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Committees as Active Audiences: Reputation Concerns and Information Acquisition*

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Abstract

We study committees that acquire information, deliberate and vote. A member cares about state-dependent decision payoffs and about his reputation for expertise. The state remains unobserved, even after the decision has been taken. In such inconclusive environments, in equilibrium, a member's internal (peer) reputation is based on deliberation patterns, while members' external (public) reputation is based on the observed group decision. Either form of reputation concerns create strategic complementarity among members' effort levels. Internal reputations create stronger incentives to become informed than external reputations, and their strength grows in committee size; external reputations create no incentives in large committees. If prior information favors a state, internal – not external – reputations may hinder deliberation. In equilibrium, reputation concerns lead to additional information acquisition without affecting the expected reputations. Nevertheless, moderate rates of reputation concerns relax members' participation constraints, by counteracting the often predicted underprovision of information in committees.

Keywords: committee decision making, reputation concerns, information acquisition, strategic complements, peers, markets

JEL codes: D71, D83

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1 Introduction

Committees of experts often operate in environments that are best characterized as inconclusive. The consequences of the decisions taken by, for example, monetary policy committees, health care panels, judges, senior management teams or corporate boards are often only fully experienced in the long run.[1] Even then, the lack of counterfactual information means that the quality of a decision remains hard to assess. As a result, career-related decisions (retention, promotion etc.) cannot be based on a comparison of decision and state. In such inconclusive environments, a reputation for being well-informed about the matter at hand, among one's fellow members in the committee and in the eyes of external evaluators (the public, the market), is a valuable asset.

We show that in inconclusive environments a member who cares about his reputation in the eyes of a representative fellow member, his internal reputation, acquires more information the larger is the committee. Moreover, members' effort levels are strategic complements. This stands in sharp contrast to the consequences for effort that would stem from a sole concern with the decision payoff. With decision-relevant information a public good, an increase in group size would lead to a reduction in individual effort levels. Moreover, members' information collection efforts would be strategic substitutes. We also find that external reputations motivate less than internal reputations. Besides, external reputations loose their power to motivate members to acquire information in large committees. We obtain these results in a model of committees in which members acquire information, deliberate and vote. Members care about state-dependent decision payoffs and about their reputations, internal and external, for expertise. A member can exert effort to become informed. The effort of a competent member is more likely to produce a signal that matches the state than the effort of a less competent member. Thus, the efforts of two competent members are more likely to lead to congruent views between these members than the efforts of a competent and a less competent member (or of two less competent members). Deliberation patterns therefore allow a member's peer to revise his belief about the level of competence of that member. Larger committees

[1] For example, Gabel and Shipan (2004, p. 544) have argued that in the health care profession the correct treatment decision is not known, making it hard to "empirically evaluate the accuracy and performance of expert panels in prescribing treatments."

allow a fellow member to make sharper comparisons. As a result, the marginal benefits from exerting effort are larger. Hence the committees as *audiences* in the title: the larger committees are, the more prepared one wishes to be. External reputations, on the other hand, are based on the decision that the committee as a whole takes. In a large committee, the chance that a member's signal is pivotal in the decision tends to zero. As a result, the market looses its motivating power in large committees.

By and large, the literature on information acquisition in groups has focused on groups that are exclusively motivated by a state-dependent decision payoff net of the cost of information acquisition. Decision-relevant information is a public good. It is underprovided as individual members don't care about the positive externalities of their information acquisition decisions. To counter the underprovision, researchers have studied the role played by features of the decision-making process, including the voting rule, whether information is collected simultaneously or sequentially, and the efficiency or inefficiency of the decision conditional on the information collected. Others have investigated how conflict or preference heterogeneity among members about the desirable outcome provides incentives to produce decision-relevant information.[2]

Given the underprovision, the additional investment in information acquisition thanks to reputation concerns is welcomed by a social planner who cares about the state-dependent decision and the costs of members' effort. But the presence of reputation concerns may also induce an individual member to actually participate in the meeting and invest in information collection rather than to leave the decision to a fellow member. This is true, even though investing in information will, in expected terms, leave one's reputation – internal or external – unaffected. After all, Bayesian beliefs form a martingale.

If members are only interested in the state-dependent decision, the public good nature of decision-relevant information has another consequence. If one member is anticipated to invest less to become informed, the other member compensates by investing more. Reputation concerns

[2] Gersbach (1995) is among the first to study underprovision of information in committees. Kartik et al. (2017) is a recent study. Mukhopadhaya (2003) shows numerically that majority voting may induce large groups to take worse decisions than small groups. Persico (2004) studies for which group size the optimal voting rule induces members to acquire information. Dewatripont and Tirole (1999) compare the efficiency of information acquisition by advocates and a nonpartisan advisor. See Li and Suen (2009) for a lucid survey of the literature.

create a different relationship between members. Consider a member who is concerned with his internal reputation. The more he invests in becoming informed, the more likely it becomes that his signal corresponds with the (unobserved) state. As a result, the reputation from agreeing with him goes up, and the reputation from disagreeing with him goes down. The increase in the gain in reputation from agreeing with him induces a fellow member to also invest more to become informed. In other words, a concern with how one is viewed by one's peers creates strategic complementarity between members' information acquisition decisions. Hence, the committees as *active* audiences in the title: other committee members also exert effort, and it is their effort that stimulates an individual member to exert effort.

We are, to the best of our knowledge, the first to formally study a concern with internal reputation for being well-informed and its interaction with external reputations. However, both concerns already play a key role in the informal argument of Fama (1980) as to why corporations can bring about efficient outcomes even though they are characterized by a separation of ownership and control. He views managers as decision makers who are concerned with the information that is generated about their decision-making ability in the internal and external labor market, like the experts that we study.

There is a growing literature on committees of experts. Visser and Swank (2007) relate the quality of deliberation to the voting rule and differences among members' preferences over project value and external reputation. In the current paper, we show among others that deliberation may be hampered even if the interests of members are perfectly aligned. This is the case if members care considerably about their internal reputation and *ex ante* one state is considerably more likely than the other. Internal reputation concerns then dictate to say what is commonly expected, rather than to share one's view.

Fehrler and Janas (2019) have written one of the few other studies that analyse information acquisition by agents concerned with their external reputation rather than with state-dependent decision payoffs. Their focus is different. They study a principal who must decide whether to delegate decision making to a committee of experts or to decide herself after consulting each expert on an individual basis. The analysis revolves around experts' incentives to acquire information and the quality of information aggregation in the two decision processes. The incentives to acquire information are stronger if experts are consulted on an individual basis. The quality of information aggregation is higher in a group as an expert is unwilling to tell the principal that she is not knowledgeable.

Models of committees of experts are often used to analyze the behavior of monetary policy committees, especially to study the effect of a change in the 'transparency regime' – the information that becomes publicly available about the way the final decision was reached – on observed behavior.[3] In line with empirical evidence, transparency leads to more frequent united fronts or conformity and tends to discipline members.[4] Transparency regimes differ in terms of the information that becomes available to an evaluator about the decision process. Typically, the literature compares opaque or secretive regimes with transparent regimes. In an opaque regime, no information about the decision process becomes available apart from the final decision. In a transparent regime, information about how this decision was reached also becomes available. As a result, the information base of internal reputations in our paper is similar to that of reputations in a transparent regime, while the information base of external reputations is similar to that of reputations in an opaque regime. This analogy is particularly clear in Gersbach and Hahn (2012), the only study in the literature on transparency that endogenizes quality of information in committees. Moreover, they assume, like us, that members have career concerns. Obviously, a major difference between our paper and those on transparency regimes is that only one regime can apply at any given moment to a given committee, whereas members care about their peer and external reputations at the same time.

[3]Levy (2007) and Gersbach and Hahn (2008, 2012) study the effects of transparency in situations in which committee members care about their reputation for expertise. Swank and Visser (2013) study how imposing transparency leads to a change in the locus of decision making through the emergence of pre-meetings. Meade and Stasavage (2005), Swank, Swank and Visser (2008) and Hansen, McMahon and Prat (2018) test implications of models of reputation-concerned committees using data about behavior at the U.S. Federal Open Market Committee. Fehrler and Hughes (2018) and Mattozzi and Nakaguma (2017) are the first lab experiments of the effects of transparency regimes on committee behavior. Gersbach and Hahn (2004), Sibert (2003) and Stasavage (2007) study the effects of transparency on the behavior of group members if there is uncertainty about interest alignment with the principal. For general discussions about transparency and decision making by monetary policy committees, see Blinder (2007), Geraats (2002) and Reis (2013).

[4]Models of committees of experts have also been used to understand the behavior of judges, see e.g., Iaryczower, Lewis and Shum (2013), and company boards, e.g., Malenko (2014).

Other papers that explore the effects of reputation concerns on information acquisition and project choice are Milbourn, Shockley and Thakor (2001), Suurmond, Swank and Visser (2004) and Bar-Isaac (2012). Unlike us, they study single-agent settings. As a result, attention is limited to external reputations.

More generally, our paper contributes to the literature on reputation or career concerns. The seminal paper is Holmström (1999), originally published in 1982. It showed that if a principal bases an agent's wage on observable outcomes generated by the agent, then the agent acts with a view to influencing the principal's inferences. Such behavior may conflict with maximizing value for the principal.[5] In Scharfstein and Stein (1990) agents care about a reputation for being well-informed about the state. They show how such a concern may lead to herding when decisions are taken sequentially.[6]

The rest of the paper is organized as follows. We present the model in the next section. In section 3, we analyse the symmetric equilibrium of this model and discuss the effect of committee size on the incentives to acquire information. We discuss various extensions in section 4. Section 5 concludes. Proofs can be found in the Appendix.

2 A model of committee decision making with peer and external reputation concerns

The decision problem. A committee of two members, $i \in \{1, 2\}$, has to decide whether to maintain the status quo, $X = 0$, or to implement a project, $X = 1$. By normalization, status quo delivers a project payoff equal to zero. Project payoff in case of implementation is uncertain and state dependent. It equals $k + \mu$, where $\mu \in \{-h, h\}$ with $\Pr(\mu = h) = \alpha$.[7] In section 3, we assume that the *ex ante* uncertainty about the state is maximal, $\alpha = 1/2$. In section 4.1 we relax this

[5] Incidentally, Holmström's paper was written in an attempt to understand Fama's claim about career concerns.

