Accountability with Large Electorates*

Short title: Accountability with Large Electorates

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Abstract

We show that ignorant voters can succeed in establishing high levels of electoral accountability. In our model, an incumbent politician is confronted with a large number of voters who receive fuzzy private signals about her performance. A sampling effect enables the incumbent to form a precise estimate of the median voter's signal, and the resulting level of accountability is as if the incumbent faced a perfectly informed social planner. Public information or ideological preferences can impair the beneficial impact of the sampling effect on accountability; overconfidence of voters can restore the full benefit of the sampling effect.

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Popular belief has it that elections can serve to hold incumbent politicians accountable only if 'the people' are sufficiently informed about the incumbent's performance. This notion can be evidenced, for example, in Thomas Jefferson's fear that

> 'If once they [the people] become inattentive to the public affairs, you and I, and Congress, and Assemblies, judges and governors shall all become wolves' (Jefferson, 1787),

in James Madison's letter to William T. Barry where he writes that

> 'A popular Government without popular information or the means of acquiring it, is but a Prologue to a Farce or a Tragedy or perhaps both' (Madison, 1822),

or in Lyndon B. Johnson's statement on the Freedom of Information Act

> 'A democracy works best when the people have all the information that the security of the Nation permits' (Johnson, 1966).

It is, however, not clear what 'the people' actually means nor which kind of information is thought to be necessary for accountability (see Bartels, 1996; Ashworth and Bueno de Mesquita, 2014, for a discussion of this problem). Empirical evidence suggests that many voters know little about politics (Delli Carpini and Keeter, 1996), and thus real electorates are far away from an 'ideal' electorate where all voters are well-informed about public affairs. From a theoretical point of view, voter ignorance regarding the political sphere is not surprising because an individual vote is not likely to be decisive for the collective decision. Therefore, it is simply rational for voters not to waste time and energy on grasping the complex world of politics.

Some scholars sought to develop theories that can help explain how accountability can be ensured even though most voters know little about their representatives. One prominent argument says, for example, that incumbents can be held accountable as long as there are informed specialists who can inform the electorate about their politicians. For example, these specialists may include competing politicians, interest groups, or 'watchdog voters' who like being informed about the details of politics. In summary, these theories claim that having some type of informed elite can be sufficient for establishing electoral accountability (see, for example, Schumpeter, 1947; Dahl, 1956; Downs, 1957; Bartels, 1986; Dalager, 1996).

Other scholars doubt that incumbents can be held accountable (Delli Carpini and Keeter, 1996). In line with this reasoning, recent books with expressive titles like *Democracy for Realists: Why Elections Do Not Produce Responsive Government* (Achen and Bartels, 2016) or *Against Democracy* (Brennan, 2017) argue that elections cannot serve their role in holding politicians accountable because voters are ignorant and irrational.

In contrast to this line of reasoning, we show that a large electorate can hold incumbents accountable, although there is no informed elite and *all* voters are poorly informed. This is possible because it is not only voter knowledge that determines accountability but also what the incumbent knows about the decisive opinion in the electorate. In a large electorate, there is a sampling effect that implies that the decisive opinion can be based on a very precise estimate of the incumbent's competence. Being aware of that, the incumbent works hard to make a positive impression of herself, which gives rise to a high level of accountability. We further show that accountability can be improved when voters are overconfident and hold highly erroneous beliefs about a politician.

We demonstrate this result in a political agency model where an incumbent's performance influences the level of public goods in a society. Given our main focus on accountability, we consider a setup where all voters prefer to have a higher level of public goods. For instance, this may be a situation where the incumbent is providing a public good funded by a fixed budget, and every voter hopes for the most efficient use of the budget to produce the public good. The incumbent can try to boost public good provision in order to appear competent, and thus improve the chance of being re-elected. Each voter passively acquires a vague private impression of the incumbent's performance through his perception and use of public goods: While each voter can observe the utility derived from public goods, he is assumed to be ignorant regarding the political sphere, which makes it difficult for him to attribute the utility from public goods to the responsible politician. Thus, the incumbent's effort to boost public good provision has only a minor impact on a voter's opinion, when compared to a situation where well-informed voters observe her performance.

The incentives of the incumbent, however, are not only determined by the effect of effort on voter opinions but also by the effect of manipulating opinions on the prospects of re-election. In other words, how does a given change in voter opinions increase the probability of re-election? For the incumbent, the expected magnitude of this effect depends on the decisive opinion in the electorate. While the incumbent's knowledge of some voter's opinion is quite fuzzy, a sampling effect allows the incumbent to form a much more precise estimate of the decisive median voter's opinion. This sampling effect on the incumbent's side counteracts the low impact of performance on voter opinions and increases the payoff of exerting effort. Actually, when the electorate is large the incumbent exerts effort as if a voter who can perfectly observe her performance will decide the election, although the median voter is unaware of the high precision of his information.

The sampling effect improves accountability unless there is a strong electoral advantage or disadvantage for the incumbent. This (dis)advantage may originate from ideological preferences of voters or from a difference in prior expected competence between the incumbent and a challenger. In this case, higher precision of the median voter's information reduces the incumbent's effort level since it becomes less likely that the incumbent's performance sways the median voter who will vote either for or against the incumbent anyway.

Introducing public information about the incumbent's performance to the model blurs the median voter's estimate of the incumbent's competence since the median voter is not aware that his private signal is very precise and therefore overweights the public signal in his estimate. This induces a lower level of accountability as long as the incumbent has little or no electoral advantage or disadvantage. The result has two interesting implications: first, information spread via mass media reduces voter welfare due to lower effort by the incumbent. Even critical media coverage about the incumbent's performance leaves voters worse off as compared to a world where voters only receive private information. Second, incumbents who face a neutral to moderately biased electorate have incentives to disclose some information about their performance in order to help create public information and reduce their effort level. Interestingly, if incumbents are successful in creating public information that voters cannot avoid, the accountability-enhancing role of critical media coverage is restored. When public information is inevitable, journalists can increase the precision of public information which in turn makes the incumbent work harder.

In the case of a strong electoral advantage or disadvantage of the incumbent, however, introducing public information results in a higher level of accountability. When the median opinion is blurred by public information, the incumbent is less sure that the median voter will vote either for or against her regardless of her performance, which makes it more lucrative to manipulate his opinion by exerting effort. To summarise, the impact of public information depends on the magnitude of the (dis)advantage of the incumbent.

In both cases, electoral (dis)advantages of incumbents and public information, voter welfare is impaired by the discrepancy between the voters' perspective on the noise in their private signals and the incumbent's perspective on the median of these noise terms. We find, however, that overconfidence of voters can reduce or even eliminate this knowledge discrepancy which increases accountability in all scenarios and can even fully restore the beneficial impact of the sampling effect on accountability in some scenarios. This result adds an accountability angle to the recent critique by Levy and Razin (2015) of the claim that overconfidence of voters implies bad collective decisions.

We interpret accountability in our model as the leeway incumbents have regarding the allocation of resources between selfish goals and the benefit of voters. In the model, there is no option for the incumbent to engage in stark abuses of power such as establishing arbitrary government or engaging in criminal activities. Therefore, an important caveat is that we implicitly assume a functioning system of checks and balances (Locke [1690] 1976, Montesquieu [1748] 1991, Madison *et al.* [1788] 1961) that ensures that incumbents who abuse their power are removed from office via court decisions, parliamentary procedures, or elections. Our result then implies that the incumbent does not exploit her leeway given by the system of checks and balances for selfish goals even if voters are poorly informed.

The sampling effect that can improve accountability in our analysis is closely connected to a prominent result regarding a different purpose of elections: the jury theorem. While our analysis focuses mainly on the *incentives* of incumbent politicians, we also consider the *selection problem* to which the jury theorem applies.[1] The key question regarding the selection problem is whether the decisions of individual voters result in a collective decision that selects the better of two alternatives (the more talented candidate, for example).[2] Our results show that the main message of the jury theorem (which says that having a larger

[1] Ashworth *et al.* (2017) show that the impact of voter knowledge on welfare is not always trivial because there can be a trade-off between the incentive and the selection problem.

[2] Scholars who study this problem examine whether having a large number of voters can result in a distribution of votes such that the better alternative is selected although each voter is poorly informed (see, for example, Young, 1988; Ladha,

electorate can improve or perfectly solve the selection problem) can remain valid even if we introduce strategic interaction between incumbent and voters: In our model, the precision of the median voter's opinion is going towards infinity as the size of the electorate goes to infinity, implying that the selection problem is perfectly solved in our benchmark case in the sense that only incumbents with above-average talent are re-elected. Taken together, our analysis shows that elections can enable ignorant voters to achieve both: *selecting* talented politicians and *holding incumbents accountable*. As discussed above, the introduction of a public signal or a smaller electorate blurs the median voter's information, which results in less successful selection, except in the case of a strong electoral (dis)advantage of the incumbent.

In contrast to the implications of having a large number of voters for the selection problem, the implications for accountability have been largely left unexplored. Many papers that study electoral accountability use a representative voter to model the electorate: Ashworth and Bueno de Mesquita (2014) and Ashworth *et al.* (2017) are similar to our study because they also focus on the role of information for accountability. Ashworth and Bueno de Mesquita (2014) show that in contrast to a widely held intuition, an increase in voter knowledge can result in reduced democratic performance. Ashworth *et al.* (2017) demonstrate that there can be a trade-off between electoral accountability and electoral selection because higher levels of effective accountability can reduce the informativeness of policy performance about an incumbent's characteristics. Ashworth (2005) analyses the determinants and consequences of the incumbency advantage, Alesina and Tabellini (2007, 2008) discuss the types of policy tasks better suited for a bureaucrat versus for a politician, and Dewatripont *et al.* (1999) study the organisation of government agencies. Kotsogiannis and Schwager (2008) show that fiscal equalisation affects the accountability of politicians in the presence of yardstick competition. As all these papers assume a representative voter, the sampling effect due to a large number of voters cannot be observed. One implication of our analysis is that the assumptions regarding voter knowledge should be chosen carefully because an ignorant representative voter can be an inappropriate description of an electorate that consists of ignorant voters.

Bruns and Himmler (2016) also use the career concern framework to study the influence of information on electoral accountability. They provide an explanation for why rational voters demand instrumental

1992; Austen-Smith and Banks, 1996; Feddersen and Pesendorfer, 1997, 1998; Martinelli, 2006).

information, which is then provided by commercial media. In contrast, our paper studies accountability for given information structures, but their study can be informative regarding the precision of public information in our model. Further, they focus on small electorates whereas we are mainly concerned with a large number of voters.

The paper is structured as follows. We describe the baseline model where voters only have private information in section 1. In section 2 we present several extensions of the baseline model: public information, ideological preferences of voters, and overconfidence of voters. Section 3 concludes.

1. Baseline Model

There are n voters, where n is an odd and large number. Further, there are two time periods. In period 1, there is an incumbent politician (I) who provides a public good. At the end of period 1, an election takes place where the voters can either re-elect the incumbent or elect a challenger (C). The candidate who receives the majority of the votes wins the election and provides the public good in period 2.

Our model follows the 'career concern' approach of political agency problems as described in Persson and Tabellini (2002). We start the analysis with a baseline model where voters have common preferences and where each voter receives a private signal about the incumbent's performance before the election. After having observed the signal, each voter votes sincerely for the candidate who appears to be the better alternative for him. These assumptions are inspired by standard models on information aggregation in elections that show the well-established result that a large electorate of poorly informed voters can succeed in selecting the better alternative.

