2)}{2}.\end{aligned}$$

This has a unique maximum of p at $r = q = 1$, so for $q < 1$ we get $\Pr[o=\theta] < p$.

We now show that in the limit as $p \to 1$, the probability of correctness in anonymous voting is bounded away from 1. Recall from the proof of Proposition 5 that when

$$c \le \frac{1}{4}\sqrt{\frac{32p^2-32p+9}{(2p-1)^2}} + \frac{1}{4(2p-1)} \tag{5}$$

there is a unique equilibrium in anonymous voting in which players vote sincerely on signal a, but mix on signal b. In particular, on signal b they vote b with probability

$$q = \frac{c+(2p-1)}{c(4p^2-4p+2)+2p-1}.$$

Now,

$$\lim_{p\to 1} q = \frac{c+1}{2c+1},$$

and so in this case

$$\lim_{p\to 1} \Pr[o=\theta] = \lim_{p\to 1} \frac{2-2q+q^2-r^2-2p(1-2q+q^2-r^2)}{2}$$
$$= \frac{2-\frac{2c+2}{2c+1}+\left(\frac{c+1}{2c+1}\right)^2-1-2(-\frac{2c+2}{2c+1}+\left(\frac{c+1}{2c+1}\right)^2)}{2}$$
$$= \frac{2+8c+7c^2}{2+8c+8c^2} < 1.$$

When (5) is not satisfied, the unique equilibrium has mixing on both a and b with probabilities r and q, respectively, where

$$q = \frac{c^2(4p-2)+c-2p+1}{(4c^2-1)(2p-1)}$$

and

$$r = \frac{c(2c(2p-1)+1)}{(4c^2-1)(2p-1)}.$$

Furthermore,

$$\lim_{p\to 1} q = \frac{2c^2+c-1}{4c^2-1}$$

and

$$\lim_{p\to 1} r = \frac{2c^2+c}{4c^2-1}.$$

Thus,

$$\lim_{p\to 1} \Pr[o=\theta] = \lim_{p\to 1} \frac{2-2q+q^2-r^2-2p(1-2q+q^2-r^2)}{2}$$
$$= \frac{2-2\left(\frac{2c^2+c-1}{4c^2-1}\right)+\left(\frac{2c^2+c-1}{4c^2-1}\right)^2-\left(\frac{2c^2+c}{4c^2-1}\right)^2}{2}$$
$$- \frac{2\left(1-2\left(\frac{2c^2+c-1}{4c^2-1}\right)+\left(\frac{2c^2+c-1}{4c^2-1}\right)^2-\left(\frac{2c^2+c}{4c^2-1}\right)^2\right)}{2}$$
$$= \frac{1-8c^2+8c^3+16c^4}{2(1-4c^2)^2}.$$

This, in turn, is bounded above by $17/18 < 1$ for the region in which (5) is not satisfied (the region in which $c \geq 1$, the limit as $p \to 1$ of the right-hand-side of (5)). ■

Proof of Proposition 8: Consider first the equilibrium profile σ_α^A. For large enough α, since $C_\alpha(1)$ will be large, the equilibrium will be one in which players mix on both signals a and b. The proof of Proposition 5 calculates the precise probabilities r_α and q_α of mixing on signals a and b respectively. Observe that $r_\alpha \to 1/2$ and $q_\alpha \to 1/2$ as $\alpha \to \infty$. This means that as the privacy concerns increase and α gets large, the equilibrium profile is one in which the cost due to privacy loss approaches $C_\alpha(1)/2$: with probability 1/2 both players will vote the same, leading to a privacy cost of $C_\alpha(1)$, and with probability 1/2 they will vote differently, leading to a privacy cost of 0.

Next, consider the equilibrium profile σ_α^S. Assume the profile is the responsive one (the statement is trivial for the unresponsive equilibrium). The proof of Proposition 6 calculates the probabilities of mixing in this equilibrium. First, in Equation (3) the proposition states that

$$c - C\left(\frac{1}{1+2p(1-p)}\right) \leq \frac{2p-1}{p^2+(1-p)^2}$$

is necessary and sufficient for sincerity to be an equilibrium. However, note that as α increases, the difference between $C_\alpha(1)$ and $C_\alpha\left(\frac{1}{1+2p(1-p)}\right)$ also increases, and so for large enough α sincerity will no longer be an equilibrium. Thus, the equilibrium is one in which players mix with some probability r_α on signal a.