[6] Kandel and Lazear (1992) study various forms of peer pressure as a means to counter the underprovision of effort in large groups – shame, guilt, norms, mutual monitoring and empathy. With the exception of guilt, for peer pressure to work, effort should be observable. In our model, effort is unobservable. Internal reputations nevertheless provide strong incentives to acquire information.

[7] Thus, μ represents both the state and the state-dependent value.

assumption. We assume throughout the paper that (i) $k < 0$, i.e., the unconditional expected value of an implemented project is negative, implying that the committee has a bias against project implementation; (ii) $k + h > 0$, implying that the optimal decision depends on the state.

The decision-making process. The decision-making process starts with an **information collection stage** in which each member exerts effort $e_i \geq 0$ to receive a signal $s_i \in \{s^b, s^g\}$ about the state μ. A signal refers to a member's assessment, forecast or view of μ (b is bad and g is good). The quality of this signal depends on i's effort and on his ability $a_i \in \{L, H\}$. The likelihood that a member's signal is correct, i.e., corresponds with the state, given effort e_i and ability level a_i equals

$$p^{a_i}(e_i) = \Pr(s_i^g | \mu = h, a_i, e_i) = \Pr(s_i^b | \mu = -h, a_i, e_i),$$

for $a_i \in \{L, H\}$. For $a_i \in \{L, H\}$, $p^{a_i}(\cdot)$ is an increasing, strictly concave function with $p^{a_i}(0) \geq 1/2$, $p^{a_i\prime}(0) = \infty$, $\lim_{e_i \to \infty} p^{a_i\prime}(e_i) = 0$. We assume that higher ability means a higher likelihood of receiving the right signal, for all $e_i > 0$, $p^H(e_i) > p^L(e_i)$. *Ex ante* there is no asymmetric information about the ability level of a committee member: each member in the committee, including member i, believes that i is of high ability with probability $\Pr(a_i = H) = \pi$.[8] Define the *ex ante* likelihood that a signal is correct as

$$p^M(e_i) = \Pr(s_i^g | \mu = h, e_i) = \pi p^H(e_i) + (1 - \pi) p^L(e_i).$$

The costs of exerting effort are increasing and strictly convex, with $c(e_i) > 0$, $c(0) = c'(0) = 0$ and $\lim_{e_i \to \infty} c'(e_i) = \infty$. The other member (call her j) does not observe i's effort choice.

The information collection stage is followed by a **deliberation stage** in which members simultaneously send a message to the other member. We assume that private information is truthfully revealed. In section 4.1, we show that members do not have incentives to misrepresent private information and discuss an extension of the model in which incentives to misrepresent information do exist.[9]

[8] The absence of private information on a decision-maker's ability is a common assumption in the literature on career concerns, see e.g. Holmström (1999) and Scharfstein and Stein (1990).

[9] The assumption that private information is truthfully revealed may be realistic if other committee members have

In the **voting stage**, members simultaneously cast their votes on the project, $v_i \in \{v^0, v^1\}$, where $v_i = v^0$ ($v_i = v^1$) denotes that i votes against (in favor of) the project. The voting strategy $v_i(s_i, s_j, e_i) = \Pr(v_i = v^1 | s_i, s_j, e_i)$ of i is a function that maps the signal that i received, the signal of j that he learned in the deliberation stage and the effort he exerted to a probability that he votes v^1. We assume that implementation requires unanimity, a natural assumption given that the expected project payoff is negative.

Objectives of committee members. Each member cares about the value of the project and about his internal and external reputation. A member's **external reputation** equals the *ex post* probability that he is of high ability in the eyes of an evaluator, like the market or the public, outside the committee. The market observes the decision X taken by the committee, but observes neither their deliberation, nor their voting, nor the state of the world. Let $\hat{\pi}_i^E(X) = \Pr(a_i = H|X)$ denote i's external reputation if the market observes the decision X. A member's **internal reputation** equals the *ex post* probability that he is of high ability in the eyes of a fellow committee member. Both members know each others' signals because of the assumption of truthful revelation. Let $\hat{\pi}_i^I(s_i, s_j) = \Pr(a_i = H|s_i, s_j)$ denote i's internal reputation if his fellow member observes the signal pair (s_i, s_j).[10] Again, this reputation is not based on a comparison with the state of the world.[11] In keeping with the *ex ante* symmetry of information about member i's ability within the committee, we also assume that the market's *ex ante* belief that a member is of high ability equals $\Pr(a_i = H) = \pi$.

The payoff member i obtains from exerting effort e_i, with decision X in state μ and with signal pair (s_i, s_j) equals

$$X(k + \mu) + \gamma\hat{\pi}_i^I(s_i, s_j) + \lambda\hat{\pi}_i^E(X) - c(e_i),$$

time to ask probing questions to verify claims made in the meeting. A second reason why making this assumption the point of departure of the analysis is that the analysis that results suggests which member has an incentive to misrepresent his private information and in what situation. See also Visser and Swank (2007).

[10] If signals could be misrepresented in the deliberation stage, then member j would condition her assessment of member i not just on observed statements but also on i's vote as this vote can 'correct' an impression j inferred about i's ability from his statement.

[11] In other words, the internal and external reputations are determined before the state of the world becomes known. In some sense, we are dealing here with decisions that take a long time before it becomes known whether they were good or bad.

where $X(k+\mu)$ should be read as "X times $k+\mu$." The parameters γ and λ are the weights both members attach to their peer and external reputations, respectively.

An equilibrium consists of an effort level and a voting strategy for each member, and reputations, both internal and external. In equilibrium,

1. internal reputations are updated probabilities that a member is of high ability consistent with prior beliefs and effort levels, using Bayes' rule whenever possible;

2. external reputations are updated probabilities that a member is of high ability consistent with prior beliefs, effort levels and voting strategies, using Bayes' rule whenever possible;

3. for given e_i, given (s_i, s_j), given internal and external reputations and given v_j, v_i is a best reply;

4. for given voting strategies of i and j, given internal and external reputations and given e_j, e_i is a best reply;

5. in the voting stage each member behaves as if his vote is pivotal.

Requirement 5 rules out the uninteresting equilibrium in which each member always votes against implementation. It is tantamount to assuming that a member votes v^1 if he prefers $X=1$ over $X=0$ and v^0 in the opposite case.

We write $\hat{\pi}_i^I(s_i, s_j; \mathbf{e})$ and $\hat{\pi}_i^E(X; \mathbf{e})$ to denote i's internal and external reputations, respectively, consistent with effort choices $\mathbf{e}=(e_i, e_j)$. Let $\mathbf{e}^*=\left(e_i^*, e_j^*\right)$ denote the pair of equilibrium effort levels.

A member acquires information to improve the decision and his reputation. The acquisition of decision-relevant information is akin to the provision of a public good as both members benefit from the information acquired by a member. Models of public good provision can have two types of equilibria, see e.g. Mueller (1989). In the first type, members contribute jointly and equally. In the second type, one member does the heavy lifting, while the other leans back. The main part of the paper deals with a joint decision-making process. In section 4.2, we turn to a chicken decision-making process that reflects unequal contributions of its members.

Note the absence of a participation stage in which a member considers whether to join the committee or not. In practice, participation in meetings often cannot be avoided. We start the analysis by assuming that members have to participate in the meetings. In section 3.1, we endogenize participation and study how reputation concerns affect members' participation constraints.

3 The joint decision-making process

In a joint decision-making process, in equilibrium members contribute to the same degree to the production of information, $e_i^* = e_j^* = e^*$. As a result, the information that they obtain is treated symmetrically: members vote for implementation if both signals are positive and vote for the status quo if at least one signal is negative,

$$(v_1, v_2) = \begin{cases} (1,1) & \text{for } (s_i, s_j) = (s^g, s^g) \\ (0,0) & \text{otherwise.} \end{cases} \tag{1}$$

We call a member's voting strategy in a joint decision-making process a joint voting strategy. Lemma 1 presents members' internal reputations for each signal pair. It also shows how $\hat{\pi}_i^I(s_i, s_j; \mathbf{e})$ changes with a member's own effort, e_i, and the effort of the other member, e_j. Item 4 in Lemma 1 relies on Assumption 1.

Assumption 1 (Elasticity) *The effort-elasticity of the probability of receiving correct information is higher for a high ability member than for a low ability member: for all e_i, $\frac{\frac{\partial p^H(e_i)}{\partial e_i}}{p^H(e_i)} e_i \geq \frac{\frac{\partial p^L(e_i)}{\partial e_i}}{p^L(e_i)} e_i$.*

Lemma 1 *The following holds for internal reputations consistent with effort levels:*

1. for given pair of effort levels $\mathbf{e}$,

$$\begin{aligned} \hat{\pi}_i^I\left(s_i^g, s_j^g; \mathbf{e}\right) &= \hat{\pi}_i^I\left(s_i^b, s_j^b; \mathbf{e}\right) > \pi \\ &> \hat{\pi}_i^I\left(s_i^g, s_j^b; \mathbf{e}\right) = \hat{\pi}_i^I\left(s_i^b, s_j^g; \mathbf{e}\right); \end{aligned} \tag{2}$$

2. if $e_i = e_j$, then, for a given signal pair, the internal reputation is the same for both members,

$\hat{\pi}_i^I = \hat{\pi}_j^I$;

3. if $e'_j > e_j$*, then* $\hat{\pi}_i^I\left(s, s; e_i, e'_j\right) > \hat{\pi}_i^I\left(s, s; e_i, e_j\right)$ *whereas* $\hat{\pi}_i^I\left(s', s; e_i, e'_j\right) < \hat{\pi}_i^I\left(s', s; e_i, e_j\right)$*, where* $s \neq s'$ *and* $s, s' \in \left\{s^g, s^b\right\}$*;*

4. if $e'_i > e_i$ *and Assumption 1 holds, then* $\hat{\pi}_i^I\left(s, s; e'_i, e_j\right) > \hat{\pi}_i^I\left(s, s; e_i, e_j\right)$ *and* $\hat{\pi}_i^I\left(s', s; e'_i, e_j\right) < \hat{\pi}_i^I\left(s', s; e_i, e_j\right)$*, where* $s \neq s'$ *and* $s, s' \in \left\{s^g, s^b\right\}$*.*

Point (1) says that if members receive the same signals, a member's internal reputation improves relative to the prior value π. Conflicting signals hurt a member's internal reputation. These results stem from the fact that high ability members are more likely to receive informative signals – and thus equal signals – than low ability members. In other words, the signals of high ability members are correlated more strongly than those of low ability members. Point (2) says that if members contribute equally to the production of information, then their internal reputations are the same for a given signal pair. Point (3) shows that member i enjoys a stronger internal reputation if he agrees with a fellow member who is better informed, and a lower reputation if he disagrees with such a fellow member. Finally, (4) shows that under Assumption 1 the internal reputation i commands is increasing in his own effort if he agrees with his fellow member while it is decreasing in his own effort if he disagrees with her.