1.1 *Public Good Provision*

The politicians' performances in public good provision are

$$g_1^I = e_1^I + \theta^I \quad \text{in period 1 and}$$
$$g_2^j = e_2^j + \theta^j \quad \text{with } j \in \{I, C\} \text{ in period 2.}$$

The variables $e_1^I, e_2^j \geq 0$ denote the effort of the politician in office in the respective time period, and the parameter θ^j denotes her competence. So the level of effort is a period-specific choice whereas competence remains constant over time.[3]

We assume that both politicians and voters share the common prior belief that θ^I and θ^C are realised values of a normal distribution with mean $\bar{\theta}$ and variance $1/\tau_\theta$ (so τ_θ is the precision of the distribution). Thus, as usual in models of the career concern type, an incumbent does not know her own competence, so we do not need to consider signalling issues in the analysis.

Effort can be interpreted as the amount of time an incumbent devotes to activities like attracting grant monies, monitoring bureaucrats, or negotiating contracts.[4] According to this interpretation, working hard for the constituents reduces the time that is left for enjoying the amenities associated with political office or for pursuing selfish career goals. We introduce the cost function $c(e)$ that measures how much benefit the incumbent forgoes by exerting effort. We assume that $c(e)$ is strictly convex with $c(0) = 0$, $c'(e) > 0$, $c(e)'' > 0$ and $\lim_{e \to 0} c'(e) = 0$.

When deciding on her effort level, the incumbent knows that voters evaluate her performance to decide whether to re-elect her. By exerting more effort, the incumbent can increase public good provision to try to impress the voters, and thus raise the probability of her re-election p. The incumbent's objective in period 1 is to maximise

$$p(e_1^I) \cdot [R - c(e_2^I)] - c(e_1^I), \tag{1}$$

where $R > 0$ denotes an exogenous rent from being in office. The incumbent's objective function shows that she has to weigh the cost of effort in period 1 against the expected rent in period 2.[5]

1.2 *Voters*

A voter either votes for the incumbent or for the challenger and we label voter i's decision $v_i \in \{I, C\}$. There is no abstention. We assume that each voter votes sincerely for the candidate whom he expects

[3]We use the simple additive production function for ease of exposition. The result holds for production functions $g = \theta(\alpha e + \beta) + \gamma e$ with $\alpha, \beta, \gamma \geq 0$ (as in Dewatripont *et al.*, 1999), where effort and talent can be both additive and multiplicative.

[4]The variable e can also be interpreted as a measure of rent-seeking (see, for example, Alesina and Tabellini, 2007; Gehlbach, 2007).

[5]We abstract from discounting throughout the analysis because including it would not generate any interesting insight.

to provide higher utility in period 2.

Voters have identical preferences and we assume that each voter's utility from the incumbent's performance simply is $u_1 = g_1$ in period 1 and $u_2 = g_2$ in period 2. If voters can observe u_1 and know that they can observe it, they know that they have a perfect observation of incumbent performance and there would be no interesting information problem. However, considering the empirical evidence on voter ignorance it seems to be unrealistic to assume perfect observation and we assume that each voter receives a private signal

$$s_i = g_1^I + x_i,$$

where the noise terms are independently and identically distributed normal random variables with $x_i \sim N(0, 1/\tau_x)$. In principle, the precision τ_x of the noise can take on any positive value but we expect the precision to be low, reflecting voter ignorance. This assumption appears appropriate for our case of a large electorate where a single vote is not likely to be decisive, and thus there is no incentive for voters to privately gather additional information.

The assumptions that voter utility in period 1 is $u_1 = g_1$ but that voters receive noisy signals before the election can be reconciled when we interpret our model as a shortcut to describe the following situations:

Incumbent performance has long-lasting consequences such as investments in infrastructure, and voters cannot observe their future utility when they consider whom to vote for (Besley and Prat, 2006). Further, in the real world, public good provision results from a complex political process where many different actors (bureaucrats and other politicians, for example) or factors such as the state of the economy are involved. Voters may observe the aggregate level of public good provision determined by the political process, but as voters are usually poorly informed about the details of political processes, they will find it difficult to disentangle the contributions of different politicians and thus will make mistakes when estimating the performance of a single politician.

1.3 *Timing of the Game*

Period 1:

- Nature selects the incumbent's competence (θ^I) which remains unknown to all players.
- The incumbent chooses e_1^I and $g_1^I = e_1^I + \theta^I$ is realised but not observed by the voters.
- Each voter receives a private signal $s_i = g_1^I + x_i$ about the incumbent's performance.
- The election takes place.

Period 2:

- The winner of the election chooses effort and either $g_2^I = e_2^I + \theta^I$ or $g_2^C = e_2^C + \theta^C$ is realised.

1.4 *Equilibrium Analysis*

We solve for an equilibrium in pure strategies. Let the voters' equilibrium beliefs[6] regarding the incumbent's and the challenger's effort levels be ${e_1^I}^*, {e_2^I}^*, {e_2^C}^*$. The incumbent chooses effort levels that maximise her payoff given that the voters hold equilibrium beliefs ${e_1^I}^*, {e_2^I}^*, {e_2^C}^*$ and apply equilibrium voting rule v_i^*:

$$
\begin{aligned}
{e_1^I}^* &= \arg\max_{e_1^I} \; p[e_1^I | v_i^*({e_1^I}^*)] \cdot [R - c({e_2^I}^*)] - c(e_1^I), \\
{e_2^I}^* &= \arg\max_{e_2^I} \; -c(e_2^I).
\end{aligned}
$$

If elected, the challenger chooses an effort level that satisfies

$$
{e_2^C}^* = \arg\max_{e_2^C} \; -c(e_2^C).
$$

[6]Thus, in equilibrium, each voter believes that both the incumbent and the challenger choose their respective effort levels with probability one. Voters hold correct and therefore identical beliefs in equilibrium.

Each voter wants to elect the candidate that he expects to provide higher utility in period 2:

$$v_i^* = \begin{cases} I & \text{for} \quad E(u_2^I | s_i, e_1^{I^*}, e_2^{I^*}) \geq E(u_2^C | e_2^{C^*}) \\ C & \text{for} \quad E(u_2^I | s_i, e_1^{I^*}, e_2^{I^*}) < E(u_2^C | e_2^{C^*}), \end{cases}$$

where $E(u_2^I | s_i, e_1^{I^*}, e_2^{I^*}) = e_2^{I^*} + E(\theta^I | s_i, e_1^{I^*})$ and $E(u_2^C | e_2^{C^*}) = e_2^{C^*} + E(\theta^C) = e_2^{C^*} + \bar{\theta}$.

It will become apparent below that voters apply a cutoff strategy such that for equilibrium beliefs $e_1^{I^*}, e_2^{j^*}$ we have $v_i^* = I$ if and only if $s_i \geq \hat{s}$ and $v_i^* = C$ if and only if $s_i < \hat{s}$.

Thus, an equilibrium consists of a tuple $[e_1^{I^*}, e_2^{I^*}, e_2^{C^*}, \hat{s}, E(\theta^I | s_i, e_1^{I^*})]$ that is sequentially rational and consistent. We apply backward induction to find the equilibrium.

Finding $e_2^{I^*}$ and $e_2^{C^*}$ is trivial. As the game ends after period 2, the winner of the election has nothing to gain from exerting costly effort and thus does not exert any effort ($e_2^{I^*} = e_2^{C^*} = 0$). This means that voters' utility in period 2 is solely determined by the competence of the respective candidate.

Therefore, each voter votes for the candidate that he expects to be more competent:

$$v_i^* = \begin{cases} I & \text{for} \quad E(\theta^I | s_i, e_1^{I^*}) \geq E(\theta^C) = \bar{\theta} \\ C & \text{for} \quad E(\theta^I | s_i, e_1^{I^*}) < E(\theta^C) = \bar{\theta}. \end{cases}$$

The incumbent is aware of this and can try to manipulate the voters' beliefs about her competence by exerting effort. We simplify notation and use $e := e_1^I$ and $\theta := \theta^I$ for the remainder of the analysis, since it is clear that the key aspect of the model is the strategic interaction between the incumbent and voters in period 1.

Voters update their beliefs using Bayes' rule. Voter i knows that his signal contains information about θ and wants to extract this information. From his perspective, the incumbent's effort (e) is a systematic bias of his signal and he believes this bias to be e^*. Then, his signal $s_i = e^* + \theta + x_i$ is the realised value of a normal random variable with mean $e^* + \bar{\theta}$ and variance $(1/\tau_\theta) + (1/\tau_x)$. We show in Appendix A that voter i's posterior belief of the incumbent's competence is described by a normal distribution with

$$E(\theta|s_i, e^*) = \frac{\tau_\theta \cdot \bar{\theta} + \tau_x \cdot (s_i - e^*)}{\tau_x + \tau_\theta} \text{ and } Var(\theta|s_i, e^*) = \frac{1}{\tau_\theta + \tau_x}.$$

Intuitively, $E(\theta|s_i, e^*)$ is a precision-weighted average of old and new information and the voter corrects his signal for the bias as shown by the term $(s_i - e^*)$.

Having established voter i's posterior belief, we can describe his decision as follows:

$$\begin{aligned} v_i^* = I \quad &\Leftrightarrow \quad \frac{\tau_\theta \cdot \bar{\theta} + \tau_x \cdot (s_i - e^*)}{\tau_x + \tau_\theta} \geq \bar{\theta} \\ &\Leftrightarrow \frac{\tau_x}{\tau_x + \tau_\theta} \cdot [s_i - (e^* + \bar{\theta})] \geq 0. \end{aligned} \tag{2}$$

Note that the weight that a voter attaches to his signal $[\tau_x/(\tau_x + \tau_\theta)]$ does not affect his decision but that it is only the term in brackets that determines his decision. Define $\hat{s} := e^* + \bar{\theta}$. Then we can say that each voter's decision is characterised by the following cutoff strategy:

Lemma 1. *Voter i votes for the incumbent if and only if $s_i \geq \hat{s}$.*

Proof. See Appendix A. □

Lemma 1 means that a voter will re-elect the incumbent if and only if his observation of the incumbent's performance is better than the expected performance of a politician with average talent.

The incumbent knows that she will get re-elected if at least half of the voters receive a signal with $s_i \geq \hat{s}$. Let s_m be the median of the realised signals. Then, the incumbent will get re-elected if and only if $s_m \geq \hat{s}$ and thus the probability of re-election is $p = Pr[s_m \geq \hat{s}]$.

In statistical terminology, the incumbent has to determine the median of a sample of size n to compute the probability of getting re-elected. For given e and θ, the median signal is determined by the median realisation of the noise terms (x_i). It is a well-known result that in a large sample of independently and identically distributed normal random variables with mean μ and variance $1/\tau$, the sample median can be described approximately by a normal distribution with mean μ and variance $\pi/(2n\tau)$ (see, for example, Cramér, 1946, p. 369). It follows that in our model the median x_m of the individual noise terms can be described approximately by a normal distribution with mean zero and variance $1/\tau_m = \pi/(2n\tau_x)$. As a consequence, the incumbent's knowledge about the median signal is much more precise than about some individual signal s_i.