Now, in Equation (4) the proposition states that in equilibrium, the equality

$$C_\alpha(1) - C_\alpha\left(I_{r_\alpha}\right) = \frac{2p-1}{p^2+(1-p)^2}$$

must be satisfied, where I_{r_α} is the inference made on outcome B when players mix on signal a with probability r_α. Again, for a fixed r, as α increases the difference $C_\alpha(1) - C_\alpha(I_r)$ will also increase. To maintain the equality, I_{r_α} must approach 1, which means that r_α must approach 0. To conclude, in the strategy profile σ_α^S, the mixing rate $r_\alpha \to 0$ as $\alpha \to \infty$. Thus, the equilibrium becomes one in which players vote b almost always (with probability 1 on signal b and with probability approaching 1 on signal a). However, if both player vote b the inference is 1 and the privacy cost is maximal. Thus, as $\alpha \to \infty$, the privacy loss incurred by each player approaches $C_\alpha(1)$.

Since the privacy cost under anonymous voting approaches $C_\alpha(1)/2$, that of secret voting approaches $C_\alpha(1)$, and the added utility of getting the correct outcome becomes negligible, the $U^A_\alpha(\sigma^A_\alpha) > U^S_\alpha(\sigma^S_\alpha)$ as for all large enough α. ■

Proof of Proposition 9: Fix p_1 so that

$$c_0 \leq \min \left\{ \frac{1}{4}\sqrt{\frac{32p_1^2 - 32p_1 + 9}{(2p_1 - 1)^2}} + \frac{1}{4(2p_1 - 1)}, \frac{2p_1 - 1}{p_1^2 + (1 - p_1)^2} \right\}$$

(this is possible since both elements of the minimization approach 1 as $p \to 1$ – the first from above and the second from below). This upper bound on c and choice of p_1 imply that for all $p > p_1$, σ^A is an equilibrium in which $r = 1$ but $q < 1$ and σ^S is either the sincere voting profile or the unresponsive profile in which both players always vote b (by the proofs of Propositions 5 and 6).

Now, the proof of Proposition 5 also implies that

$$\begin{aligned}\lim_{p\to 1} U^A(\sigma^A, p) &= \lim_{p\to 1} \frac{p - (1 - 2pq + 2p^2q)c + p - (1 - 2p + 2p^2)qc}{2} \\ &= 1 - \frac{(1 - 2q + 2q)c + (1 - 2 + 2)qc}{2} \\ &= 1 - \frac{c\left(1 + \frac{c+1}{2c+1}\right)}{2} \\ &> 1 - c.\end{aligned}$$

By the proof of Proposition 6,

$$\begin{aligned}\lim_{p\to 1} U^S(\sigma^S, p) &= \lim_{p\to 1} \frac{p - \tilde{c}_S + p - (p^2 + (1 - p)^2)c - (p - p^2 + (1 - p)p)\tilde{c}_S}{2} \\ &= \lim_{p\to 1} 1 - \frac{c + \tilde{c}_S}{2} \\ &= 1 - c,\end{aligned}$$

where σ^S is the sincere voting profile and $\tilde{c}_S$ is the cost of the observer's inference on outcome B. The last equality holds because $\lim_{p\to 1} \tilde{c}_S = c$: in the limit on outcome B, the observer's inference is $I = 1$, and $\tilde{c}_S = C(I) = c$.

Furthermore, for the unresponsive profile σ^S_U, the welfare is

$$\lim_{p\to 1} U^S(\sigma^S_U, p) = \frac{1}{2} - c,$$

since the outcome is correct only with probability 1/2 but the inference is always $I = 1$, and so the privacy cost is $C(1) = c$. Thus, in the limit we have $U^A(\sigma^A, p) >$

$U^S(\sigma^S, p) > U^S(\sigma^S_U, p)$. But c is continuous, and so there exists some $1 > p_0 \geq p_1$ for which $U^A(\sigma^A, p) > U^S(\sigma^S, p) > U^S(\sigma^S_U, p)$ for all $p > p_0$. ■