Let $\Delta\hat{\pi}_i^I\left(s_i, s_j; \mathbf{e}\right) = \hat{\pi}_i^I\left(s, s; \mathbf{e}\right) - \hat{\pi}_i^I\left(s', s; \mathbf{e}\right)$ denote i's **internal reputation premium** from holding the same view as j rather than a conflicting view. Here, $s, s' \in \left\{s^g, s^b\right\}$ and $s \neq s'$. It follows from the first lemma that this difference is positive, increasing in e_j and, under Assumption 1, in e_i. In equilibrium, since $e_i^* = e_j^* = e^*$, the internal reputation premium is the same for both members.

Lemma 2 presents members' external reputations. It also shows how $\hat{\pi}_i^E\left(X; \mathbf{e}\right)$ changes with a member's own effort e_i and the effort of the other member e_j.

Lemma 2 *With voting described by (1), the following holds for external reputations consistent with effort levels:*

1. for given pair of effort levels $\mathbf{e}$*,*

$$\hat{\pi}_i^E\left(1; \mathbf{e}\right) > \pi > \hat{\pi}_i^E\left(0; \mathbf{e}\right); \tag{3}$$

2. *if* $e_i = e_j$*, then, for a given decision, the external reputation is the same for both members,* $\hat{\pi}_i^E = \hat{\pi}_j^E$*;*

3. *if* $e_j' > e_j$*, then* $\hat{\pi}_i^E \left(1; e_i, e_j'\right) > \hat{\pi}_i^E \left(1; e_i, e_j\right)$ *whereas* $\hat{\pi}_i^E \left(0; e_i, e_j'\right) < \hat{\pi}_i^E \left(0; e_i, e_j\right)$*;*

4. *if* $e_i' > e_i$ *and Assumption 1 holds, then* $\hat{\pi}_i^E \left(1; e_i', e_j\right) > \hat{\pi}_i^E \left(1; e_i, e_j\right)$ *and* $\hat{\pi}_i^E \left(0; e_i', e_j\right) < \hat{\pi}_i^E \left(0; e_i, e_j\right)$*.*

Point (1) says that if the committee decides to implement the project, a member's external reputation improves relative to the prior value. Maintaining the status quo hurts his reputation. As implementation only takes place after two positive, and thus equal signals, while maintaining the status quo can also result from two conflicting signals, $X = 1$ commands a higher external reputation than $X = 0$. Point (2) says that if members contribute equally to the production of information, then their external reputations are the same for a given decision. Point (3) shows that if his fellow member acquired more information, member i enjoys a stronger external reputation from project implementation while his external reputation drops more after maintaining the status quo. Point (4) shows that under Assumption 1 the external reputation i commands is increasing in his own effort if the committee implements the project while it is decreasing if it maintains the status quo.

Let $\Delta\hat{\pi}_i^E (X; \mathbf{e}) = \hat{\pi}_i^E (1; \mathbf{e}) - \hat{\pi}_i^E (0; \mathbf{e}) > 0$ denote i's **external reputation premium** from implementing the project. It follows from the second lemma that this difference is positive, increasing in e_j and, under Assumption 1, in e_i. In equilibrium, since $e_i^* = e_j^* = e^*$, the internal reputation premium is the same for both members. Notice that members who hold the same, negative view, $(s_i, s_j) = \left(s^b, s^b\right)$, experience a boost in their internal reputations, while their external reputations are hurt.

What remains to be determined are the equilibrium levels of effort $\mathbf{e}^*$. The expected payoff to member i when choosing effort equals

$$\Pr\left(s_i^g, s_j^g; \mathbf{e}\right)\left(k + \mathbb{E}\left[\mu | s_i^g, s_j^g; \mathbf{e}\right]\right) + \gamma\mathbb{E}\left[\hat{\pi}_i^I\left(s_i, s_j; \mathbf{e}^*\right)\right] + \lambda\mathbb{E}\left[\hat{\pi}_i^E\left(X; \mathbf{e}^*\right)\right] - c\left(e_i\right). \quad (4)$$

When determining how much effort to exert, a member can only influence the *likelihood* of commanding a certain reputation, not the reputation itself.[12] How do reputation concerns affect effort? The marginal benefits from exerting effort equal[13]

$$\begin{aligned} MB_i\left(e_i, e_j, \mathbf{e}^*\right) &= \frac{\partial p_i^M}{\partial e_i}\left(\left(p_j^M\left(e_j\right)-\frac{1}{2}\right)k+\frac{h}{2}\right) \\ &\quad +2\gamma\frac{\partial p_i^M}{\partial e_i}\left(p_j^M\left(e_j\right)-\frac{1}{2}\right)\Delta\hat{\pi}^I\left(s_i, s_j; \mathbf{e}^*\right) \\ &\quad +\lambda\frac{\partial p_i^M}{\partial e_i}\left(p_j^M\left(e_j\right)-\frac{1}{2}\right)\Delta\hat{\pi}^E\left(X; \mathbf{e}^*\right) \text{ for } i=1,2. \end{aligned} \tag{5}$$

Recall that p_i^M denotes the *ex ante* probability that i's signal is correct. Both forms of reputation concerns add incentives to exert effort, as both reputation premiums are positive. If a member cares to the same degree about either reputation, $\gamma = \lambda$, internal reputations create stronger incentives to become informed than a concern with external reputations. The reason is twofold. First, it is more damaging to a member's internal reputation to be found out to have a signal that is different from that of his fellow committee member than it is to his external reputation to maintain the status quo, $\hat{\pi}^I\left(s_i^g, s_j^b; \mathbf{e}^*\right) < \hat{\pi}^E\left(0; \mathbf{e}^*\right) < \hat{\pi}^I\left(s_i^g, s_j^g; \mathbf{e}^*\right) = \hat{\pi}^E\left(1; \mathbf{e}^*\right)$. Second, exerting more effort helps in attaining a strong internal reputation irrespective of the signal of the other member, whereas effort improves a member's external reputation only if the other member has a positive signal.

Committees, then, create audiences to members, and thereby make concerns with internal reputations possible. Such concerns give incentives to members to exert effort.

It follows from (5) and Lemmas 1 and 2 that both forms of reputation concerns create strategic complementarity between effort levels. Two things happen if j acquires more information. First, it makes it more likey that additional effort of i prevents conflicting signals and the status quo. This is beneficial from an internal and external reputation point of view, respectively. Second, both reputation premiums grow in size. This further amplifies the marginal reputation benefits. Of course,

[12] Note that $\mathbb{E}\left[\hat{\pi}_i^I\left(s_i, s_j; \mathbf{e}^*\right)\right] = \sum_{(s_i, s_j)} \Pr\left(s_i, s_j; \mathbf{e}\right)\hat{\pi}^I\left(s_i, s_j; \mathbf{e}^*\right)$ and $\mathbb{E}\left[\hat{\pi}_i^E\left(X; \mathbf{e}^*\right)\right] = \sum_X \Pr\left(X; \mathbf{e}\right)\hat{\pi}^E\left(X; \mathbf{e}^*\right)$.

[13] For the derivation, see the proof of Proposition 2.

if members were only to care about project value, their effort levels would be strategic substitutes as decision-relevant information is a public good. The net effect of these three components will depend on parameter values. Proposition 1 summarizes the discussion above.

Proposition 1 *In a* ***joint decision-making process****,*

(1) the concern with project value creates strategic substitutability among members' effort levels;

(2) the concern with reputations, peer or public, creates strategic complementarity among members' effort levels;

(3) for $\lambda = \gamma$, a concern with internal reputations creates stronger incentives to exert effort than a concern with external reputations;

(4) if $(s_i, s_j) = \left(s^b, s^b\right)$, then a member's internal reputation is strengthened whereas his external reputation is hurt.

Characterizing the equilibrium levels of effort in this game requires some care. There are potentially multiple equilibria due to the fact that the internal and external reputations of member i enter i's marginal benefits from effort and are based on conjectured effort levels. Nevertheless, for *given* ex post reputations based on $\hat{\mathbf{e}}$ and *given* (conjectured) effort level e_j^+, member i's payoff is strictly concave in e_i, and the optimal effort level is unique, interior and satisfies $MB_i\left(e_i, e_j^+, \hat{\mathbf{e}}\right) = C'\left(e_i\right)$. An equilibrium pair of effort levels (e_1^*, e_2^*) should satisfy

$$MB_i\left(e_i^*, e_j^*, \mathbf{e}^*\right) = C'\left(e_i^*\right) \text{ for } i = 1, 2. \tag{6}$$

Propostition 2 provides the necessary and sufficient conditions for $\mathbf{e}^*$ and a joint decision-making process to be part of an equilibrium.

Proposition 2 *Effort levels $\mathbf{e}^*$ and a joint voting strategy are part of an equilibrium if and only if*

1. no member wants to implement the project in case of conflicting signals, $k + \lambda\hat{\pi}^E\left(1; \mathbf{e}^*\right) < \lambda\hat{\pi}^E\left(0; \mathbf{e}^*\right)$.