Definition 1. *Consider the distribution of the median value of individual voter characteristics such as x_i. We define the term 'sampling effect' to denote the fact that the precision τ_m of this distribution is increasing in n.*

Hence, the incumbent knows that she will get re-elected if and only if

$$s_m = e + \theta + x_m \geq e^* + \bar{\theta}, \tag{3}$$

where the median signal $s_m = e + \theta + x_m$ is a normal random variable with mean $e + \bar{\theta}$ and variance $(1/\tau_\theta) + \pi/(2n\tau_x)$. The probability of re-election is therefore

$$Pr[s_m \geq \hat{s}] = 1 - \Phi\left\{[e^* + \bar{\theta} - (e + \bar{\theta})]\sqrt{\frac{1}{\frac{1}{\tau_\theta} + \frac{1}{\tau_m}}}\right\},$$

where Φ denotes the distribution function of the standard normal distribution. The incumbent thus chooses e to maximise

$$\left\{1 - \Phi\left[(e^* - e)\sqrt{\frac{1}{\frac{1}{\tau_\theta} + \frac{1}{\tau_m}}}\right]\right\} \cdot R - c(e).$$

Taking the derivative with respect to e and applying the equilibrium condition that $e = e^*$ yields

Lemma 2. *With a large electorate where each voter receives a private signal about the incumbent's performance, equilibrium effort e^* solves*

$$\frac{1}{\sqrt{2\pi}} \cdot \sqrt{\frac{1}{\frac{1}{\tau_\theta} + \frac{1}{\tau_m}}} R = c'(e^*), \tag{4}$$

where $1/(\sqrt{2\pi})$ is the standard normal density evaluated at zero, that is, $\phi(0)$; and where $1/\tau_m = \pi/(2n\tau_x)$.

Proof. See Appendix A. □

The left-hand side of equation (4) is increasing in τ_m, and thus in n which means that effort is increasing in the size of the electorate because of the sampling effect.

Consider a social planner who receives a perfect signal s about incumbent performance. He then re-elects the incumbent if and only if $s = e + \theta \geq e^* + \bar{\theta}$, where the left-hand side is distributed as a normal distribution with mean $e + \bar{\theta}$ and variance $1/\tau_\theta$. Applying the established procedure to derive equilibrium effort shows that equilibrium effort in case of the social planner solves

$$\frac{1}{\sqrt{2\pi}} \cdot \sqrt{\tau_\theta} R = c'(e^*).$$

Since equation (4) in Lemma 2 goes towards the above condition for $\tau_m \to \infty$, we establish an accountability counterpart to the jury theorem:

Proposition 1. *Equilibrium effort is increasing in the number of voters (n) and for $n \to \infty$ equilibrium effort goes towards equilibrium effort that the incumbent would choose if he were confronted with a social planner who receives a perfect signal about her performance. The respective equilibrium effort is defined by*

$$\frac{1}{\sqrt{2\pi}} \cdot \sqrt{\tau_\theta} R = c'(e^*). \tag{5}$$

Proof. See Appendix A. □

The intuition behind Proposition 1 is as follows: The incumbent's incentives depend on the marginal benefit of effort which is determined by the increase in probability that the median signal is higher than the re-election threshold $\hat{s}$. In equilibrium, this increase is given by the density at the mean of the distribution of the median signal. Due to the sampling effect, the density at the mean is increasing in the size of the electorate because the larger the electorate, the more likely it becomes that the median voter's observation of the incumbent's performance is subject to a small random error only. This means that a larger electorate makes it more profitable for the incumbent to exert effort.

In the limit case, the median voter receives a perfect signal $s_m = g_1$ about the incumbent's performance without being aware of this fact. The incumbent, however, knows that the median voter receives a perfect signal due to the sampling effect. As a consequence, the incumbent's perspective on the median signal is not confounded by noise but is determined only by the random variable θ. It follows that the precision of the distribution of the decisive signal and thus the density of this distribution at the mean both tend towards the respective values in case of a social planner who receives a perfect signal. Thus, the incumbent's incentives to exert effort are strong.

Proposition 1 says that ignorance of voters has no severe consequences for electoral accountability in a large electorate. Instead, a large electorate of poorly informed voters can establish the same level of accountability as a perfectly informed voter. Having an electorate of 'ideal' voters who invest much time and effort to become well-informed about the incumbent's performance is then an inefficient scenario. Since improving private knowledge has no impact on the level of accountability, voters are better off when they use their resources for other purposes than becoming informed. Indeed, in a large electorate where the problem of a vote's low probability to be decisive may be considered most severe for accountability, electoral accountability is actually fine. Even if voters are not selfish but follow a group-oriented moral (Feddersen and Sandroni, 2006b), acquiring information would be considered an inefficient activity no voter should engage in, and ignorance would be rational.

In order to fully characterise the implication of the sampling effect on voter welfare, we also analyse electoral selection in addition to electoral accountability: In equilibrium, the median voter elects the incumbent if and only if $e^* + \theta + x_m \geq e^* + \bar{\theta}$. As the voters' belief about effort is correct in equilibrium, the collective decision v^* is solely determined by incumbent competence and the median voter's signal noise:[7]

$$v^* = \begin{cases} I & \text{for} \quad \theta + x_m \geq \bar{\theta} \\ C & \text{for} \quad \theta + x_m < \bar{\theta}. \end{cases}$$

Since the second-period utility of a voter is simply equal to the competence of the politician in office,

[7] If effort and competence are multiplicative, the incentive problem and the selection problem are not independent (as in the additive case) because the probability that the collective decision is wrong depends on the equilibrium effort level. Higher equilibrium effort improves the selection problem. This is not a specific feature of our model, but it applies to career concern models in general. The implication for our model is: Since equilibrium effort is increasing in n the sampling effect induces an indirect beneficial effect on the selection problem via higher levels of effort. We show this in Appendix A in the proof of Proposition 2.

expected voter utility in period 2 is

$$E(u_2) = \int_{-\infty}^{\infty} \left\{ \, Pr\left[v^* = I|\theta\right] \cdot \theta + Pr\left[v^* = C|\theta\right] \cdot \bar{\theta} \, \right\} f(\theta) d\theta,$$

where $f(\theta)$ denotes the probability density function of θ. We obtain

Proposition 2. *Expected voter utility in period 2 is increasing in the number of voters (n) and for $n \to \infty$ expected voter utility goes towards the level that would be achieved if the incumbent were confronted with a social planner who receives a perfect signal about her performance.*

Proof. See Appendix A. □

The intuition behind Proposition 2 is straightforward. Welfare is reduced if the incumbent is re-elected although her talent is below average ($v^* = I|\theta < \bar{\theta}$) or the incumbent is not re-elected although her talent is above average ($v^* = C|\theta > \bar{\theta}$). These errors can occur only because of the noise term x_m. The probability of a false collective decision is decreasing in n and goes towards zero for $n \to \infty$ since the distribution of x_m goes towards a degenerate normal distribution with mean and variance equal to 0.

Having shown how the sampling effect affects both channels of voter welfare, accountability and selection, we can conclude the following:

Proposition 3. *The sampling effect improves both electoral accountability and electoral selection. For $n \to \infty$ voter welfare tends towards the level that would be achieved if the incumbent were confronted with a single voter who can perfectly observe her performance.*

Proposition 3 summarises how a large electorate of ignorant voters can secure high levels of public goods via the voting mechanism: politicians in office are more talented than the average politician and, in addition, they have strong incentives to perform well.

The sampling effect has a beneficial impact on voter welfare because it increases the precision of the decisive median opinion and directly reduces the probability of a false decision of the median voter. Moreover, the incumbent knows that effort is very effective in swaying the median voter given his precise information and therefore exerts high effort. Note, however, that the voters' perspective on the precision of their signals does not change the result, since their voting decision is independent of the weight $\tau_x/(\tau_\theta + \tau_x)$ that they attach to their signal as it was seen in equation (2).[8]

In the following part of the paper, we study various extensions of the baseline model to analyse the impact of the sampling effect in richer environments. It will become apparent that the voters' perspective on the informativeness of their signal is relevant for the results in these environments.

2. Extensions

2.1 *Public Information*

We add a public signal about the incumbent's performance in period 1

$$t = g + y \quad \text{with} \quad y \sim N(0, 1/\tau_y)$$

to the baseline model. Now, each voter receives a private signal s_i and the public signal t about the incumbent's performance. Think of the public signal as a first approximation of media coverage, for example. It may describe information that one or more media outlets have published and which then was further spread among voters.

We assume that media coverage is at least as precise as a voter's signal ($\tau_y \geq \tau_x$). This means that a journalist is at least as informed as an ignorant voter. Alternatively, the lower bound on the precision of the public signal can be interpreted as a situation where one voter's signal is published.

Voter i then votes for the incumbent if and only if the precision-weighted average of his two signals

[8] This is different as compared to the traditional career concern approach that analyses the incentives of managers or bureaucrats (see, for example, Holmström, 1999; Dewatripont *et al.*, 1999; Alesina and Tabellini, 2007). In these papers a manager or bureaucrat can boost present performance to impress the labor market which will offer him a future wage equal to his expected talent $E(\theta|s, e^*)$. Thus, a manager maximises $E(\theta|s, e^*) - c(e)$. In contrast to the non-linear incentive scheme of the incumbent in our model, the manager's future wage is linear in exerted effort and the marginal effect of effort on the future wage depends on the prior knowledge of the labor market via the term $\tau_x/(\tau_x + \tau_\theta)$.

is larger than the expected performance of a politician of average talent:[9]

$$\begin{aligned}E(\theta|s_i,t,e^*)\geq\bar{\theta}\quad&\Leftrightarrow\quad\frac{\tau_x\cdot s_i+\tau_y\cdot t}{\tau_x+\tau_y}\geq e^*+\bar{\theta}\\&\Leftrightarrow\quad e+\theta+\frac{\tau_y}{\tau_x+\tau_y}\cdot y+\frac{\tau_x}{\tau_x+\tau_y}\cdot x_i\geq e^*+\bar{\theta}.\end{aligned}\tag{6}$$

It follows that the median voter re-elects the incumbent if and only if

$$e+\theta+\frac{\tau_y}{\tau_x+\tau_y}\cdot y+\frac{\tau_x}{\tau_x+\tau_y}\cdot x_m\geq e^*+\bar{\theta}.\tag{7}$$

Applying the same procedure as in the baseline model yields equilibrium effort as described by

Lemma 3. *When each voter receives both a private signal and the public signal, equilibrium effort e^* solves*

$$\frac{1}{\sqrt{2\pi}}\cdot\sqrt{\frac{1}{\frac{1}{\tau_\theta}+\left(\frac{\tau_x}{\tau_x+\tau_y}\right)^2\frac{1}{\tau_m}+\left(\frac{\tau_y}{\tau_x+\tau_y}\right)^2\frac{1}{\tau_y}}}\cdot R=c'(e^*).\tag{8}$$

Proof. See Appendix A. □

We can derive the following comparative statics:

Corollary 1. *Given that voters receive a private and a public signal, we have*

$$\frac{\partial e^*}{\partial n}>0,\ \frac{\partial e^*}{\partial\tau_x}>0, \textit{and}\ \frac{\partial e^*}{\partial\tau_y}>0.$$

Proof. See Appendix A. □

Corollary 1 says that equilibrium effort is higher, the more informative the signals are and the more precise the incumbent's estimate of the median noise is due to the sampling effect. We are, however, mostly interested in the effect of introducing public information on accountability which is why we shall compare accountability in the baseline model with the variant where voters also receive the public signal.

[9] See the proof of Lemma 3 in Appendix A for more details on this point.

Define

$$\frac{1}{\tau_{pub}} := \frac{\tau_y^2}{(\tau_x + \tau_y)^2} \cdot \frac{1}{\tau_y} + \frac{\tau_x^2}{(\tau_x + \tau_y)^2} \cdot \frac{1}{\tau_m}.$$

This is the variance of the compound noise term. When we compare the equations that define the respective levels of equilibrium effort (Lemma 2 and Lemma 3), we see that the only difference between them is due to the variances of the noise terms. It follows that introducing public information increases effort if $\tau_{pub} > \tau_m$ and decreases effort for $\tau_{pub} < \tau_m$, and we obtain

LEMMA 4. *Adding the public signal to the baseline model with private signals increases effort for* $n < \pi[1 + \tau_y/(2\tau_x)]$ *and decreases effort for* $n > \pi[1 + \tau_y/(2\tau_x)]$.