Proof of Proposition 10: By the proof of Proposition 5 we have that σ^A is an equilibrium in which players vote sincerely on signal a, but mix with probability q on signal b, where

$$q = \frac{c + (2p-1)}{c(4p^2 - 4p + 2) + 2p - 1}.$$

Observe that $q = 1$ at $p = 1/2$ and that

$$\frac{\partial q}{\partial p} = -\frac{c(1-2p)^2}{2} < 0$$

for all $p \in (1/2, 1)$. Thus, for any $p > 1/2$ there exists a δ such that $q = 1 - \delta$. Now,

$$\begin{aligned}
U^A(\sigma^A, p) &= \frac{p - (1 - 2pq + 2p^2 q)c + p - (1 - 2p + 2p^2)qc}{2} \\
&= p - \frac{(1 + q(2p^2 - 2p - 2p + 2p^2 + 1))\, c}{2} \\
&= p - \frac{(1 - q + 2q(1 - 2p(1-p)))\, c}{2} \\
&= p - \left((1-\delta)(1 - 2p(1-p)) + \frac{\delta}{2}\right) c.
\end{aligned}$$

Now, σ^S can be either the sincere profile or the unresponsive profile in which players always vote b. In the former case, we have

$$\begin{aligned}
U^S(\sigma^S, p) &= \frac{p - c_S + p - (p^2 + (1-p)^2)c - (p - p^2 + (1-p)p)c_S}{2} \\
&= p - \frac{(1 - 2p(1-p))c + (1 + 2p(1-p))c_S}{2} \\
&< p - c(1 - 2p(1-p)) + \varepsilon,
\end{aligned}$$

where

$$c_S = C\left(\frac{1}{1 + 2p(1-p)}\right) < \ell\left(\frac{1}{1 + 2p(1-p)}\right) + \varepsilon = \left(\frac{1 - 2p(1-p)}{1 + 2p(1-p)}\right) c + \varepsilon$$

by assumption and the proof of Proposition 2. If σ^S is the unresponsive equilibrium in which players always vote b, then

$$U^S(\sigma^S, p) = \frac{1}{2} - c,$$

which is less than the welfare under sincere voting (for small enough ε).

We want

$$\begin{aligned}
&U^S(\sigma^S, p) < U^A(\sigma^A, p) \\
&\Leftarrow p - c(1-2p(1-p)) - \varepsilon < p - \left((1-\delta)(1-2p(1-p)) + \frac{\delta}{2}\right)c \\
&\Leftrightarrow c(1-2p(1-p)) - \varepsilon > \left((1-\delta)(1-2p(1-p)) + \frac{\delta}{2}\right)c \\
&\Leftrightarrow 1-2p(1-p) - \frac{\varepsilon}{c} > (1-\delta)(1-2p(1-p)) + \frac{\delta}{2} \\
&\Leftrightarrow 1-2p(1-p) > \frac{1}{\delta}\left(\frac{\delta}{2} + \frac{\varepsilon}{c}\right) = \frac{1}{2} + \frac{\varepsilon}{2\delta}.
\end{aligned}$$

Since $p > 1/2$, the last inequality holds for small enough $\varepsilon > 0$, as required. ■

F Proofs from Section 3

Proof of Proposition 11: Fix some small $\varepsilon > 0$ that satisfies $1/2 + 3\varepsilon < p$. Let

$$d_{\min} = \min_{I \in (1/2+\varepsilon, 1)} \frac{dC(I)}{dx},$$

the smallest derivative of C on points sufficiently far from $1/2$. Suppose players vote sincerely, and consider some player i. On any given signal, the probability that she affects the outcome—namely, the probability that she is pivotal—is bounded above by the probability that players other than i do not have a strict majority voting for the state, θ. Letting M_{-i} denote the number of players other than i voting for θ,

$$\begin{aligned}
\Pr[M_{-i} = (n-1)/2] &< \Pr[M_{-i} < n/2] \\
&\leq e^{-2(2p-1)np^3},
\end{aligned} \tag{6}$$

where the second inequality follows from a Chernoff bound.