2. effort levels are sufficiently high that a member wants to implement the project in case of two *positive signals,* $k + \mathbb{E}[\mu|s^g, s^g; \mathbf{e}^*] + \lambda\hat{\pi}^E(1; \mathbf{e}^*) > \lambda\hat{\pi}^E(0; \mathbf{e}^*)$*.*

3. $\mathbf{e}^*$ *satisfies (6) and no member wants to deviate to zero effort: for* $i = 1, 2$*,*

$$\Pr(s_1^g, s_2^g; \mathbf{e}^*)(k + \mathbb{E}[\mu|s^g, s^g; \mathbf{e}^*]) + \gamma\pi + \lambda\pi - c(e_i^*) > \frac{1}{2}\left(k + \mathbb{E}\left[\mu|s^g; e_j^*\right]\right) + \gamma\pi + \lambda\frac{1}{2}\left[\hat{\pi}^E(1; \mathbf{e}^*) + \hat{\pi}^E(0; \mathbf{e}^*)\right].$$

Condition 1 guarantees that no member wants to implement the project in case of conflicting signals. Notice that with conflicting signal pairs (s_1^g, s_2^b) or (s_1^b, s_2^g), the conditionally expected project payoff equals k. The temptation to implement with two conflicting signals exists because implementation yields a better external reputation than maintaining the status quo. It is worth emphasizing that indirectly, through $\mathbf{e}^*$, the condition also depends on γ, the weight members attach to their internal reputations.

Condition 2 states that two positive signals must be sufficient to warrant implementation. A higher weight on external reputation concerns directly relaxes the condition by making implementation more attractive. Indirectly, through encouraging effort, both public and internal reputations relax the condition.

Condition 3 guarantees that a member not merely attends the meeting without becoming informed, but actively participates by exerting effort. It is formulated under the assumption that at the beginning of the deliberation stage, before signals are exchanged, a member can make claims about the level of effort he has exerted. Such claims about sunk effort are credible, as the interests of the members, one the sender, the other the receiver of the claim, are perfectly aligned at this stage. The deviation considered in the condition assumes that the implementation decision will be based on the other member's signal only. The benefit of this deviation for a member is twofold. First, it avoids costly effort. Second, it maximizes the likelihood of implementation, and thereby increases the probability of a boost of a member's external reputation. Note that the external reputation is based on $\mathbf{e}^*$ as the market does not observe the deviation. The cost of foregoing effort is a lower project value.[14]

[14] Whether member 2 sticks to equilibrium play or deviates, his expected internal reputation equals $\gamma\pi$.

Overall, Proposition 2 shows that when members are not overly interested in project value, reputation concerns may make a joint decision-making process viable by relaxing the second condition. Strong external reputation concerns may backfire, however. They may make members too interested in implementation. As a result, the committee may want to implement the project even in the absence of two positive signals, violating the first condition. An equilibrium in mixed strategies exists. With some probability the project is implemented when members' signals disagree. We provide a detailed discussion of the resulting equilibrium behavior in Appendix A.2.

Remark: In (1), we have specified the relationship between votes and signals on the equilibrium path characterized by $\mathbf{e} = \mathbf{e}^*$. To fully characterize the equilibrium, we need to specify the equilibrium voting strategy. Let $\Delta U_i (s_i, s_j, e_i)$ denote the difference in expected payoffs from implementing the project and rejecting it, given a pair of signals (s_i, s_j) and effort levels (e_i, e_j). That is,[15]

$$\Delta U_i (s_i, s_j, e_i) = k + E[\mu | s_i, s_j; \mathbf{e}] + \lambda \Delta \hat{\pi}^E (X; \mathbf{e}^*) . \tag{7}$$

Member i's equilibrium voting strategy satisfies for all (s_i, s_j, e_i)

$$v_i^* (s_i, s_j, e_i) = \begin{cases} 1 & \text{if } \Delta U_i (s_i, s_j, e_i) > 0 \\ \beta_i & \text{if } \Delta U_i (s_i, s_j, e_i) = 0 \\ 0 & \text{if } \Delta U_i (s_i, s_j, e_i) < 0, \end{cases} \tag{8}$$

with $\beta_i \in [0, 1]$.

3.1 How do reputation concerns affect a member's decision to participate in a joint decision-making process?

So far, we have taken the participation constraints of the committee members for granted. Our motivation was that in many situations attendance is unavoidable. Thus, we have studied behavior within the committee, and specified the condition for active participation, $e > 0$, to be prefered over mere presence with $e = 0$. In this section, we investigate the related question of a member's

[15] To be precise, $E[\mu | s_i, s_j; \mathbf{e}]$ is based on e_i and i's conjecture about e_j.

willingness to participate in a joint decision-making meeting. We assume that if member 1 chooses not to participate, the decision on the project is made by member 2. Throughout, we assume that member 1's decision to take part in the committee or not is publicly observed before effort levels are chosen.

Consider a situation *without* reputation concerns. Assume that member 2 implements the project only if $s_2 = s^g$. Her optimal effort level, $\bar{e}_2$, satisfies

$$\bar{e}_2 = \arg\max_e \Pr\left(s_2^g; e\right)\left(k + \mathbb{E}[\mu | s_2^g; e]\right) - c\left(e\right).$$

The payoff that results for member 1 is $\Pr\left(s_2^g; \bar{e}_2\right)\left(k + \mathbb{E}[\mu | s_2^g; \bar{e}_2]\right)$. If member 1 participates, the resulting effort levels for members 1 and 2, denoted by $\mathbf{e}_0^*$, satisfy (6) for $i = 1, 2$ with $\gamma = \lambda = 0$. Member 1 wants to join the meeting if

$$\Pr\left(s^g, s^g; \mathbf{e}_0^*\right)\left(k + \mathbb{E}[\mu | s^g, s^g; \mathbf{e}_0^*]\right) - c\left(e_0^*\right) > \Pr\left(s_2^g; \bar{e}_2\right)\left(k + \mathbb{E}[\mu | s_2^g; \bar{e}_2]\right). \tag{9}$$

How do reputation concerns affect member 1's decision to participate in a joint decision-making process? Notice that whether member 1 participates or not, the *ex ante* expected *ex post* reputations equal $(\gamma + \lambda)\,\pi$ as Bayesian beliefs form a martingale. As a result, reputation concerns do not directly affect members' participation decisions. However, they do induce *both* members to exert additional effort. Given that $\mathbf{e}_0^*$ falls short of the first-best levels $\mathbf{e}^{FB} = \left(e^{FB}, e^{FB}\right)$, some additional effort relaxes member 1's participation constraint.

The upshot is that sufficiently weak reputation concerns relax members' participation constraints. As long as the equilibrium effort levels, $\mathbf{e}^*$, move closer to the first-best effort levels, $\mathbf{e}^{FB}$, the expected payoff of participation increases. If reputation concerns are strong, such that $\mathbf{e}^* > \mathbf{e}^{FB}$, stronger concerns tighten members' participation constraints. As a result, members may opt out of the meeting.

3.2 Committee size

The size of a committee is an important design variable. In this section, we discuss how committee size influences the effects of reputation concerns on members' incentives to exert effort. To put this discussion in context, notice that if a member only cares about project value and not about his reputation, a member's choice of effort depends on the probability that his signal affects the final decision on the project. If an agent were to decide on his own, his signal, if sufficiently informative, would always be decisive. In a two-member committee with joint decision-making, member i's signal is only decisive if member j's signal is positive. As a result, the marginal benefits from exerting effort are lower. More generally, if members care exclusively about project value, a growing group size weakens incentives to become informed as the probability that a member's signal is decisive goes down.

To isolate the effect of committee size on reputations, we assume that members exert effort and focus on the two reputation components in members' objective functions. We compare a two-member committee with a single agent and with a large committee in which the number of members tends to infinity. We state the main result in the following proposition.

Proposition 3 *A concern with* ***internal reputations*** *(i) does not motivate a member who decides on his own to acquire information; (ii) provides stronger incentives to acquire information in a large committee than in a two-person committee. A concern with* ***external reputations*** *motivates neither a member who decides on his own to acquire information nor a member in a large committee.*

Consider internal reputations. By definition, internal reputation concerns are eliminated when the decision on the project is made by a single agent. If the committee is large, we can invoke the Condorcet Jury Theorem. In our context, this Theorem says that if all committee members truthfully reveal their signals, then the probability that the majority of signals correctly points to the true state goes to one if the size of the committee goes to infinity. Thus, if members share their views, a comparison of the view that member i expressed with those of the other members amounts to a comparison between i's view and the true state μ. Intuitively, as observing μ is the best evidence available to establish member i's reputation, the difference in reputation between member i correctly or incorrectly assessing the state is larger than the difference in reputation between member i agreeing and disagreeing with member j. Besides, the change in probability of commanding the better reputation thanks to an increase in effort is larger for a large committee than for a two-person committee. As a result, a member's marginal benefits from exerting effort to improve his internal reputation are larger in a large committee than in a two-person committee.

Consider external reputations. If a single member decides on the project, the external evaluator does not learn anything about this member's ability. On the other hand, in a large committee, in any equilibrium in which members follow the same strategies, the effect of a member's signal on the final decision goes to zero. This means that the final decision contains no information about an individual member's signal. Hence, for very large committees, external reputation concerns do not motivate members to exert effort.

There is thus a fundamental difference between internal and external reputation concerns. In case of internal reputation concerns, a member's signal is compared to the signals of the other members. The more comparisons can be made, the better one can assess the ability of a member. An increase in the number of members widens a member's internal reputation premium. Larger audiences create larger incentives. In case of external reputation concerns, the market assesses the influence of a member's signal on the project decision. This influence declines when more members are involved. If the number of committee members tends to infinity, the effect of higher effort of one member on the project decision goes to zero.

Remark about μ observable. If conclusive evidence about the correctness of the decision were available, a member's internal reputation would be determined by a comparison between the state and the signal he revealed in the deliberation stage, as if the committee were large and μ unobservable. Internal reputations would no longer gain strength with any increase in committee size. Instead, internal reputation concerns would provide relatively strong incentives to exert effort for any size of the committee. If the market learns the state μ before determining members' reputations, then members who care about those reputations would be encouraged to acquire information especially in small committees. When one person makes a decision on the project, the market can compare the decision with the state, giving strong incentives to this person to exert effort in order to make the correct decision. When the committee is large, generally, the decision on the project does not contain much information about the signal of an individual member. The effects of external reputation concerns are weak.