Proof. See Appendix A. □

This result implies that for $n > \pi[1 + \tau_y/(2\tau_x)]$, introducing public information lowers accountability although all voters are better informed about the incumbent's performance. This happens because of the discrepancy between the voters' perspective on the noise in their private signals and the incumbent's perspective on the median of these noise terms. Consider condition (7) that describes the decision of the median voter with a public signal. Like any other voter, the median voter employs the weights $\tau_y/(\tau_x + \tau_y)$ and $\tau_x/(\tau_x + \tau_y)$ on y and x_m, whereas the real precision of x_m is much larger than τ_x, a fact that the median voter is not aware of. Compare condition (7) with the corresponding condition when the incumbent is confronted with a social planner who receives the signals t and s_m. The social planner would use the weight $\tau_y/(\tau_m + \tau_y)$ on y and the weight $\tau_m/(\tau_m + \tau_y)$ on x_m. With these weights the variance of the compound noise term is always lower than $1/\tau_m$, and thus the adverse effect of introducing the public signal would not occur.

We have shown in the baseline model that expected voter utility in period 2 is increasing in τ_m, and therefore introducing public information increases expected utility for $\tau_{pub} > \tau_m$ and decreases expected utility for $\tau_{pub} < \tau_m$ which yields

LEMMA 5. *Adding the public signal to the baseline model with private signals increases expected utility in period 2 for* $n < \pi[1 + \tau_y/(2\tau_x)]$ *and decreases expected utility for* $n > \pi[1 + \tau_y/(2\tau_x)]$.

Proof. See Appendix A. □

Thus, the effects of introducing public information on both electoral accountability and electoral selection go in the same direction. Combining Lemma 4 and Lemma 5 yields

Proposition 4. *For $n > \pi[1 + \tau_y/(2\tau_x)]$, adding the public signal to the baseline model decreases voter welfare via both reduced effort and worse selection.*

If we take the case with $n \to \infty$ as the appropriate description for a large electorate, we can observe that welfare is lower than in the baseline model: Although the incumbent knows that the median voter receives a perfect private signal about performance, her estimate of the median belief still is blurred by the influence of the public signal and thus effort is lower than in the baseline model. Obviously, the collective decision also is not perfect because of the influence of the public signal on the belief of the median voter.

Proposition 4 means that publishing the news report of a well-informed journalist reduces welfare in a large electorate. This result may be irritating at first sight because it contradicts the popular idea that critical media coverage helps establish accountability. Voters would be better off in a world without public information where each voter only receives a private signal. The question is, however, whether such a world can be considered realistic or if it is just a hypothetical first best world. Answering this question in depth is beyond the scope of the paper but we can offer the following observations: In reality, people talk to each other and share their knowledge. From the incumbent's perspective, this corresponds to a situation where voters within a group receive a common signal. The model with private signals is still an appropriate description of a world with this type of communication, as long as groups of voters who talk to each other are sufficiently small such that we still have a large number of independent opinions. On the other hand, mass media increases the size of groups observing the same information and therefore reduces the likelihood of a large number of independent opinions.

We can learn from Proposition 4 that the incumbent has an interest in sending some vague public information about her performance to the voters because this will allow her to exert less effort than in the case with only private signals. Incumbents can give vague hints about which projects they are involved in whenever they have an audience and mass media can further disseminate these pieces of information.

This reasoning may be an explanation for why politicians like to be in the news with reports where they present, for example, new roads, public buildings, police cars, fire trucks, or other facilities. Although this type of media coverage gives voters an impression about which politicians may have been involved in the respective project, and thus indeed increases voter knowledge a little bit, these reports can hardly be considered what Bowles *et al.* (2013) refer to as (critical) accountability reporting. If, however, politicians succeed in feeding pieces of information to the public, the accountability-enhancing role of critical journalism is restored. In such a second best world where voters cannot avoid receiving some form of public information anyway, critical journalism can serve to increase the quality of public information which forces the incumbent to work harder. While the level of accountability can be improved by critical media reporting, it will still be lower than in a world with private signals, except for the unlikely case where journalists are perfectly informed about the incumbent's performance.

The analysis in this section can help shed light on how informative media coverage can affect accountability in the presence of the sampling effect. However, there can also be media content that is not informative but just caters to different opinions that voters hold about politicians. Given that nowadays people can consume highly personalised media content (Oliveros and Várdy, 2015; Sunstein, 2017), the market outcome can result in a distribution of many different (ideological) opinions about politicians. In the next section, we analyse how introducing such a given distribution of heterogenous individual opinions affects the impact of the sampling effect on voter welfare.

2.2 *Ideological Preferences*

In this section, we discuss the implications of the sampling effect when we add a second dimension to voter preferences. In general, this second dimension of preferences can measure how voters evaluate some characteristic of the candidates not related to public good provision. For ease of exposition, we shall refer to the second dimension of preferences as ideology.

Let $u_{i2}^I = \theta + b_i$ be voter i's utility in period 2 if the incumbent is in power, where b_i denotes ideological closeness of the incumbent to voter i relative to the challenger.[10] For instance, a positive value of b_i implies that voter i prefers the incumbent in the ideological dimension. We assume that each

[10]Recall that neither the incumbent nor the challenger exerts any effort in period 2.

voter knows his b_i with certainty whereas for the incumbent $b_i \sim N(b, 1/\tau_b)$.

The incumbent knows that voter i votes for her if and only if

$$E(\theta|s_i, e^*) + b_i \geq \bar{\theta} \quad \Leftrightarrow \quad e + \theta + \underbrace{x_i + \frac{\tau_x + \tau_\theta}{\tau_x} b_i}_{\text{individual component}} \geq e^* + \bar{\theta},$$

and that the median of the individual component is normally distributed with

$$\text{mean } \frac{\tau_x + \tau_\theta}{\tau_x} b \quad \text{and variance } \frac{1}{\tau_m} + \frac{\pi}{2n} \frac{(\tau_x + \tau_\theta)^2}{\tau_x^2 \tau_b}.$$

So the sampling effect now also applies to the incumbent's knowledge about ideology. Applying the same procedure as above yields equilibrium effort described by

Lemma 6. *When each voter receives a private signal and voters also have ideological preferences, equilibrium effort e^* solves*

$$\phi \left[\frac{-b \frac{\tau_x + \tau_\theta}{\tau_x}}{\sqrt{\frac{1}{\tau_\theta} + \frac{1}{\tau_m} + \frac{\pi}{2n} \frac{(\tau_x + \tau_\theta)^2}{\tau_x^2 \tau_b}}} \right] \frac{1}{\sqrt{\frac{1}{\tau_\theta} + \frac{1}{\tau_m} + \frac{\pi}{2n} \frac{(\tau_x + \tau_\theta)^2}{\tau_x^2 \tau_b}}} R = c'(e^*). \tag{9}$$

Given the bell curve shape of $\phi(.)$ we can observe the familiar result that effort is decreasing in $|b|$ and that effort is maximal if the ideological preferences of voters are balanced in the sense that $b = 0$. The sampling effect has an ambiguous effect on accountability:

Proposition 5. *For each n there exists a threshold $\bar{b} > 0$ such that the sampling effect increases effort for $|b| < \bar{b}$ and decreases effort for $|b| > \bar{b}$. Further, $\bar{b}$ is decreasing in n.*

Proof. See Appendix A. □

The intuition behind Proposition 5 is straightforward: When the probability is high enough that the median is somewhere close to the threshold for re-election, the payoff of effort is high because additional effort can swing the decision of the median voter in favour of the incumbent. The sampling effect allows the incumbent to form a precise estimate of the median position. Thus, she knows that for large $|b|$ it is very likely that the median voter will vote either for or against her anyway and will exert little effort. For small $|b|$, however, the sampling effect informs the incumbent that the median is close to the threshold, and thus she will exert more effort. Intuitively, the stronger the sampling effect already is, the smaller the set of b for which additional sampling increases effort.

Consider the case where the incumbent is confronted with a single voter with ideology preference b who receives s_m and correctly weights it with τ_m. Then, there is no informational discrepancy between the incumbent and the voter but we would still observe that an increase in τ_m can either increase or decrease effort in a similar pattern as just described. For $n \to \infty$, effort would be described by

$$\phi\left[-b\sqrt{\tau_\theta}\right]\sqrt{\tau_\theta}R = c'(e^*). \tag{10}$$

Now evaluate equation (9) in Lemma 6 for $n \to \infty$ which yields

$$\phi\left[-b\frac{\tau_x + \tau_\theta}{\tau_x}\sqrt{\tau_\theta}\right]\sqrt{\tau_\theta}R = c'(e^*). \tag{11}$$

We observe that for any $b \neq 0$, effort is lower than in the case with the perfectly informed single voter because of the knowledge discrepancy between the incumbent and voters which is manifest in the term $(\tau_x + \tau_\theta)/\tau_x$. We can learn two things: First, as long as the ideological preferences of voters are balanced in the sense that $b = 0$, accountability is not impaired by voter ignorance but accountability is as if a perfectly informed voter decides the election. Thus, as long as the ideological leanings of voters are symmetric, even a strongly polarised electorate can establish high levels of electoral accountability. Second, as soon as the electorate exhibits collective ideological leanings in the sense that $b \neq 0$, accountability is impaired by voter ignorance.

For the single voter with b and signal s_m, an increase of τ_m can imply either higher or lower effort but the increase will always improve his voting decision and for $n \to \infty$ he will make a perfect decision. In our model, however, due to the knowledge discrepancy, the sampling effect can be harmful for selection. We use average expected utility in period 2

$$E(u_2) = \int_{-\infty}^{\infty}\left\{Pr[v^* = I|\theta]\cdot(\theta + b) + Pr[v^* = C|\theta]\cdot\bar{\theta}\right\}f(\theta)d\theta$$

to measure social welfare and obtain

PROPOSITION 6. *For $n > (\pi/2) \cdot [1 + (\tau_x + \tau_\theta)^2/(\tau_x \tau_b)]$, expected utility in the second period decreases with n if and only if $|b|$ is sufficiently high.*

Proof. See Appendix A. □

There are two types of mistakes that the electorate can make. The first type is simply due to the signal noise as it would also occur in the benchmark case without ideology, that is, for given θ the collective decision can be wrong because of the noise. This type of error becomes less likely as n grows, and disappears in the limit. This is the benefit of precision provided by a larger electorate. The second type of errors occurs when $b \neq 0$ and persists even in the limit case: the median voter is unaware of the precision of his signal, and thus uses a biased threshold for his decision. Let's assume $b > 0$ for the sake of explanation. In this case, there is an interval of the incumbent's competence level, $[\bar{\theta} - b(1 + \tau_\theta/\tau_x), \bar{\theta} - b]$, for which the incumbent is re-elected although the challenger is better for welfare in expectation, i.e., $\theta + b < \bar{\theta}$. This type of error happens because of the difference between the true precision of the median voter's signal and its precision as perceived by the median voter. Therefore, a weaker sampling effect may be beneficial by decreasing this gap. From another perspective, imprecision of the median voter's signal is beneficial, since a negative noise term may alleviate the problem of the biased threshold. This benefit of imprecision increases when this problem becomes more severe as b increases. For sufficiently large b, the benefit of imprecision is larger than its cost, and, as a consequence, selection deteriorates as the electorate becomes larger.