What is player i's gain from deviating from sincerity? Suppose that a strict majority of the other players voted b, and that if $m_i = b$ then the resulting fraction of players voting for B is some $I \in (1/2 + 2\varepsilon, 1]$. If i were to deviate to $m_i = a$ then the fraction would be $I' = I - 1/n$. Then, the cost would decrease from $C(I)$ to $C(I')$, where

$$C(I) - C(I') = C(I) - C(I - 1/n) \geq \frac{d_{\min}}{n}.$$

Suppose that $s_i = b$ (a symmetric argument will hold for $s_i = a$. What is player i's gain from deviating from the sincere $m_i = b$ to $m_i = a$? Suppose that a strict majority of the other players voted b and that if $m_i = b$ then the resulting fraction of players voting for B is some $I \in (1/2 + 2\varepsilon, 1]$. If i were to deviate to $m_i = a$ then the fraction would be $I' = I - 1/n$. Then, the cost would decrease from $C(I)$ to $C(I')$, where

$$C(I) - C(I') = C(I) - C(I - 1/n) \geq \frac{d_{\min}}{n}.$$

Of course, it is not necessarily the case that $I \in (1/2 + \varepsilon, 1]$. Furthermore, if $I \leq 1/2$ then a deviation to $m_i = a$ would lead to $I' < I$ for which $C(I') > C(I)$, namely a greater privacy loss. Letting I be the fraction of players voting b (including player i), observe that $\Pr[I|s_i = \theta] = \Pr[1 - I - 1/n|s_i \neq \theta]$. Thus,

$$(C(I) - C(I - 1/n)) \Pr[I|s_i = \theta] = -(C(1 - I) - C(1 - I - 1/n)) \Pr[I|s_i \neq \theta].$$

Letting $\mathcal{I} = \{1/n, \ldots, (n-1)/n, 1\}$, the expected benefit of a deviation is

$$\begin{aligned}
E[C(I) - C(I - 1/n)] &= \sum_{I \in \mathcal{I}} (C(I) - C(I - 1/n)) \Pr[I] \\
&= E[C(I) - C(I - 1/n)|s_i = \theta] \Pr[s_i = \theta] - E[C(I) - C(I - 1/n)|s_i \neq \theta] \Pr[s_i \neq \theta] \\
&= (2p - 1) \cdot E[C(I) - C(I - 1/n)|s_i = \theta].
\end{aligned}$$

Furthermore, the probability that $I > 1/2 + 2\varepsilon$, conditional on $s_i = b = \theta$, is $1 - \delta$, where $\delta < \exp\left(-\frac{(1/2+2\varepsilon)^2 p^3 n}{2}\right)$, again by a Chernoff bound. For large enough n it holds that $\delta < 1/2$, and so in this case the gain from a deviation is at least

$$\begin{aligned}
&E[C(I) - C(I - 1/n)|s_i = \theta] \\
&\quad = E[C(I) - C(I - 1/n)|s_i = \theta, I \in (1/2 + 2\varepsilon, 1]] \Pr[I \in (1/2 + 2\varepsilon, 1]] \\
&\qquad + E[C(I) - C(I - 1/n)|s_i = \theta, I \notin (1/2 + 2\varepsilon, 1]] \Pr[I \notin (1/2 + 2\varepsilon, 1]] \\
&\quad \geq \frac{(2p - 1)d_{\min}}{n}(1 - \delta) \\
&\quad > \frac{(2p - 1)d_{\min}}{2n}.
\end{aligned}$$

The loss from a deviation, given by equation (6), is at most $\exp(-2(2p - 1)np^3)$. For large enough n the gain dominates the loss, and then a deviation from sincerity is profitable. ■

Proof of Proposition 12: Fx some small $\varepsilon > 0$ that satisfies $1/2 + 3\varepsilon < p$ and $p + \varepsilon < 1$. Consider first the case of secret, sincere voting. On any outcome o the privacy cost will be I_o, the corresponding inference. By the law of large numbers, as n grows the inference I_o will approach p or $1 - p$, depending on whether $o = B$ or $o = A$. Thus, for large enough n, the corresponding privacy cost will be at least $C(p - \varepsilon)$. Since the probability that the outcome $o = \theta$ is at most 1, the utility of players under sincere, secret voting is bounded above by $1 - C(p - \varepsilon) < 1$.

Consider now the case of anonymous voting. For any symmetric strategy profile we will use q to denote the probability that $m_i = \theta$, where $q \in [1/2, p]$ (for example, $q = p$ if players play $m_i = s_i$, and $q = 1/2$ if players randomize irrespective of their signals). Let $\text{piv}_q = \Pr[M_{-i} = (n-1)/2|q]$, the probability that players other than i are evenly split between votes for a and b when the probability that each player plays his signal is q; that is, piv_q is the probability that a player is pivotal.