3.3 A Numerical Illustration

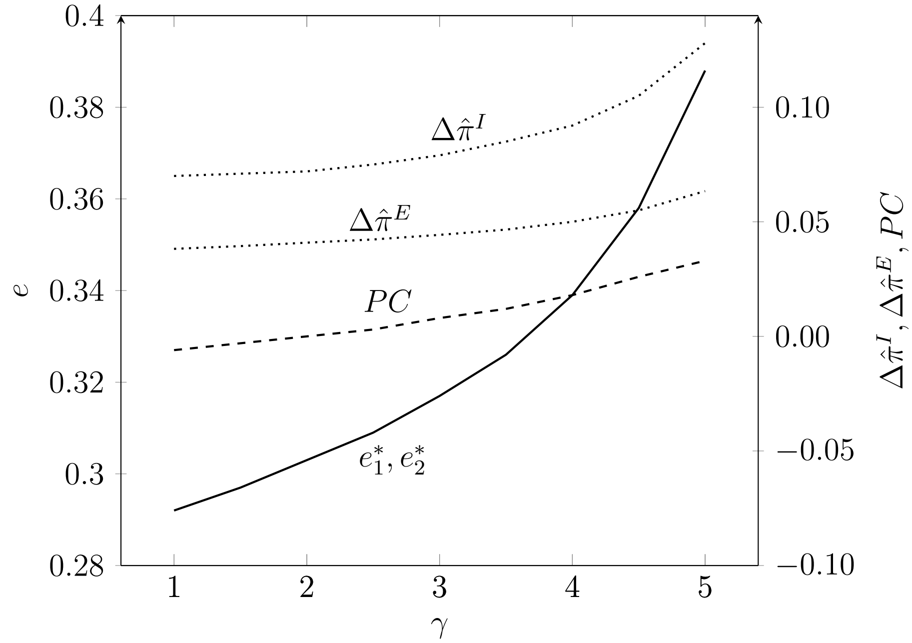
This section presents a numerical analysis of our model to illustrate the effects of reputation concerns on (1) members' willingness to participate in the committee, and (2) members' effort decisions. We have made some specific assumptions for this section. The probablity with which a high ability member receives a correct signal is $p^H(e) = \frac{1}{2} + e$, while the probability that a low ability member receives a correct signal is $p^L(e) = \frac{1}{2} + \frac{1}{2}e$.[16] The cost of effort function is quadratic, $c(e) = \frac{9}{8}e^2$. The ex ante probability that a member is smart equals $\pi = \frac{1}{2}$. The ex ante expected value of the project is $k = -\frac{3}{4}$. Finally, the state dependent value equals $h = 2$. The last two assumptions imply that the value of the project is either $-2\frac{3}{4}$ or $1\frac{1}{4}$.

In the assumed environment, the first-best effort levels equal 0.365. In the absence of reputation concerns, and assuming that both members participate, each member would choose an effort level equal to 0.28. In the assumed setting in the absence of reputation concerns, a joint decision-making process is not an equilibrium outcome, because members' participation constraints are violated. We deliberately choose an environment for which members are not willing to participate in the absence of reputation concerns to highlight that reputation concerns may relax participation constraints, see Proposition 2.

Figure 1 depicts a number of key variables for various weights γ that a member attaches to his internal reputation. We assume a fixed weight on the external reputation equal to $\lambda = \frac{3}{2}$. The drawn line shows the (common) equilibrium effort level. Its value can be read on the y-axis on the left. The dotted lines show the size of the two reputation premiums. The dashed line shows the difference in expected utility between participating in the meeting and not participating. The

[16] Notice that neither $p^H(\cdot)$ nor $p^L(\cdot)$ satisfy all the (strong) assumptions formulated in section 2. The numerical example thus shows that some of those assumptions can be relaxed.

Figure 1: Key variables as a function of the weight γ that committee members put on their internal reputations



Note: The figure reports the equilibrium values of members' effort levels e_1^* and e_2^* on the left axis and the external and internal reputation premiums, $\Delta\hat{\pi}^E$ and $\Delta\hat{\pi}^I$ resp., on the right axis. The dashed line labeled PC shows a member's net benefit from participating in the meeting (compared with not participating). Functional forms and parameter values used are $p^H(e) = \frac{1}{2} + e$, $p^L(e) = \frac{1}{2} + \frac{1}{2}e$, $c(e) = \frac{9}{8}e^2$, $\pi = \frac{1}{2}$, $k = -\frac{3}{4}$, $h = 2$ and $\lambda = \frac{3}{2}$.

values of the reputation premiums and of the gain in expected utility from participating can be read on the y-axis on the right. This graph shows that for $\gamma < 2$, a two-member committee in which participation is a choice cannot exist as the net value from participation is negative. Reputation concerns, if sufficiently strong, make committee decision-making possible. It also shows that higher values of γ increase effort and both reputation premiums. Clearly, the internal reputation premium is larger than the external reputation premium.

4 Further analysis

In this section, we extend the analysis in two directions. In section 4.1, we study the conditions under which information sharing is incentive compatible in a joint decision-making process. In section 4.2, we turn to a chicken process.

4.1 When is information sharing incentive compatible?

So far we have assumed that members cannot misrepresent their private information in the deliberation stage. This is of course best from a project-value perspective. For the analysis above this assumption is relatively innocuous for two reasons. First, once members have collected information, their preferences are perfectly alligned. If members were to differ in the way they trade off project value and external reputations, they could have incentives to misrepresent their private information in the deliberation stage. These incentives are not discussed in the present paper, as they are studied in detail in Visser and Swank (2007). Second, misrepresentation of private information would hurt a member's expected internal reputation.

To better understand what makes information sharing incentive compatible, we replace the assumption that $\Pr(\mu = h) = \frac{1}{2}$ with the assumption that $\Pr(\mu = h) = \alpha \in (0,1)$. As we will see, if one state is more likely to occur than another, then a concern with internal reputations may make misrepresenting one's private information attractive. To focus on the role of internal reputations, we assume that members exert effort and care exclusively about internal reputations.

Suppose therefore that members have exerted effort and have received their signals. Consider the deliberation stage. For truth telling by member i to be incentive compatible, the following conditions must hold for s_i^g and s_i^b,

$$\Pr\left(s_j^g|s_i^g\right)\left[\hat{\pi}_i^I\left(s_i^g,s_j^g\right)-\hat{\pi}_i^I\left(s_i^b,s_j^g\right)\right] \geq \Pr\left(s_j^b|s_i^g\right)\left[\hat{\pi}_i^I\left(s_i^b,s_j^b\right)-\hat{\pi}_i^I\left(s_i^g,s_j^b\right)\right] \tag{10}$$

$$\Pr\left(s_j^b|s_i^b\right)\left[\hat{\pi}_i^I\left(s_i^b,s_j^b\right)-\hat{\pi}_i^I\left(s_i^g,s_j^b\right)\right] \geq \Pr\left(s_j^g|s_i^b\right)\left[\hat{\pi}_i^I\left(s_i^g,s_j^g\right)-\hat{\pi}_i^I\left(s_i^b,s_j^g\right)\right], \tag{11}$$

respectively.[17] Consider the *ex post* peer reputation terms that appear in the squared brackets. The following lemma holds.

[17]For notational simplicity we have suppressed the chosen effort levels in the conditional probabilities and the conjectured effort levels in the *ex post* internal reputation terms.

Lemma 3 *For a given $\alpha \in (0,1)$ and given effort level of member j, the internal reputations of i that are consistent with members who truthfully reveal their private signals satisfy*

$$\begin{aligned}(i)\ \hat{\pi}_i^I\left(s_i^g, s_j^g\right) &\gtreqless \hat{\pi}_i^I\left(s_i^b, s_j^b\right) \Leftrightarrow \alpha \gtreqless 1/2 \\ (ii)\ \hat{\pi}_i^I\left(s_i^g, s_j^b\right) &\gtreqless \hat{\pi}_i^I\left(s_i^b, s_j^g\right) \Leftrightarrow \alpha \gtreqless 1/2 \\ (iii)\ \hat{\pi}_i^I\left(s_i^b, s_j^b\right) &\gtreqless \hat{\pi}_i^I\left(s_i^g, s_j^b\right) \Leftrightarrow p_j^M\left(e_j\right) \gtreqless \alpha \\ (iv)\ \hat{\pi}_i^I\left(s_i^g, s_j^g\right) &\gtreqless \hat{\pi}_i^I\left(s_i^b, s_j^g\right) \Leftrightarrow p_j^M\left(e_j\right) \gtreqless 1-\alpha.\end{aligned} \tag{12}$$

Member i's signal improves his *ex post* internal reputation if his signal becomes more likely to be correct in the perception of member j. Two forces are at work. First, the more likely it is that j has received a correct signal, *i.e.*, the higher is p_j^M, the more important it is for i's internal reputation that his signal concurs with that of j. Second, the more likely it is *ex ante* that one of the states will realize, *i.e.*, the more α deviates from $\frac{1}{2}$, the more important it is for i's reputation that his signal concurs with the more likely state. If $\frac{1}{2} < \alpha < p_j^M$ or $\frac{1}{2} < 1-\alpha < p_j^M$, the first force dominates. Otherwise, the second force dominates.[18]

Using Lemma 3, we can now identify the conditions under which the incentive compatibility constraints for truth telling, (10) and (11), are satisfied. First, suppose that, as in section 3, $\alpha = 1/2$. This implies that the only force at work is that member i's message should concur with j's signal. This makes that i strictly prefers to tell the truth: both inequalities (10) and (11) hold with slack as can readily be checked by using Lemma 3.[19] Point A, with $\left(\alpha, p_j^M\right) = (1/2, p)$, in the left panel of Figure 1 illustrates such a parameter constellation.