After having described both the effect of adding public information to the baseline model and the implications of the sampling effect for the case with private signals and ideological preferences, it is straightforward to see the implications of introducing public information to the variant of our model in this section: When the electorate is large enough such that the public information increases the noise in the collective decision, accountability will increase for large $|b|$ and decrease for small $|b|$. There also is a corresponding ambiguous effect on selection.[11]

The model with individual ideological preferences b_i comprises – as a special case – a common value

[11] The proofs are available in the Online Appendix.

election where it is common knowledge that all voters share some b. We obtain the results for this scenario by evaluating Lemma 6 and Propositions 5 and 6 for $\tau_b \to \infty$. The parameter b can still denote a common evaluation in a preference dimension unrelated to public good provision but there also is an instructive alternative interpretation where the common b measures a prior difference in expected competence between the candidates.

Let $E(\theta^I) = \bar{\theta}$ and $E(\theta^C) = \bar{\theta} - b$ where $b > 0$ represents a higher expected competence of the incumbent and $b < 0$ represents a higher expected competence of the challenger. Then, in the case of private signals, voter i votes for the incumbent if and only if

$$E(\theta^I | s_i, e^*) \geq \bar{\theta} - b.$$

As stated above, the results for this scenario are described by Lemma 6 and Propositions 5 and 6 evaluated for $\tau_b \to \infty$. Therefore, we can conclude that the sampling effect is beneficial for both the incentive problem and the selection problem if the difference in expected competence between candidates is limited, and harmful if the difference is large.

2.3 *Overconfidence*

The analysis above shows that the discrepancy between a voter's perspective on his private signal and the incumbent's perspective on the median signal can impair the collective decision. Inspired by recent papers on overconfident voters (see, for example, Ortoleva and Snowberg, 2015 and Levy and Razin, 2015) we show that overconfidence can improve the collective decision and characterise the resulting level of accountability.

Consider a variant of our model where all voters receive a private and a public signal and where all voters share a preference parameter b. According to Daniel *et al.* (2001) people tend to be overconfident regarding their private information but not regarding public information. We apply this assumption to our model and define overconfidence as follows:

Definition 2. *Voters are overconfident if they attribute precision τ_x^v to their private signal when the true precision is $\tau_x < \tau_x^v$.*

As in Ortoleva and Snowberg (2015), our concept of overconfidence belongs to the category of *overconfidence as overprecision* (Moore and Healy, 2008).

Voters are still assumed to be rational Bayesians except for the fact that they use $\tau_x^v > \tau_x$ when they update their belief about the incumbent's talent. The incumbent still knows and uses the true precision τ_x of the private signals, and both incumbent and voters know and use the correct precision τ_y for public information.

Recall that in career concern models, voters are forward-looking and thus want to use the election and their available knowledge to maximise future utility. In other words, voters focus on the selection problem and the incentives of the incumbent then result from the voters' decision rule regarding the selection problem. The incumbent is re-elected if and only if

$$\frac{\tau_\theta \bar{\theta} + \tau_x^v(s_m - e^*) + \tau_y(t - e^*)}{\tau_\theta + \tau_x^v + \tau_y} + b \geq \bar{\theta}.$$

As we have seen in the discussion regarding public information, the closer the median voter's perceived precision of his private signal is to its real precision, the better the collective decision. It follows that expected utility is strictly increasing in τ_x^v for $\tau_x^v < \tau_m$ and maximised for $\tau_x^v = \tau_m$. Then we obtain

LEMMA 7. *For given n, there is an optimal level of overconfidence $\tau_x^{v*} = \tau_m$ that maximises expected utility in the second period. For $n \to \infty$, τ_x^{v*} approaches ∞, and the incumbent is re-elected if and only if $\theta \geq \bar{\theta} - b$.*

Proof. See Online Appendix. □

We can make the following observations: Although overconfidence corrupts each individual voting decision it can improve the collective decision. This result is similar to Levy and Razin (2015) and we can add the observation that there is an optimal level of overconfidence. For $n \to \infty$, voters vote based on their private signals only, and thus selection is perfect since the median voter's estimate is perfectly accurate.

Overconfidence can improve the collective decision because all $\tau_x^v \in]\tau_x, \tau_m]$ reduce the discrepancy between the optimal weights on the median private signal and the public signal and the actual weights that result from individual voting decisions.[12] As a consequence, overconfidence can reduce the adverse effects on information aggregation that we have observed in the above sections on both public information and ideology. The sampling effect is less impaired by a sub-optimal weight on the median private signal. At the same time, the blurring effect of public information on information aggregation is reduced because the relative weights now better account for the informativeness of the median private signal as compared to the public signal. For $\tau_x^{v*} = \tau_m$, the variance $1/\tau_{pub}$ of the compound noise term is always smaller than $1/\tau_m$, and thus, public information never hurts but improves the collective decision for given n.

Let us assume that for some reason voters are overconfident with $\tau_x^{v*} = \tau_m$ and consider the accountability problem for the limit case $n \to \infty$. We obtain

Proposition 7. *Let all voters be overconfident with $\tau_x^{v*} = \tau_m$. Then, for $n \to \infty$ the game between the incumbent and the electorate tends towards a game where the incumbent is confronted with a perfectly informed voter with preference parameter b. Effort in the limit case is defined by*

$$\phi\left[-b\sqrt{\tau_\theta}\right]\sqrt{\tau_\theta}R = c'(e^*). \tag{12}$$

Proof. See Appendix A. □

This characterises accountability in a situation where each voter's decision is based purely on his private signal because the weights on the prior information and the public signal are zero. By assumption, the private signals are very noisy which means that each voter's decision is subject to large mistakes. In contrast, accountability is not at all adversely influenced by these mistakes since the decisive median voter has a perfect private signal of the incumbent's competence and because of his being overconfident ($\tau_x^{v*} \to \infty$) he gives full weight to his private signal.

Thus, when voters apply the simple rule to vote based on their private impression, the sampling effect leads to a situation where the selection problem is perfectly solved and where the accountability of the incumbent depends on perceived differences between the candidates but not on the actual precision of voter information. It would be interesting to study whether this kind of overconfidence is a purely behavioural phenomenon or whether it could be explained by some kind of rational behaviour. For

[12]Levels of overconfidence characterised by $\tau_x^v > \tau_m$ can also reduce the discrepancy, compared to $\tau_x^v = \tau_x$ but these cases are no longer interesting when we consider the limit case $n \to \infty$.

example, some authors study elections where the behaviour of voters is guided by ethical norms based on Kantian-style reasoning (Coate and Conlin, 2004; Feddersen and Sandroni, 2006a,b). In the common value election that we have studied so far, each voter should be willing to follow the simple rule that he should vote based on his private signal because this rule maximises expected utility for everyone.

Note that Proposition 7 not only applies to a common value election but also characterises accountability in situations where overconfident voters have different ideological preferences b_i with average ideology b. In this case, a collective decision based on $\tau_x^{v*} = \tau_m$ maximises average utility but individual voters can be adversely affected. With conflicting interests among voters, it therefore appears to be problematic that voters agree on a simple rule regarding overconfidence.

It is also interesting to note that informative media content would not affect expected utility and thus overconfident voters would have little demand for information. However, if they demand and consume ideological content, this might affect the distribution of ideological positions. As long as ideological positions in a large electorate become more polarised but remain balanced around average ideology b, accountability will not be affected whereas changes of b will result in corresponding changes of accountability.

3. Concluding Remarks

The sampling effect enables incumbents to form precise estimates of the decisive median opinion in the electorate. As a consequence, even an electorate where voters cast their ballot based on vague private impressions of an incumbent's performance can enjoy high levels of accountability. Since these vague impressions can result from voters just living their lives, this minimal condition for accountability should be satisfied in reality. This result can attenuate concerns that a lack of knowledge among voters hampers a well-functioning democracy.

The benefits of the sampling effect can be impaired when voters receive public information or feature evaluations of the candidates such that there is a (dis)advantage for the incumbent. However, overconfidence of voters can restore the beneficial impact of the sampling effect and help establish high levels of accountability. Thus, this paper joins Ashworth and Bueno de Mesquita (2014), Levy and Razin (2015), and Lockwood (2017) who also provide theoretical results which show that ignorant and/or irrational voters do not necessarily hamper the ability of elections to serve their role to enable good collective decisions and hold politicians accountable.

Our result on overconfidence implies that even in a world where voters consume highly individualised ideological news and fully base their voting decision on vague private impressions of public good provision, accountability can be as high as if the incumbent were confronted with a perfectly informed social planner who might have ideological leanings. Further, the collective decision can be perfect in the sense of electing the right candidate. The fact that overconfident voters will not rely on public information but still establish high levels of accountability may attenuate the concerns that a lack of 'hard news' or 'accountability journalism' will make it difficult to establish accountability (Gentzkow and Shapiro, 2008; Downie and Schudson, 2009; Waldman, 2011).

It would further be instructive to study whether overconfidence actually is an irrational, behavioural phenomenon or can rather be explained as a type of rational behaviour by voters. At least for common value elections, our result suggests that voters might agree on overconfidence as a norm of behaviour.

Finally, our analysis suggests that models which use a representative voter to study accountability should be handled and interpreted carefully with respect to the informational assumptions. According to our analysis, a representative voter who receives a noisy signal does not best describe a situation where all voters in an electorate receive noisy signals. This discrepancy may lead to wrong conclusions.

Appendix A. Proofs

Proof of Lemma 1. Let the level of the public good result from a production function $g = \theta(\alpha e + \beta) + \gamma e$, where $\alpha, \beta, \gamma \geq 0$. Further, let e^* be the voters' equilibrium belief about the incumbent's effort in period 1. Then, for each voter, his signal is $s_i = \theta(\alpha e^* + \beta) + \gamma e^* + x_i$ which is a realised value of a normal random variable s_i with mean $\bar{\theta}(\alpha e^* + \beta) + \gamma e^*$ and variance $[(\alpha e^* + \beta)^2/\tau_\theta] + (1/\tau_x)$.

For equilibrium belief e^* of the voters, the joint PDF of the two random variables θ and $s_i = \theta(\alpha e^* + \beta) + \gamma e^* + x_i$ is a bivariate normal distribution characterised by the parameters $E(\theta) = \bar{\theta}$, $E(s_i) = \bar{\theta}(\alpha e^* + \beta) + \gamma e^*$, $Var(\theta) = 1/\tau_\theta$, $Var(s_i) = [(\alpha e^* + \beta)^2/\tau_\theta] + (1/\tau_x)$, and correlation coefficient ρ. For ρ, we have

$$\rho = \frac{cov(\theta, s_i)}{\sqrt{Var(\theta) \cdot Var(s_i)}},$$

where

$$\begin{aligned} cov(\theta, s_i) &= E(\theta \cdot s_i) - E(\theta)E(s_i) \\ &= E(\theta^2)(\alpha e^* + \beta) + \bar{\theta} \cdot \gamma e^* + \underbrace{E(\theta x_i)}_{=0} - \bar{\theta}[\bar{\theta}(\alpha e^* + \beta) + \gamma e^*], \end{aligned}$$

and with $E(\theta x_i) = 0$ because θ and x_i are independent and thus $E(\theta x_i) = E(\theta)E(x_i)$ where $E(x_i) = 0$. With $Var(\theta) = E(\theta^2) - [E(\theta)]^2$, it follows that

$$\begin{aligned} cov(\theta, s_i) &= \left(\frac{1}{\tau_\theta} + \bar{\theta}^2\right)(\alpha e^* + \beta) + \bar{\theta} \cdot \gamma e^* - \bar{\theta}[\bar{\theta}(\alpha e^* + \beta) + \gamma e^*] \\ &= \frac{\alpha e^* + \beta}{\tau_\theta}. \end{aligned}$$