Let $d_p = \frac{dC(p-2\varepsilon)}{dx}$. In equilibrium, players must be indifferent between voting $m_i = s_i$ and $m_i \neq s_i$, namely that if q is the probability that $m_i = s_i$ then

$$(2p-1)\text{piv}_q = (2p-1)E[C(I) - C(I - 1/n)|s_i = \theta], \tag{7}$$

where the left-hand-side (LHS) is the change in utility from getting the outcome right, and the right-hand-side (RHS) is the change in utility from privacy costs (see the proof of Proposition 11 for the definition of I and explanation of the RHS). Observe that if $q = p$ then the LHS is exponentially small in n, and the RHS is at least $C(p-\varepsilon) - C(p - \varepsilon - 1/n)$ for large enough n, by the law of large numbers. Also note that $C(p-\varepsilon) - C(p-\varepsilon-1/n) > d_p/n$ by convexity of C. Thus, for large enough n, the LHS is smaller than the RHS. But as q gets smaller, the LHS increases and the RHS decreases. The unique q where they are equal is an equilibrium.

Next, observe that, for large enough n, the RHS of (7) is at most $C(p + \varepsilon) - C(p + \varepsilon - 1/n) < d_p^+/n$, where $d_p^+ = \frac{dC(p+\varepsilon)}{dx}$, again by the law of large numbers and convexity of C. Thus, in equilibrium, $\text{piv}_q < d_p^+/n$.

Let SM be a variable with values $\{a, b, \perp\}$, where $\text{SM} = x$ is the event that a strict majority of players other than i voted x, and if $x = \perp$ then the players other than i are split evenly. We now claim that that for large enough n, in equilibrium, $\Pr[\text{SM} \neq \theta] < d_p^+\sqrt{\ln n/(2n)}$.

To see this, suppose that $\theta = B$ (a symmetric argument holds for $\theta = A$), and again let M_{-i} be the number of votes, other than i, for outcome B. Note that, by a Chernoff bound, $\Pr\left[M_{-i} < (n-1)/2 - \sqrt{n \ln n}\right] < 1/n^2$. Since the maximal probability of any $M_{-i} \leq n/2$ is at most piv_q, it holds that

$$\begin{aligned}\Pr[\text{SM} \neq b] &= \Pr\left[M_{-i} \in [(n-1)/2 - \sqrt{n \ln n}, (n-1)/2]\right] + \Pr\left[M_{-i} < (n-1)/2 - \sqrt{n \ln n}\right] \\ &< \sqrt{n \ln n} \cdot \text{piv}_q + 1/n^2 \\ &< d_p^+ \sqrt{\ln n / n} + 1/n^2 \\ &< d_p^+ \sqrt{\ln n / (2n)}\end{aligned}$$

for large enough n.

We are now ready to bound the utility of players under anonymous voting. First, the probability that the outcome is correct is at least

$$\Pr[\text{SM} = \theta] > 1 - d_p^+ \sqrt{\ln n / (2n)},$$

and note that $\Pr[\text{SM} = \theta] \to 1$ as $n \to \infty$. Furthermore, as noted above, the privacy cost is at most d_p^+/n, and this approaches 0 as $n \to \infty$. Thus, the utility under anonymous voting approaches 1 as n grows. In particular, for large enough n, this utility surpasses the utility $1 - C(p - \varepsilon)$ from secret voting. ■

References

Austen-Smith, D. and Banks, J. S. (1996). Information aggregation, rationality, and the condorcet jury theorem. *American Political Science Review*, **90** 34–45.

Battaglini, M., Morton, R. and Palfrey, T. (2007). Efficiency, equity, and timing of voting mechanisms. *American Political Science Review*, **101** 409–424.

Bender, B. and Lott, J. R., Jr. (1996). Legislator voting and shirking: A critical review of the literature. *Public Choice*, **87** 67–100.

Chen, Y., Chong, S., Kash, I. A., Moran, T. and Vadhan, S. (2013). Truthful mechanisms for agents that value privacy. In *Proceedings of the fourteenth ACM conference on Electronic commerce*. ACM, 215–232.

Coughlan, P. J. (2000). In defense of unanimous jury verdicts: Mistrials, communication, and strategic voting. *American Political Science Review*, **94** 375–393.