An increase in α, the prior probability that the state equals $\mu = h$, strengthens i's reputation whenever he holds the view that points towards the positive state, $\hat{\pi}_i\left(s_i^g, s_j^b\right)$ and $\hat{\pi}_i\left(s_i^g, s_j^g\right)$, while it hurts his reputation if she holds the view that points towards the negative state, $\hat{\pi}_i\left(s_i^b, s_j^b\right)$ and $\hat{\pi}_i\left(s_i^b, s_j^g\right)$. Moreover, an increase in α increases both $\Pr\left(s_j^g|s_i^g\right)$ and $\Pr\left(s_j^g|s_i^b\right)$, while it reduces $\Pr\left(s_j^b|s_i^b\right)$ and $\Pr\left(s_j^b|s_i^g\right)$. The net effect on the truth telling conditions is as follows: com-

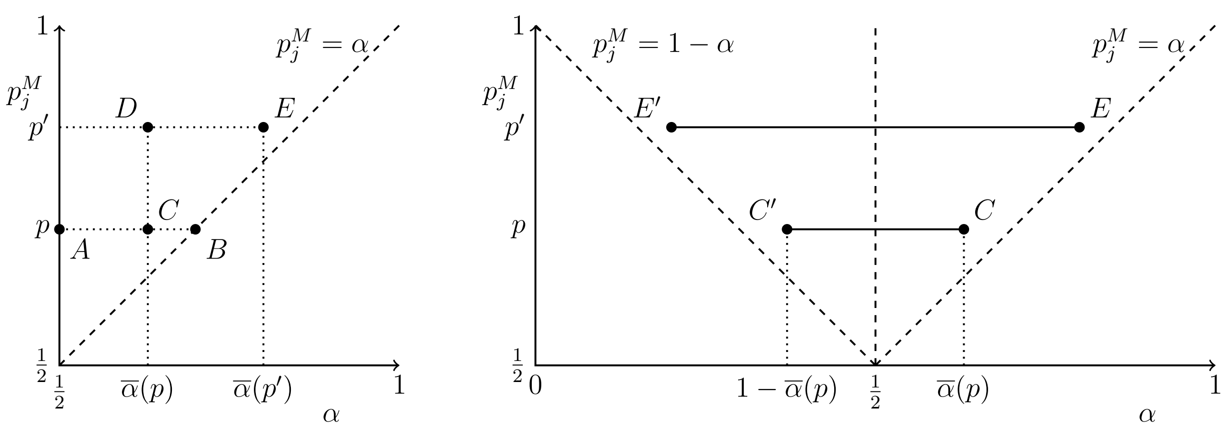
[18]Note that $\alpha \neq 1/2$ may make that conflicting signals command a higher reputation than concurring signals.
[19]Note that for $\alpha = 1/2$, $\Pr\left(s_j^g|s_i^g\right) - \Pr\left(s_j^b|s_i^g\right) = \Pr\left(s_j^b|s_i^b\right) - \Pr\left(s_j^g|s_i^b\right) = \left(2p_i^M - 1\right)\left(2p_j^M - 1\right) > 0$.

pared with $\alpha = 1/2$, the slack in (10) increases, while the slack in (11) goes down. In fact, it follows from Lemma 3 part (iii) that in point B in the left panel, where $\left(\alpha, p_j^M\right) = (p, p)$, $\left[\hat{\pi}_i\left(s_i^b, s_j^b\right) - \hat{\pi}_i\left(s_i^g, s_j^b\right)\right] = 0$. Thus, for any value of p, there is an $\bar{\alpha}(p) \in \left(\frac{1}{2}, p\right)$, such that for $\alpha = \bar{\alpha}(p)$, (11) holds with equality (point C in the left panel). If the positive state is even more likely, member i can't be induced to truthfully reveal his negative view. The truth telling condition for s_i^b fails to hold.

If, on the other hand, p_j^M increases, it becomes more important that i's message concur with j's signal. As a result, a move from C to D in the left panel creates slack in the incentive compatibility constraint for s_i^b. Thus, for values of $p_j^M = p' > p$, condition (11) holds with equality for a larger value of α, $\bar{\alpha}(p') > \bar{\alpha}(p)$. This is illustrated by point E.

The panel on the right shows for two values of p_j^M the values of α such that both (10) and (11) hold and member i truthfully reveals both signals. The next proposition summarizes the above discussion.

Figure 2: A graphical depiction of the truth telling.



Note: The left panel illustrates that for every value p of p_j^M there is an upperbound $\bar{\alpha}(p)$ on the value of α for which member i wants to reveal s_i^b. The right panel shows for two values of p_j^M the values of α for which i reveals both s_i^b and s_i^g.

Proposition 4 *Suppose that both members have exerted effort and only care about their internal reputations. A sufficient condition for member i to truthfully reveal his information is that α is close to a half. The more informative is j's signal, the more α may deviate from a half: $\alpha \in$*

$\left[1-\bar{\alpha}\left(p_j^M\right), \bar{\alpha}\left(p_j^M\right)\right]$, *with* $\bar{\alpha}\left(p_j^M\right) \in \left(\frac{1}{2}, p_j^M\right)$. $\bar{\alpha}\left(p_j^M\right)$ *is increasing in* p_j^M.

One can further show that in a large committee the conditions for truth telling are relaxed.

Proposition 5 *For a given level of individual effort* e*, truthtelling in a large committee is incentive compatible for a superset of parameters for which it is compatible in a two-member committee.*

4.2 The chicken decision-making process

When effort levels between members differ greatly, the weights attached to the resulting signals in the voting stage also differ greatly. In a chicken decision-making process, the signal of the member who leans back is ignored, while the signal of the member who does the heavy lifting is decisive. Assume for the sake of concreteness that member 2 leans back, that is $e_2^* < e_1^*$. As a result, members vote favorably if the signal of member 1 is positive and vote against if his signal is negative,

$$(v_1, v_2) = \begin{cases} (1,1) & \text{for } \left(s_1^g, s_2^g\right) \text{ and } \left(s_1^g, s_2^b\right) \\ (0,0) & \text{for } \left(s_1^b, s_2^g\right) \text{ and } \left(s_1^b, s_2^b\right). \end{cases} \tag{13}$$

We call a member's voting strategy in a chicken decision-making process a chicken voting strategy. The point of this section is to show that, although member 2's signal is ignored in the voting stage, it may still be useful to have her in the meeting. Thanks to her presence, member 1 acquires more information than in her absence because of his concern with his internal reputation. This improves the quality of the decision.

As member 2's signal is ignored, the decision on the project reveals member 1's signal. This makes external reputations independent of the decision and equal to the prior belief, π. External reputations no longer motivate members to acquire information. With his signal having no value in the voting stage and external reputations independent of the decision made, the only reason for member 2 to exert effort is his internal reputation. In a chicken process, the expected payoff to members 1 and 2 when choosing effort equals

$$\begin{aligned} \text{member 1} \quad &: \quad \Pr\left(s_1^g; e_{1D}\right)\left(k + \mathbb{E}[\mu | s_1^g; e_1]\right) + \gamma \mathbb{E}\left[\hat{\pi}_1^I\left(s_i, s_j; \mathbf{e}_C^*\right)\right] + \lambda\pi - c\left(e_1\right) && (14) \\ \text{member 2} \quad &: \quad \gamma \mathbb{E}\left[\hat{\pi}_2^I\left(s_i, s_j; \mathbf{e}_C^*\right)\right] + \lambda\pi - c\left(e_2\right), && (15) \end{aligned}$$

where $\mathbf{e}_C^*$ denotes the pair of equilibrium effort levels in a chicken process. Notice that the $\hat{\pi}^I$ carry member-subscripts as effort levels differ across members. The first-order conditions for optimality are

$$\begin{aligned} \text{member 1} \quad &: \quad h \frac{\partial p_1^M}{\partial e_1} + 2\gamma \frac{\partial p_1^M}{\partial e_1}\left(p_2^M\left(e_2\right) - \frac{1}{2}\right) \Delta \hat{\pi}_1^I\left(s_1, s_2; \mathbf{e}_C^*\right) = c'\left(e_1\right) && (16) \\ \text{member 2} \quad &: \quad 2\gamma \frac{\partial p_2^M}{\partial e_2}\left(p_1^M\left(e_1\right) - \frac{1}{2}\right) \Delta \hat{\pi}_2^I\left(s_1, s_2; \mathbf{e}_C^*\right) = c'\left(e_2\right). && (17) \end{aligned}$$

Compared with a joint decision-making process, member 1's signal now matters for the decision on the project *irrespective* of the signal of member 2, strengthening 1's incentives to exert effort. On the other hand, member 2's incentives to become informed become weaker as they now only stem from a desire to improve the chance of a strong internal reputation. The fact that member 2 now exerts less effort than in a joint decision-making process means that the pressure to become informed for internal reputation reasons becomes weaker for member 1. The net effect on member 1's incentives is ambiguous. Proposition 6 summarizes the discussion above.

Proposition 6 *In a **chicken decision-making process**,*

(1) external reputations do not provide incentives to become informed, whereas internal reputations do;

(2) a concern with internal reputations creates strategic complementarity among members' effort levels;

(3) member 2's incentives to become informed are weaker than in a joint decision-making process;

(4) member 1's incentives to become informed may be weaker or stronger than in a joint decision-making process.

We noted earlier that committees create audiences to members, and that the resulting concern with internal reputations gives incentives to become informed. This mechanism even works when the audience of member 1, here member 2, is not directly relevant for the final decision.

Propostition 7 provides the necessary and sufficient conditions for $\mathbf{e}_C^*$ and a chicken decision-making process to be part of an equilibrium.