Then, we have

$$\rho = \frac{\frac{\alpha e^* + \beta}{\tau_\theta}}{\sqrt{\frac{1}{\tau_\theta}}\sqrt{(\alpha e + \beta)^2 \frac{1}{\tau_\theta} + \frac{1}{\tau_x}}}.$$

After having observed s_i, voter i's posterior expectation of the incumbent's talent is

$$E(\theta|s_i, e^*) = E(\theta) + \rho\sqrt{\frac{Var(\theta)}{Var(s_i)}}[s_i - E(s_i|e^*)].$$

Then, voter i votes for the incumbent if and only if

$$\begin{aligned} & E(\theta|s_i, e^*) \geq \bar{\theta} \\ \Leftrightarrow \quad & \bar{\theta} + \rho\sqrt{\frac{Var(\theta)}{Var(s_i)}}[s_i - E(s_i|e^*)] \geq \bar{\theta} \\ & \Leftrightarrow \quad s_i \geq \bar{\theta}(\alpha e^* + \beta) + \gamma e^*. \end{aligned}$$

Thus, we can say that voter i applies a cutoff strategy where he votes for the incumbent if and only if $s_i \geq \hat{s} = \bar{\theta}(\alpha e^* + \beta) + \gamma e^*$. For the additive case $(\alpha = 0, \beta = \gamma = 1)$, we have $\hat{s} = \bar{\theta} + e^*$. □

Proof of Lemma 2. For the incumbent, the median signal s_m is a normal random variable with mean $\bar{\theta}(\alpha e + \beta) + \gamma e$ and variance $[(\alpha e + \beta)^2/\tau_\theta] + \pi/(2n\tau_x)$. Then,

$$p = Pr[s_m \geq \hat{s}] = 1 - \Phi\left(\left\{[\bar{\theta}(\alpha e^* + \beta) + \gamma e^*] - [\bar{\theta}(\alpha e + \beta) + \gamma e]\right\}\sqrt{\frac{1}{(\alpha e + \beta)^2 \frac{1}{\tau_\theta} + \frac{\pi}{2n\tau_x}}}\right),$$

and thus

$$\begin{aligned} \frac{dp}{de} = & -\phi\left(\left\{[\bar{\theta}(\alpha e^* + \beta) + \gamma e^*] - [\bar{\theta}(\alpha e + \beta) + \gamma e]\right\}\sqrt{\frac{1}{(\alpha e + \beta)^2 \frac{1}{\tau_\theta} + \frac{\pi}{2n\tau_x}}}\right) \\ & \cdot \left[\frac{-(\alpha\bar{\theta} + \gamma)}{\sqrt{(\alpha e + \beta)^2 \frac{1}{\tau_\theta} + \frac{\pi}{2n\tau_x}}} - \frac{\left\{[\bar{\theta}(\alpha e^* + \beta) + \gamma e^*] - [\bar{\theta}(\alpha e + \beta) + \gamma e]\right\}}{\left[(\alpha e + \beta)^2 \frac{1}{\tau_\theta} + \frac{\pi}{2n\tau_x}\right]^{3/2}} \frac{\alpha(\alpha e + \beta)}{\tau_\theta}\right]. \end{aligned}$$

Applying the equilibrium condition $e = e^*$ yields

$$\begin{aligned} \frac{dp}{de}_{|e=e^*} & = \phi(0)\sqrt{\frac{1}{(\alpha e^* + \beta)^2 \frac{1}{\tau_\theta} + \frac{\pi}{2n\tau_x}}} \cdot (\alpha\bar{\theta} + \gamma) \\ & = \frac{1}{\sqrt{2\pi}}\sqrt{\frac{1}{(\alpha e^* + \beta)^2 \frac{1}{\tau_\theta} + \frac{\pi}{2n\tau_x}}} \cdot (\alpha\bar{\theta} + \gamma). \end{aligned}$$

Thus, equilibrium effort solves

$$\frac{1}{\sqrt{2\pi}}\sqrt{\frac{1}{(\alpha e^* + \beta)^2 \frac{1}{\tau_\theta} + \frac{\pi}{2n\tau_x}}} \cdot (\alpha\bar{\theta} + \gamma) \cdot R - c'(e^*) = 0. \tag{A.1}$$

For $\alpha = 0$, $\beta = 1$, and $\gamma = 1$, we have the result for the simple additive production function $g = e + \theta$ that

$$\frac{1}{\sqrt{2\pi}}\sqrt{\frac{1}{\frac{1}{\tau_\theta} + \frac{\pi}{2n\tau_x}}} \cdot R - c'(e^*) = 0,$$

and for $\alpha = 1$, $\beta = 0$, and $\gamma = 0$, we have the result for the simple multiplicative production function $g = e \cdot \theta$ that

$$\frac{1}{\sqrt{2\pi}}\sqrt{\frac{1}{(e^*)^2 \frac{1}{\tau_\theta} + \frac{\pi}{2n\tau_x}}} \cdot \bar{\theta} \cdot R - c'(e^*) = 0.$$

□

Proof of Proposition 1. Consider the equilibrium condition for given n and define

$$\lambda := \frac{1}{\sqrt{2\pi}}\sqrt{\frac{1}{(\alpha e^* + \beta)^2 \frac{1}{\tau_\theta} + \frac{\pi}{2n\tau_x}}} \cdot (\alpha\bar{\theta} + \gamma) \cdot R - c'(e^*).$$

For $\lambda = 0$, implicit differentiation yields

$$\begin{aligned}\frac{de^*}{dn} &= -\frac{\frac{\partial\lambda}{\partial n}}{\frac{\partial\lambda}{\partial e^*}} \\ &= \frac{-\frac{1}{\sqrt{2\pi}}\frac{1}{2}[(\alpha e^* + \beta)^2 \frac{1}{\tau_\theta} + \frac{\pi}{2n\tau_x}]^{-\frac{3}{2}} \cdot \frac{\pi}{2n^2\tau_x}(\alpha\bar{\theta} + \gamma)R}{-\frac{1}{\sqrt{2\pi}}[(\alpha e^* + \beta)^2 \frac{1}{\tau_\theta} + \frac{\pi}{2n\tau_x}]^{-\frac{3}{2}}(\alpha e^* + \beta)\frac{\alpha}{\tau_\theta}(\alpha\bar{\theta} + \gamma)R - c''(e^*)} > 0.\end{aligned}$$

In the numerator, all factors after the minus sign are positive and thus the numerator is negative. In the first summand of the denominator, all factors after the minus sign are positive, and since $c''(e^*) \geq 0$, the denominator is negative. Thus, $de^*/dn > 0$.

Consider now a social planner who receives a perfect signal s about incumbent performance. He then re-elects the incumbent if and only if $s = \theta(\alpha e + \beta) + \gamma e \geq \bar{\theta}(\alpha e^* + \beta) + \gamma e^*$, where the left-hand side is distributed as a normal distribution with mean $\bar{\theta}(\alpha e+\beta)+\gamma e$ and variance $(\alpha e+\beta)^2/\tau_\theta$. Applying the established procedure to derive equilibrium effort shows that equilibrium effort in case of the social planner solves

$$\frac{1}{\sqrt{2\pi}}\sqrt{\frac{1}{(\alpha e^*+\beta)^2\frac{1}{\tau_\theta}}}\cdot(\alpha\bar{\theta}+\gamma)\cdot R-c'(e^*)=0. \tag{A.2}$$

For $n\to\infty$ equation (A.1) in the proof of Lemma 2 goes towards equation (A.2). □

Proof of Proposition 2. We prove the result for the more general case with $g=\theta(\alpha e+\beta)+\gamma e$. In equilibrium, the collective decision is

$$v^*=\begin{cases} I & \text{for} \quad x_m\geq(\alpha e^*+\beta)\cdot(\bar{\theta}-\theta)\\ C & \text{for} \quad x_m<(\alpha e^*+\beta)\cdot(\bar{\theta}-\theta)\end{cases}.$$

As opposed to the additive case, we need to assume here that the minimum possible effort level is $\underline{e}>0$. We need this assumption, since otherwise the second-period public good level is 0 independent of the competence of the politician in office in the case of the pure multiplicative case, where $g=e\cdot\theta$.

Expected utility in period 2 is

$$\begin{aligned}E(u_2)=\int_{-\infty}^{\infty}\Big(&\left\{1-\Phi\left[(\alpha e^*+\beta)(\bar{\theta}-\theta)\sqrt{\tau_m}\right]\right\}\cdot[\theta(\alpha\underline{e}+\beta)+\gamma\underline{e}]\\ &+\Phi\left[(\alpha e^*+\beta)(\bar{\theta}-\theta)\sqrt{\tau_m}\right]\cdot[\bar{\theta}(\alpha\underline{e}+\beta)+\gamma\underline{e}]\Big)f(\theta)d\theta,\end{aligned}$$

where $f(\theta)$ denotes the probability density function (PDF) of θ. We have to determine

$$\frac{dE(u_2)}{dn}=\frac{\partial E(u_2)}{\partial n}+\frac{\partial E(u_2)}{\partial e^*}\frac{\partial e^*}{\partial n}.$$

First,

$$\frac{\partial E(u_2)}{\partial n}=(\alpha e^*+\beta)(\alpha\underline{e}+\beta)\frac{1}{\sqrt{\tau_m}}\frac{\tau_x}{\pi}\int_{-\infty}^{\infty}\phi\left[(\alpha e^*+\beta)(\bar{\theta}-\theta)\sqrt{\tau_m}\right]\cdot(\bar{\theta}-\theta)^2 f(\theta)d\theta>0,$$

because all terms are larger than zero (recall that $\phi[.]$ denotes the standard normal PDF).[13] Further, we have

$$\frac{\partial E(u_2)}{\partial e^*} = \alpha(\alpha \underline{e} + \beta)\sqrt{\tau_m} \int_{-\infty}^{\infty} \phi\left[(\alpha e^* + \beta)(\bar{\theta} - \theta)\sqrt{\tau_m}\right] \cdot (\bar{\theta} - \theta)^2 f(\theta) d\theta \geq 0,$$

where $\partial E(u_2)/\partial e^* > 0$ for $\alpha > 0$ and $\partial E(u_2)/\partial e^* = 0$ in the additive case where $\alpha = 0$. We have already shown in the proof of Proposition 1 that $\partial e^*/\partial n > 0$. Thus, $dE(u_2)/dn > 0$.