Dal Bó, E. (2007). Bribing voters. *American Journal of Political Science*, **51** 789–803.

Downs, A. (1957). An economic theory of democracy.

Dziuda, W. and Gradwohl, R. (2015). Achieving cooperation under privacy concerns. *American Economic Journal: Microeconomics*, **7** 142–173.

Feddersen, T. and Pesendorfer, W. (1998). Convicting the innocent: The inferiority of unanimous jury verdicts under strategic voting. *American Political Science Review*, **92** 23–35.

Fehrler, S. and Hughes, N. (2014). How transparency kills information aggregation: Theory and experiment. Tech. rep., Mimeo Zurich.

Felgenhauer, M. and Grüner, H. P. (2008). Committees and special interests. *Journal of Public Economic Theory*, **10** 219–243.

Fingleton, J. and Raith, M. (2005). Career concerns of bargainers. *Journal of Law, Economics, and Organization*, **21** 179–204.

Gersbach, H. and Hahn, V. (2008). Should the individual voting records of central bankers be published? *Social Choice and Welfare*, **30** 655–683.

Gradwohl, R. and Smorodinsky, R. (2014). Perception games and privacy. *arXiv preprint arXiv:1409.1487*.

Holmström, B. (1999). Managerial incentive problems: A dynamic perspective. *The Review of Economic Studies*, **66** 169–182.

Hurley, P. A. (2001). David Mayhew's Congress: The Electoral Connection after 25 years. *Political Science & Politics*, **34** 259–261.

Jones, D. R. (2003). Position taking and position avoidance in the US Senate. *Journal of Politics*, **65** 851–863.

Kearns, M., Pai, M. M., Roth, A. and Ullman, J. (2012). Mechanism design in large games: Incentives and privacy. *arXiv preprint arXiv:1207.4084*.

Lau, R. R. (1985). Two explanations for negativity effects in political behavior. *American Journal of Political Science* 119–138.

Levy, G. (2007a). Decision making in committees: Transparency, reputation, and voting rules. *American Economic Review*, **97** 150–168.

Levy, G. (2007b). Decision-making procedures for committees of careerist experts. *American Economic Review*, **97** 306–310.

Mayhew, D. R. (1974). *Congress: The Electoral Connection*. Yale University Press.

Meade, E. E. and Stasavage, D. (2008). Publicity of debate and the incentive to dissent: Evidence from the us federal reserve*. *The Economic Journal*, **118** 695–717.

Nissim, K., Orlandi, C. and Smorodinsky, R. (2012). Privacy-aware mechanism design. In *Proceedings of the 13th ACM Conference on Electronic Commerce*. ACM, 774–789.

Razin, R. (2003). Signaling and election motivations in a voting model with common values and responsive candidates. *Econometrica*, **71** 1083–1119.

Robbins, I. P. (2007). The importance of the secret ballot in law faculty personnel decisions: Promoting candor and collegiality in the academy. *J. Legal Educ.*, **57** 266.

Seidmann, D. J. (2011). A theory of voting patterns and performance in private and public committees. *Social Choice and Welfare*, **36** 49–74.

Shepsle, K. A. (1972). The strategy of ambiguity: Uncertainty and electoral competition. *The American Political Science Review* 555–568.

Sibert, A. (2003). Monetary policy committees: Individual and collective reputations. *The Review of Economic Studies*, **70** 649–665.

Snyder, J. M. and Ting, M. M. (2005). Why roll calls? A model of position-taking in legislative voting and elections. *Journal of Law, Economics, and Organization*, **21** 153–178.

Stasavage, D. (2007). Polarization and publicity: Rethinking the benefits of deliberative democracy. *Journal of Politics*, **69** 59–72.

Swank, J., Swank, O. H. and Visser, B. (2008). How committees of experts interact with the outside world: some theory, and evidence from the fomc. *Journal of the European Economic Association*, **6** 478–486.

Thomas, M. (1991). Issue avoidance: Evidence from the US senate. *Political Behavior*, **13** 1–20.

Visser, B. and Swank, O. H. (2007). On committees of experts. *The Quarterly Journal of Economics*, **122** 337–372.

Weaver, R. K. (1986). The politics of blame avoidance. *Journal of public policy*, **6** 371–398.