Proposition 7 *Effort levels* $\mathbf{e}_C^*$ *and a chicken voting strategy are part of an equilibrium if and only if*

1. a positive signal of member 1 warrants implemention, even if member 2 received a negative signal, $k + \mathbb{E}\left[\mu | s_1^g, s_2^b; \mathbf{e}_C^*\right] \geq 0$*;*

2. a negative signal of member 1 makes the status quo the best decision, even if member 2 received a positive signal, $k + \mathbb{E}\left[\mu | s_1^b, s_2^g; \mathbf{e}_C^*\right] < 0$*;*

3. $\mathbf{e}_C^*$ *jointly satisfies (16) and (17);*

4. member 1 does not want to deviate to zero effort, $\frac{1}{2}\left(k + E\left[\mu | s_1^g, s_2; \mathbf{e}_C^*\right]\right) + \gamma\pi - c\left(e_{1C}^*\right) > \gamma\pi$*;*

5. member 2 does not want to deviate and exert more effort, $e_2 = e^{BR} > e_{2C}^*$*, such that her signal becomes decision relevant:*

$$\frac{1}{2}\left(k + \mathbb{E}[\mu | s^g, s_2; \mathbf{e}_C^*]\right) + \gamma\pi - c\left(e_{2C}^*\right) >$$

$$\Pr\left(s_1^g, s_2^g; e_{1C}^*, e^{BR}\right)\left(k + \mathbb{E}\left[\mu | s^g, s^g; e_{1C}^*, e^{BR}\right]\right) + \gamma\pi - c\left(e^{BR}\right),$$

with

$$e^{BR} = \arg\max_e \Pr\left(s_1^g, s_2^g; e_{1C}^*, e\right)\left(k + \mathbb{E}[\mu | s_1^g, s_2^g; e_{1C}^*, e]\right) + \gamma E\left[\hat{\pi}_2^I\left(s_1, s_2; e_{1C}^*, e^{BR}\right)\right] - c\left(e\right).$$

Notice that condition (5) assumes that at the start of the deliberation stage member 2 can claim that she chose e^{BR} rather than e_{2C}^*. This claim is credible as once members have acquired information, their interests are aligned.

Since the signal of one member is decisive, a concern with external reputations does not affect the conditions for the existence of a chicken decision-making process. An increase in the weight attached to internal reputations[20] stimulates information acquisition. This has consequences for all three conditions. It relaxes the first and makes the second more stringent. It also makes the third condition more restrictive. The latter consequence stems from the fact that internal reputation concerns increase members' efforts but, in expected terms, the extra efforts do not improve reputations.

The presence of a dominant member in combination with other members who continue to provide effort is reminiscent of a description of decision making at the Federal Open Market Committee, FOMC, when Alan Greenspan was the chairman of the Federal Reserve Board, the U.S. system of central banks. Laurence Meyer was appointed to serve on the Federal Reserve Board in 1996. Meyer (2004) writes about the dominant role of Greenspan in FOMC meetings. During his term as a Governor, neither Meyer nor many other members dissented from Greenman's policy proposals (see also Swank et al., 2008). Moreover, "I ended my term not sure I had ever influenced the outcome of an FOMC meeting" (p. 52). In spite of Greenspan's dominant role, in Meyer's view members came generally well prepared to the FOMC meetings.

5 Conclusion

In this paper, we have introduced reputations concerns into a committee context and have studied the resulting incentives to acquire decision-relevant information. As the state remains unobserved, there is neither conclusive evidence about the quality of a member's contribution to the deliberation preceding the voting, nor about the quality of the decision taken by the committee as a whole. Nevertheless, reputation concerns – both internal and external– motivate to exert effort. As a result, they counteract the underprovision of effort stemming from the public good nature of information.

The absence of conclusive evidence means that a member's internal reputation is based on deliberation patterns, in particular on a comparison between a member's expressed view and what other members think; members' external reputation is based on what outside observers infer

[20] This should be interpreted as an increase in the weight for both members.

from the observed decision about the degree of congruence among individual signals. As a result, reputation concerns create strategic complementarity among individual effort levels. This also implies that even if a member's assessment of the state is irrelevant for the decision, his presence in the meeting may be useful to make the *other* member exert more effort to assess the state. Internal reputations provide more incentives to become informed with any increase in the size of the committee. In marked contrast, external reputations vanish as a motivator in large committees.

6 References

Bar-Isaac, Heski, 2012, Transparency, Career Concerns, and Incentives for Acquiring Expertise, B.E. Journal of Theoretical Economics, 12(1), Article 4.

Blinder, Alan S., 2007, Monetary Policy by Committee: Why and How?, European Journal of Political Economy, 23(1), 106-123.

Cai, Hongbin, 2003, A Theory of Joint Asset Ownership, RAND Journal of Economics, 34(1), 63-77.

Dewatripont, Mathias, and **Jean Tirole**, 1999, Advocates, Journal of Political Economy, 107(1), 1-39.

Fama, Eugene F., 1980, Agency Problems and the Theory of the Firm, Journal of Political Economy, 88(2), 288-307.

Fehrler, Sebastian, and **Niall Hughes**, 2018, How Transparency Kills Information Aggregation: Theory and Experiment, American Economic Journal: Microeconomics, 10(1), 181-209.

Fehrler, Sebastian, and **Moritz Janas**, 2019, Delegation to a Group, unpublished paper, University of Konstanz.

Gabel, Matthew, and **Charles Shipan**, 2004, "A Social Choice Approach to Expert Consensus Panels," Journal of Health Economics, 23 , 543–546.

Geraats, Petra M., 2002, Central Bank Transparency, Economic Journal, 112(483), 532–565.

Gersbach, Hans, 1995, Information Efficiency and Majority Decisions, Social Choice and Welfare, 12(4), 363-370.

Gersbach, Hans and **Volker Hahn**, 2008, Should the Individual Voting Records of Central Bankers be Published?, Social Choice and Welfare, 30(4), 655-683.

Gersbach, Hans and **Volker Hahn**, 2012, Information Acquisition and Transparency in Committees, International Journal of Game Theory, 41(2), 427-453.

Hahn, Volker, 2017, Committee Design with Endogenous Participation, Games and Economic Behavior, 102, 388-408.

Hansen, Stephen, **Michael McMahon**, and **Andrea Prat**, 2018, Transparency and Deliberation Within the FOMC: A Computational Linguistics Approach, Quarterly Journal of Economics, 133(2), 801–870.

Holmström, Bengt, 1999, Managerial Incentive Problems: A Dynamic Perspective, Review of Economic Studies, 66(1), 169–182.

Iaryczower, Matias, **Garrett Lewis**, and **Matthew Shum**, 2013, To elect or to Appoint? Bias, Information, and Responsiveness of Bureaucrats and Politicians, Journal of Public Economics, 97(2), 230-244.

Kandel, Eugene and **Edward P. Lazear**, 1992, Peer Pressure and Partnerships, Journal of Political Economy 100(4), 801-817.

Kartik, Narvin, **Frances Xu Lee**, and **Wing Suen**, 2017, Investment in Concealable Information by Biased Experts, RAND Journal of Economics, 48(1), 24-43.

Levy, Gilat, 2007, Decision Making in Committees: Transparency, Reputation and Voting Rules, American Economic Review, 97(1), 150-168.

Li, Hao, and **Wing Suen**, 2009, Viewpoint: Decision-Making in Committees, Canadian Journal of Economics, 42(2), 359-392.

Malenko, Nadya, 2014, Communication and Decision-Making in Corporate Boards, Review of Financial Studies, 27 (5), 1486-1532.

Mattozzi, Andrea, and **Nakaguma, Marcos Y.**, 2017, Public Versus Secret Voting in Committees, working paper.

Meade, Ellen E., and **David Stasavage**, 2008, Publicity of Debate and the Incentive to Dissent: Evidence from the US Federal Reserve, Economic Journal 118(2), 695-717.

Meyer, Laurence H., 2004, A Term at the FED: An Insider's View. HarperCollins Publishers, New York.

Milbourn, Todd T., **Richard L. Shockley**, and **Anjan V. Thakor**, 2001, Managerial Career Concerns and Investments in Information, RAND Journal of Economics 32(2), 334-51.

Mueller, Dennis C., 1989, Public Choice II, Cambridge University Press, Cambridge.

Mukhopadhaya, Kaushik, 2003, Jury Size and the Free Rider Problem, Journal of Law, Economics, and Organization, 19(1), 24–44.

Persico, Nicola, 2004, Committee Design with Endogenous Information, Review of Economic Studies, 71(1), 165-91.

Scharfstein, David S., and **Jeremy C. Stein**, 1990, Herd Behavior and Investment, American Economic Review 80(3), 465-79.

Reis, Ricardo, 2013, Central Bank Design, Journal of Economic Perspectives, 27(4), 17-44.

Sibert, Anne, 2003,Monetary Policy Committees: Individual and Collective Reputations, Review of Economic Studies, 70(3), 649–665.

Suurmond, Guido, **Otto H. Swank**, and **Bauke Visser**, 2004, On the Bad Reputation of Reputational Concerns, Journal of Public Economics, 88(12), 2817–2838.

Swank, Job, **Otto H. Swank**, and **Bauke Visser**, 2008, How Committees of Experts Interact With the Outside World: Some Theory, and Evidence from the FOMC, Journal of the European Economic Association, 6(2-3), 478-486.

Swank, Otto H., and **Bauke Visser**, 2013, Is Transparency To No Avail?, Scandinavian Journal of Economics, 115(4), 967-994.

Visser, Bauke, and **Otto H. Swank**, 2007, On Committees of Experts, Quarterly Journal of Economics, 122(1), 337-372.

Appendix

A.1 Proofs

Proof of Lemma 1: Consider the general case $\Pr(\mu = h) = \alpha \in (0,1)$. In what follows we suppress the effort pair $\mathbf{e}$ in the expressions and write $p_i^{a_i}$ instead of $p^{a_i}(e_i)$ etc.