Consider now

$$\lim_{n\to\infty} \Phi\left[(\alpha e^* + \beta)(\bar{\theta} - \theta)\sqrt{\tau_m}\right] = \begin{cases} 0 & \text{for} \quad \theta > \bar{\theta} \\ 1 & \text{for} \quad \theta < \bar{\theta} \end{cases} .$$

It follows that

$$\begin{aligned}
\lim_{n\to\infty} E(u_2) &= \int_{-\infty}^{\bar{\theta}} \left\{0 \cdot [\theta(\alpha\underline{e} + \beta) + \gamma\underline{e}] + 1 \cdot [\bar{\theta}(\alpha\underline{e} + \beta) + \gamma\underline{e}]\right\} f(\theta) d\theta \\
&+ \int_{\bar{\theta}}^{\infty} \left\{1 \cdot [\theta(\alpha\underline{e} + \beta) + \gamma\underline{e}] + 0 \cdot [\bar{\theta}(\alpha\underline{e} + \beta) + \gamma\underline{e}]\right\} f(\theta) d\theta \\
&= \int_{-\infty}^{\bar{\theta}} [\bar{\theta}(\alpha\underline{e} + \beta) + \gamma\underline{e}] f(\theta) d\theta + \int_{\bar{\theta}}^{\infty} [\theta(\alpha\underline{e} + \beta) + \gamma\underline{e}] f(\theta) d\theta \\
&= (\alpha\underline{e} + \beta) \int_{-\infty}^{\bar{\theta}} \bar{\theta} f(\theta) d\theta + (\alpha\underline{e} + \beta) \int_{\bar{\theta}}^{\infty} \theta f(\theta) d\theta + \gamma\underline{e} \\
&= (\alpha\underline{e} + \beta) \cdot \left(\bar{\theta} + \frac{1}{\sqrt{2\pi\tau_\theta}}\right) + \gamma\underline{e}.
\end{aligned}$$

Recall that $f'(\theta) = -\tau_\theta(\theta - \bar{\theta})f(\theta)$, and thus $\theta f(\theta) = \bar{\theta} f(\theta) - f'(\theta)/\tau_\theta$ to calculate the integral. A social planner who receives a perfect signal knows in equilibrium that either $\theta < \bar{\theta}$ or $\theta \geq \bar{\theta}$. Thus, when he

[13] By assumption we have either ($\alpha > 0$ and $\beta > 0$), ($\alpha = 0$ and $\beta > 0$), or ($\alpha > 0$ and $\beta = 0$) because otherwise output would not depend on competence. Further, to be precise, we have $(\bar{\theta} - \theta)^2 = 0$ for $\theta = \bar{\theta}$ which obviously is not relevant for the result.

decides the election, expected utility is

$$E(u_2) = \int_{-\infty}^{\bar{\theta}} [\bar{\theta}(\alpha \underline{e} + \beta) + \gamma \underline{e}] f(\theta) d\theta + \int_{\bar{\theta}}^{\infty} [\theta(\alpha \underline{e} + \beta) + \gamma \underline{e}] f(\theta) d\theta,$$

which yields the identical expression as in the limit case of the collective decision. Set $\underline{e} = 0$, $\alpha = 0$, and $\beta = \gamma = 1$ to get the simple additive case. □

Proof of Lemma 3. All the computations below hold for a given equilibrium belief e^* of the voters. To save on notation, we do not make it explicit since there is no risk of confusion. For instance, we write $E(\theta|s_i, t)$ instead of $E(\theta|s_i, t, e^*)$.

After having observed s_i and t, voter i's posterior expectation of the incumbent's talent is

$$E(\theta|s_i, t) = E(\theta|s_i) + \rho(\theta, t|s_i) \frac{\sqrt{Var(\theta|s_i)}}{\sqrt{Var(t|s_i)}} \cdot [t - E(t|s_i)].$$

Substituting

$$\begin{aligned}
E(\theta|s_i) &= \frac{\tau_\theta \bar{\theta} + \tau_x(s_i - e^*)}{\tau_\theta + \tau_x}, \\
E(t|s_i) &= e^* + E(\theta|s_i), \\
Var(\theta|s_i) &= Var(\theta) \cdot \{1 - [\rho(\theta, s_i)]^2\} = \frac{1}{\tau_\theta + \tau_x}, \\
Var(t|s_i) &= \frac{1}{\tau_\theta + \tau_x} + \frac{1}{\tau_y} = \frac{\tau_\theta + \tau_x + \tau_y}{(\tau_\theta + \tau_x)\tau_y}, \\
cov(\theta, t|s_i) &= E(\theta \cdot t|s_i) - E(\theta|s_i)E(t|s_i) = \frac{1}{\tau_\theta + \tau_x}, \\
\rho(\theta, t|s_i) &= \frac{cov(\theta, t|s_i)}{\sqrt{Var(\theta|s_i)Var(t|s_i)}} = \frac{\frac{1}{\tau_\theta + \tau_x}}{\sqrt{\frac{1}{\tau_\theta + \tau_x} \frac{\tau_\theta + \tau_x + \tau_y}{(\tau_\theta + \tau_x)\tau_y}}}
\end{aligned}$$

yields

$$E(\theta|s_i, t) = \frac{\tau_\theta \bar{\theta} + \tau_x(s_i - e^*) + \tau_y(t - e^*)}{\tau_\theta + \tau_x + \tau_y},$$

and thus

$$E(\theta|s_i, t) \geq \bar{\theta} \quad \Leftrightarrow \quad \frac{\tau_x \cdot s_i + \tau_y \cdot t}{\tau_x + \tau_y} \geq e^* + \bar{\theta}.$$

Thus, the incumbent is re-elected if and only if

$$e + \theta + \frac{\tau_y}{\tau_x + \tau_y} \cdot y + \frac{\tau_x}{\tau_x + \tau_y} \cdot x_m \geq e^* + \bar{\theta},$$

where the left-hand side is a normal random variable with mean $e + \bar{\theta}$ and variance

$$\frac{1}{\tau_\theta} + \frac{\tau_y^2}{(\tau_x + \tau_y)^2} \frac{1}{\tau_y} + \frac{\tau_x^2}{(\tau_x + \tau_y)^2} \frac{1}{\tau_m}.$$

It follows that the incumbent chooses e to maximise

$$1 - \Phi \left[-(e - e^*) \sqrt{\frac{1}{\frac{1}{\tau_\theta} + \frac{\tau_y^2}{(\tau_x+\tau_y)^2} \frac{1}{\tau_y} + \frac{\tau_x^2}{(\tau_x+\tau_y)^2} \frac{1}{\tau_m}}} \right].$$

Taking the derivative with respect to e and imposing $e = e^*$ yields the result. □

Proof of Corollary 1. A close look at equation (8) shows that the denominator under the square root decreases in n. Thus, $\partial e^*/\partial n > 0$.

It follows from Lemma 3 that

$$\operatorname{sgn}\left(\frac{\partial e^*}{\partial \tau_y}\right) = \operatorname{sgn}\left\{ -\frac{\partial}{\partial \tau_y} \left[\frac{1}{\tau_\theta} + \left(\frac{\tau_x}{\tau_x + \tau_y}\right)^2 \frac{\pi}{2n\tau_x} + \left(\frac{\tau_y}{\tau_x + \tau_y}\right)^2 \frac{1}{\tau_y} \right] \right\},$$

where

$$\frac{\partial}{\partial \tau_y} \left[\frac{1}{\tau_\theta} + \left(\frac{\tau_x}{\tau_x + \tau_y}\right)^2 \frac{\pi}{2n\tau_x} + \left(\frac{\tau_y}{\tau_x + \tau_y}\right)^2 \frac{1}{\tau_y} \right] = \frac{1}{(\tau_x + \tau_y)^3} \left[(1 - \pi/n)\tau_x - \tau_y \right] < 0$$

given our assumptions that $\tau_y \geq \tau_x$ and that n is large and thus $n > \pi$. Thus, $\partial e^*/\partial \tau_y > 0$.

It follows from Lemma 3 that

$$\operatorname{sgn}\left(\frac{\partial e^*}{\partial \tau_x}\right) = \operatorname{sgn}\left\{-\frac{\partial}{\partial \tau_x}\left[\frac{1}{\tau_\theta} + \left(\frac{\tau_x}{\tau_x+\tau_y}\right)^2 \frac{\pi}{2n\tau_x} + \left(\frac{\tau_y}{\tau_x+\tau_y}\right)^2 \frac{1}{\tau_y}\right]\right\},$$

where

$$\frac{\partial}{\partial \tau_x}\left[\frac{1}{\tau_\theta} + \left(\frac{\tau_x}{\tau_x+\tau_y}\right)^2 \frac{\pi}{2n\tau_x} + \left(\frac{\tau_y}{\tau_x+\tau_y}\right)^2 \frac{1}{\tau_y}\right] = \frac{1}{(\tau_x+\tau_y)^3}\left[(\tau_y-\tau_x)\frac{\pi}{2n} - 2\tau_y\right] < 0$$

for $n > (1-\tau_x/\tau_y)\cdot(\pi/4)$ which is satisfied given our assumptions that $\tau_y \geq \tau_x$ and that n is large and thus $n > \pi > (1-\tau_x/\tau_y)\cdot(\pi/4)$. Thus, $\partial e^*/\partial \tau_x > 0$. □

Proof of Lemma 4. Define e^*_{priv} and $e^*_{priv,pub}$ as the equilibrium efforts given by Lemmas 2 and 3, respectively. When we compare these lemmas, it follows that

$$e^*_{priv} \geq e^*_{priv,pub} \quad \Leftrightarrow \quad \frac{1}{\tau_\theta} + \frac{\pi}{2n\tau_x} \leq \frac{1}{\tau_\theta} + \left(\frac{\tau_x}{\tau_x+\tau_y}\right)^2 \frac{\pi}{2n\tau_x} + \left(\frac{\tau_y}{\tau_x+\tau_y}\right)^2 \frac{1}{\tau_y}$$

$$\Leftrightarrow \quad \tau_x^2 \frac{\pi}{2n\tau_x} + (2\tau_x\tau_y + \tau_y^2)\frac{\pi}{2n\tau_x} \leq \tau_x^2 \frac{\pi}{2n\tau_x} + \tau_y \quad \Leftrightarrow \quad \left(1 + \frac{\tau_y}{2\tau_x}\right)\pi \leq n.$$

□

Proof of Lemma 5. Recall that

$$\tau_{pub} := \frac{1}{\frac{\tau_y^2}{(\tau_x+\tau_y)^2}\cdot\frac{1}{\tau_y} + \frac{\tau_x^2}{(\tau_x+\tau_y)^2}\cdot\frac{1}{\tau_m}}.$$

We consider the difference between expected second-period utilities in the case of only a private signal,

$E[u_2(priv)]$, and in the case of a private signal and a public signal, $E[u_2(priv,pub)]$:

$$\begin{aligned}
E[u_2(priv)] - E[u_2(priv,pub)] &= \int\limits_{-\infty}^{\infty} \left(\{1 - \Phi\left[(\bar{\theta}-\theta)\sqrt{\tau_m}\right]\} \cdot \theta + \Phi\left[(\bar{\theta}-\theta)\sqrt{\tau_m}\right] \cdot \bar{\theta}\right) f(\theta)d\theta \\
&- \int\limits_{-\infty}^{\infty} \left(\{1 - \Phi\left[(\bar{\theta}-\theta)\sqrt{\tau_{pub}}\right]\} \cdot \theta + \Phi\left[(\bar{\theta}-\theta)\sqrt{\tau_{pub}}\right] \cdot \bar{\theta}\right) f(\theta)d\theta \\
&= E(\theta) + \int\limits_{-\infty}^{\infty} \Phi\left[(\bar{\theta}-\theta)\sqrt{\tau_m}\right] \cdot (\bar{\theta}-\theta) f(\theta)d\theta \\
&- \left[E(\theta) + \int\limits_{-\infty}^{\infty} \Phi\left[(\bar{\theta}-\theta)\sqrt{\tau_{pub}}\right] \cdot (\bar{\theta}-\theta) f(\theta)d\theta\right] \\
&= \int\limits_{-\infty}^{\infty} \left\{\Phi\left[(\bar{\theta}-\theta)\sqrt{\tau_m}\right] - \Phi\left[(\bar{\theta}-\theta)\sqrt{\tau_{pub}}\right]\right\} \cdot (\bar{\theta}-\theta) f(\theta)d\theta.
\end{aligned}$$

For $\tau_m > \tau_{pub}$, we have

$$\left\{\Phi\left[(\bar{\theta}-\theta)\sqrt{\tau_m}\right] - \Phi\left[(\bar{\theta}-\theta)\sqrt{\tau_{pub}}\right]\right\} \cdot (\bar{\theta}-\theta) \begin{cases} > 0 & \text{for} \quad \bar{\theta}-\theta > 0 \\ = 0 & \text{for} \quad \bar{\theta}-\theta = 0 \\ > 0 & \text{for} \quad \bar{\theta}-\theta < 0 \end{cases},$$

and for $\tau_m < \tau_{pub}$, we have

$$\left\{\Phi\left[(\bar{\theta}-\theta)\sqrt{\tau_m}\right] - \Phi\left[(\bar{\theta}-\theta)\sqrt{\tau_{pub}}\right]\right\} \cdot (\bar{\theta}-\theta) \begin{cases} < 0 & \text{for} \quad \bar{\theta}-\theta > 0 \\ = 0 & \text{for} \quad \bar{\theta}-\theta = 0 \\ < 0 & \text{for} \quad \bar{\theta}-\theta < 0 \end{cases}.$$

Thus, it remains to find $\max\{\tau_m, \tau_{pub}\}$. Straightforward algebra shows that

$$\tau_m \geq \tau_{pub} \quad \Leftrightarrow \quad n \geq \pi\left(1 + \frac{\tau_y}{2\tau_x}\right).$$

$\square$

Proof of Proposition 5. The term

$$\phi\left[\frac{-b\frac{\tau_x+\tau_\theta}{\tau_x}}{\sqrt{\frac{1}{\tau_\theta}+\frac{1}{\tau_m}+\frac{\pi}{2n}\frac{(\tau_x+\tau_\theta)^2}{\tau_x^2\tau_b}}}\right]\frac{1}{\sqrt{\frac{1}{\tau_\theta}+\frac{1}{\tau_m}+\frac{\pi}{2n}\frac{(\tau_x+\tau_\theta)^2}{\tau_x^2\tau_b}}}$$

on the left-hand side of equation (9) can be interpreted as the PDF of a normal random variable with

$$\text{mean } \frac{\tau_x+\tau_\theta}{\tau_x}\cdot b \quad \text{and variance } \frac{1}{\tau_\theta}+\frac{1}{\tau_m}+\frac{\pi}{2n}\frac{(\tau_x+\tau_\theta)^2}{\tau_x^2\tau_b}$$

evaluated at 0. Only the variance is affected by n and the variance is decreasing in n. It is a well-established fact for normal distributions that a marginal decrease of the variance brings about an increase of the density at values in the interval between the inflection points and a decrease of the density at all values outside of this interval. In our case, the interval between the inflection points is

$$\left[\frac{\tau_x+\tau_\theta}{\tau_x}\cdot b-\sqrt{\frac{1}{\tau_\theta}+\frac{1}{\tau_m}+\frac{\pi}{2n}\frac{(\tau_x+\tau_\theta)^2}{\tau_x^2\tau_b}},\frac{\tau_x+\tau_\theta}{\tau_x}\cdot b+\sqrt{\frac{1}{\tau_\theta}+\frac{1}{\tau_m}+\frac{\pi}{2n}\frac{(\tau_x+\tau_\theta)^2}{\tau_x^2\tau_b}}\right].$$

It follows that

$$\frac{\partial e^*}{\partial n}>0 \quad\Leftrightarrow\quad |b|<\frac{\tau_x}{\tau_x+\tau_\theta}\cdot\sqrt{\frac{1}{\tau_\theta}+\frac{\pi}{2n\tau_x}+\frac{\pi}{2n}\frac{(\tau_x+\tau_\theta)^2}{\tau_x^2\tau_b}}.$$

□

Proof of Proposition 6. $v^*=I$ if and only if $s_m+[(\tau_x+\tau_\theta)/\tau_x]\cdot b_m\geq e^*+\bar{\theta}$. In equilibrium, this occurs if and only if $x_m+[(\tau_x+\tau_\theta)/\tau_x]\cdot b_m\geq\bar{\theta}-\theta$, where the left-hand side is distributed with

$$\text{mean } \frac{\tau_x+\tau_\theta}{\tau_x}b \quad \text{and variance } \frac{1}{\tau_{ideo}}=\frac{\pi}{2n}\left[\frac{1}{\tau_x}+\frac{(\tau_x+\tau_\theta)^2}{\tau_x^2\tau_b}\right].$$

Hence,

$$E(u_2)=\int_{-\infty}^{\infty}\left(\left\{1-\Phi\left[\frac{\bar{\theta}-\theta-\frac{\tau_x+\tau_\theta}{\tau_x}b}{\sqrt{\frac{\pi}{2n}(\frac{1}{\tau_x}+\frac{(\tau_x+\tau_\theta)^2}{\tau_x^2\tau_b})}}\right]\right\}(\theta+b)+\Phi\left[\frac{\bar{\theta}-\theta-\frac{\tau_x+\tau_\theta}{\tau_x}b}{\sqrt{\frac{\pi}{2n}(\frac{1}{\tau_x}+\frac{(\tau_x+\tau_\theta)^2}{\tau_x^2\tau_b})}}\right]\bar{\theta}\right)f(\theta)d\theta.$$

The derivative with respect to n gives

$$\frac{dE(u_2)}{dn} = \int_{-\infty}^{\infty} \phi \left[\frac{\bar{\theta} - \theta - \frac{\tau_x + \tau_\theta}{\tau_x} b}{\sqrt{\frac{\pi}{2n}(\frac{1}{\tau_x} + \frac{(\tau_x+\tau_\theta)^2}{\tau_x^2 \tau_b})}} \right] \frac{\bar{\theta} - \theta - \frac{\tau_x + \tau_\theta}{\tau_x} b}{2n\sqrt{\frac{\pi}{2n}(\frac{1}{\tau_x} + \frac{(\tau_x+\tau_\theta)^2}{\tau_x^2 \tau_b})}} (\bar{\theta} - \theta - b) f(\theta) d\theta.$$

The expression

$$\frac{1}{\sqrt{\frac{\pi}{2n}(\frac{1}{\tau_x} + \frac{(\tau_x+\tau_\theta)^2}{\tau_x^2 \tau_b})}} \cdot \phi \left[\frac{\bar{\theta} - \theta - \frac{\tau_x + \tau_\theta}{\tau_x} b}{\sqrt{\frac{\pi}{2n}(\frac{1}{\tau_x} + \frac{(\tau_x+\tau_\theta)^2}{\tau_x^2 \tau_b})}} \right]$$

can be seen as a normal PDF of θ with

$$\text{mean } \bar{\theta} - \frac{\tau_x + \tau_\theta}{\tau_x} b \quad \text{and variance } \frac{1}{\tau_{ideo}} = \frac{\pi}{2n} \left[\frac{1}{\tau_x} + \frac{(\tau_x + \tau_\theta)^2}{\tau_x^2 \tau_b} \right].$$

Call this PDF $z(\theta)$. The product of two normal PDFs $f(\theta) \cdot z(\theta)$ is proportional to a normal PDF $h(\theta)$ with mean $\bar{\theta} - b \cdot [\tau_{ideo}(\tau_x + \tau_\theta)]/[\tau_x(\tau_{ideo} + \tau_\theta)]$ and variance $1/(\tau_\theta + \tau_{ideo})$. Hence, we can write

$$\frac{dE(u_2)}{dn} = \frac{c}{2n} \int_{-\infty}^{\infty} (\bar{\theta} - \theta - \frac{\tau_x + \tau_\theta}{\tau_x} b)(\bar{\theta} - \theta - b) h(\theta) d\theta,$$

where $c > 0$ solves $f(\theta) \cdot z(\theta) = c \cdot h(\theta)$. Hence, we have

$$\text{sgn} \left[\frac{dE(u_2)}{dn} \right] = \text{sgn} \left\{ E[(\bar{\theta} - \theta - \frac{\tau_x + \tau_\theta}{\tau_x} b)(\bar{\theta} - \theta - b)] \right\},$$

where the expectation is formed based on $h(\theta)$. Calculating $E\left\{[\bar{\theta} - \theta - b(\tau_x + \tau_\theta)/\tau_x](\bar{\theta} - \theta - b)\right\}$ yields

$$\text{sgn}\left(E\left\{[\bar{\theta} - \theta - b(\tau_x + \tau_\theta)/\tau_x](\bar{\theta} - \theta - b)\right\}\right) = \text{sgn}\left[\tau_\theta + \tau_{ideo} - b^2 \cdot \frac{\tau_\theta^2}{\tau_x^2}(\tau_x + \tau_\theta)(\tau_{ideo} - \tau_x)\right].$$

For $n > (\pi/2) \cdot [1 + (\tau_x + \tau_\theta)^2/(\tau_x \tau_b)]$ we have $\tau_{ideo} - \tau_x > 0$. Thus, for $n > (\pi/2) \cdot [1 + (\tau_x + \tau_\theta)^2/(\tau_x \tau_b)]$ we have

$$\frac{dE(u_2)}{dn} < 0 \quad \Leftrightarrow \quad |b| > \sqrt{\frac{\tau_x^2}{\tau_\theta^2} \frac{\tau_\theta + \tau_{ideo}}{(\tau_x + \tau_\theta)(\tau_{ideo} - \tau_x)}}.$$

□

Proof of Proposition 7. We show the result for the more general case where parameter b_i is normally distributed with mean b and variance $1/\tau_b$. Proposition 7 follows for $\tau_b \to \infty$. Voter i votes for the incumbent if and only if

$$E(\theta^I | s_i, t, e^*) + b_i \geq \bar{\theta}$$

$$\Leftrightarrow \quad \frac{\tau_x^v (s_i - e^* - \bar{\theta}) + \tau_y (t - e^* - \bar{\theta})}{\tau_x^v + \tau_y + \tau_\theta} + b_i \geq 0$$

$$\Leftrightarrow \quad e + \theta + \frac{\tau_y}{\tau_x^v + \tau_y} y + \underbrace{\frac{\tau_x^v}{\tau_x^v + \tau_y} x_i + \frac{\tau_x^v + \tau_y + \tau_\theta}{\tau_x^v + \tau_y} b_i}_{\text{individual component}} \geq e^* + \bar{\theta},$$

where, from the incumbent's perspective, the median of the individual component is normally distributed with

$$\text{mean } \frac{\tau_x^v + \tau_y + \tau_\theta}{\tau_x^v + \tau_y} b \quad \text{and variance } \left(\frac{\tau_x^v}{\tau_x^v + \tau_y} \right)^2 \frac{1}{\tau_m} + \frac{\pi}{2n} \frac{(\tau_x^v + \tau_y + \tau_\theta)^2}{(\tau_x^v + \tau_y)^2 \tau_b}.$$

Applying the same procedure as above yields equilibrium effort described by

$$\phi \left[\frac{-b \frac{\tau_x^v + \tau_y + \tau_\theta}{\tau_x^v + \tau_y}}{\sqrt{\frac{1}{\tau_{over}}}} \right] \frac{1}{\sqrt{\frac{1}{\tau_{over}}}} R = c'(e^*),$$

where

$$\frac{1}{\tau_{over}} = \frac{1}{\tau_\theta} + (\frac{\tau_y}{\tau_x^v + \tau_y})^2 \frac{1}{\tau_y} + (\frac{\tau_x^v}{\tau_x^v + \tau_y})^2 \frac{1}{\tau_m} + \frac{\pi}{2n} \frac{(\tau_x^v + \tau_y + \tau_\theta)^2}{(\tau_x^v + \tau_y)^2 \tau_b}.$$

Set $\tau_x^v = \tau_x^{v*} = \tau_m$. Then, calculating $\lim_{n\to\infty} 1/\tau_{over} = 1/\tau_\theta$ and $\lim_{n\to\infty}(\tau_x^v + \tau_y + \tau_\theta)/(\tau_x^v + \tau_y) = 1$ yields the result. $\square$

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