1. We use Bayes rule to obtain

$$\begin{aligned}
\hat{\pi}_i^I\left(s_i^g, s_j^g\right) &= \Pr\left(a_i = H | s_i^g, s_j^g\right) = \frac{\Pr\left(s_i^g, s_j^g | H\right)}{\Pr\left(s_i^g, s_j^g\right)} \Pr\left(a_i = H\right) \\
&= \frac{\Pr\left(s_i^g, s_j^g | H, \mu = h\right) \Pr(\mu = h) + \Pr\left(s_i^g, s_j^g | H, \mu = -h\right) \Pr(\mu = -h)}{\Pr\left(s_i^g, s_j^g | \mu = h\right) \Pr(\mu = h) + \Pr\left(s_i^g, s_j^g | \mu = -h\right) \Pr(\mu = -h)} \pi \\
&= \frac{p_i^H p_j^M \alpha + \left(1 - p_i^H\right)\left(1 - p_j^M\right)(1-\alpha)}{p_i^M p_j^M \alpha + \left(1 - p_i^M\right)\left(1 - p_j^M\right)(1-\alpha)} \pi. \qquad \text{(A.1)}
\end{aligned}$$

Similarly,

$$\begin{aligned}
\hat{\pi}_i^I\left(s_i^b, s_j^b\right) &= \frac{p_i^H p_j^M (1-\alpha) + \left(1 - p_i^H\right)\left(1 - p_j^M\right)\alpha}{p_i^M p_j^M (1-\alpha) + \left(1 - p_i^M\right)\left(1 - p_j^M\right)\alpha} \pi \\
\hat{\pi}_i^I\left(s_i^g, s_j^b\right) &= \frac{p_i^H \left(1 - p_j^M\right)\alpha + \left(1 - p_i^H\right) p_j^M (1-\alpha)}{p_i^M \left(1 - p_j^M\right)\alpha + \left(1 - p_i^M\right) p_j^M (1-\alpha)} \pi \qquad \text{(A.2)} \\
\hat{\pi}_i^I\left(s_i^b, s_j^g\right) &= \frac{p_i^H \left(1 - p_j^M\right)(1-\alpha) + \left(1 - p_i^H\right) p_j^M \alpha}{p_i^M \left(1 - p_j^M\right)(1-\alpha) + \left(1 - p_i^M\right) p_j^M \alpha} \pi.
\end{aligned}$$

It follows that

$$\begin{aligned}
\hat{\pi}_i^I\left(s_i^g, s_j^g\right) &\gtreqless \hat{\pi}_i^I\left(s_i^b, s_j^b\right) \Leftrightarrow \alpha \gtreqless 1/2 \\
\hat{\pi}_i^I\left(s_i^g, s_j^b\right) &\gtreqless \hat{\pi}_i^I\left(s_i^b, s_j^g\right) \Leftrightarrow \alpha \gtreqless 1/2 \\
\hat{\pi}_i^I\left(s_i^b, s_j^b\right) &\gtreqless \hat{\pi}_i^I\left(s_i^g, s_j^b\right) \Leftrightarrow p_j^M \gtreqless \alpha \qquad \text{(A.3)} \\
\hat{\pi}_i^I\left(s_i^g, s_j^g\right) &\gtreqless \hat{\pi}_i^I\left(s_i^b, s_j^g\right) \Leftrightarrow p_j^M \gtreqless 1 - \alpha.
\end{aligned}$$

For $\alpha = 1/2$, the equalities and inequalities in (2) follow.

2. The result follows from (A.2) and (A.3) for $e_i = e_j$ and $\alpha = 1/2$.

3. Concerning the change in value of $\hat{\pi}_i^I$ that is consistent with a change in value of e_j, note that $\partial \hat{\pi}_i^I(\cdot)/\partial e_j = \left(\partial \hat{\pi}_i^I(\cdot)/\partial p_j^M\right)\left(\partial p_j^M(\cdot)/\partial e_j\right)$ and $\partial p_j^M/\partial e_j > 0$. Thus, $sign\left(\partial \hat{\pi}_i^I(\cdot)/\partial e_j\right) = sign\left(\partial \hat{\pi}_i^I(\cdot)/\partial p_j^M\right)$. Straigthforward derivations show that for $s, s' \in \left\{s^g, s^b\right\}$ with $s \neq s'$,

$$\begin{aligned}
\frac{\partial \hat{\pi}_i^I(s,s)}{\partial p_j^M} &= \pi\alpha(1-\alpha)\frac{p_i^H - p_i^M}{\Pr(s,s)^2} > 0 \\
\frac{\partial \hat{\pi}_i^I(s',s)}{\partial p_j^M} &= \pi\alpha(\alpha-1)\frac{p_i^H - p_i^M}{\Pr(s',s)^2} < 0
\end{aligned}$$

for any α.

4. To establish the change in value of $\hat{\pi}_i^I$ that is consistent with a change in value of e_i, define $D(e_i) = \left(\frac{\partial p_i^H(e_i)}{\partial e_i} - \frac{\partial p_i^M(e_i)}{\partial e_i}\right)$ and $d(e_i) = \left(\frac{\partial p_i^H(e_i)}{\partial e_i}p_i^M(e_i) - \frac{\partial p_i^M(e_i)}{\partial e_i}p_i^H(e_i)\right)$. In what follows, we suppress the dependence of D and d on e_i. Then,

$$\begin{aligned}
\frac{\partial \hat{\pi}_i^I\left(s_i^g, s_j^g\right)}{\partial e_i} &= \frac{\left(p_j^M + \alpha - 1\right)\left(D(1-\alpha)\left(1-p_j^M\right) + d\left(p_j^M + \alpha - 1\right)\right)}{\Pr\left(s_i^g, s_j^g\right)^2} \\
\frac{\partial \hat{\pi}_i^I\left(s_i^b, s_j^b\right)}{\partial e_i} &= \frac{\left(p_j^M - \alpha\right)\left(D\alpha\left(1-p_j^M\right) + d\left(p_j^M - \alpha\right)\right)}{\Pr\left(s_i^b, s_j^b\right)^2} \\
\frac{\partial \hat{\pi}_i^I\left(s_i^g, s_j^b\right)}{\partial e_i} &= \frac{\left(\alpha - p_j^M\right)\left(D(1-\alpha)p_j^M + d\left(\alpha - p_j^M\right)\right)}{\Pr\left(s_i^g, s_j^b\right)^2} \\
\frac{\partial \hat{\pi}_i^I\left(s_i^b, s_j^g\right)}{\partial e_i} &= \frac{\left(1-\alpha-p_j^M\right)\left(D\alpha p_j^M + d\left(1-\alpha-p_j^M\right)\right)}{\Pr\left(s_i^b, s_j^g\right)^2}.
\end{aligned}$$

As $p_i^H > p_i^M$ for any e_i by construction of p_i^M, $D > d$ holds for any e_i. Moreover, if Assumption 1 holds, then $d \geq 0$ for any e_i. It follows that

$$\begin{aligned}
\text{if } p_j^M &> 1-\alpha, \text{ then } \frac{\partial \hat{\pi}_i^I\left(s_i^g, s_j^g\right)}{\partial e_i} > 0 \text{ and } \frac{\partial \hat{\pi}_i^I\left(s_i^b, s_j^g\right)}{\partial e_i} < 0; \\
\text{if } p_j^M &> \alpha, \text{ then } \frac{\partial \hat{\pi}_i^I\left(s_i^b, s_j^b\right)}{\partial e_i} > 0 \text{ and } \frac{\partial \hat{\pi}_i^I\left(s_i^g, s_j^b\right)}{\partial e_i} < 0.
\end{aligned}$$

Clearly, for $\alpha = 1/2$ both conditions are satisfied.■

Proof of Lemma 2: Consider the general case $\Pr(\mu = h) = \alpha \in (0,1)$.

1. Write

$$\hat{\pi}_i^E(1) = \frac{\Pr\left(s_i^g, s_j^g | H\right)}{\Pr\left(s_i^g, s_j^g\right)}\pi \text{ and } \hat{\pi}_i^E(0) = \frac{1 - \Pr\left(s_i^g, s_j^g | H\right)}{1 - \Pr\left(s_i^g, s_j^g\right)}\pi, \tag{A.4}$$

where we have suppressed reference to $\mathbf{e}$. $\hat{\pi}_i^E(1) > \hat{\pi}_i^E(0) \Leftrightarrow \Pr\left(s_i^g, s_j^g | H\right) > \Pr\left(s_i^g, s_j^g\right) \Leftrightarrow \left(p_j^M + \alpha - 1\right)\left(p_i^H - p_i^M\right) > 0$. It follows that for $\alpha = 1/2$, $\hat{\pi}_i^E(1) > \pi > \hat{\pi}_i^E(0)$ holds.

2. Notice that $\hat{\pi}_i^E(1) = \hat{\pi}_i^I\left(s_i^g, s_j^g\right)$. It then follows from point 2 in Lemma 1 that $\hat{\pi}_i^E(1; e, e) = \hat{\pi}_j^E(1; e, e)$. It is straightforward to show that $\hat{\pi}_i^E(0; e, e) = \hat{\pi}_j^E(0; e, e)$.

3. Concerning the change in value of $\hat{\pi}_i^E$ that is consistent with a change in value of e_j, note that $\partial\hat{\pi}_i^E(\cdot)/\partial e_j = \left(\partial\hat{\pi}_i^E(\cdot)/\partial p_j^M\right)\left(\partial p_j^M(\cdot)/\partial e_j\right)$ and $\partial p_j^M/\partial e_j > 0$. Thus, $sign\left(\partial\hat{\pi}_i^E(\cdot)/\partial e_j\right) = sign\left(\partial\hat{\pi}_i^E(\cdot)/\partial p_j^M\right)$. Note that $\partial\hat{\pi}_i^E(1)/\partial p_j^M = \partial\hat{\pi}_i^I\left(s_i^g, s_j^g\right)/\partial p_j^M$. It follows from Lemma 1 that if $p_j^M > 1 - \alpha$, then $\partial\hat{\pi}_i^E(1)/\partial e_j > 0$. This condition is satisfied for $\alpha = 1/2$. Moreover,

$$\frac{\partial\hat{\pi}_i^E(0)}{\partial p_j^M} = \left(-\alpha^2 + \alpha - 1\right)\frac{\left(p_i^H - p_i^M\right)}{\left(1 - \Pr\left(s_i^g, s_j^g\right)\right)^2}\pi < 0.$$

for all α and in particular for $\alpha = 1/2$.

4. Finally, note that

$$\frac{\partial\hat{\pi}_i^E(1)}{\partial e_i} = \frac{\partial\hat{\pi}_i^I\left(s_i^g, s_j^g\right)}{\partial e_i}$$

which is positive if $p_j^M > 1 - \alpha$, see Lemma 1 and so in particular for $\alpha = 1/2$. Furtermore,

$$\frac{\partial\hat{\pi}_i^E(0)}{\partial e_i} = \frac{\left(1 - \alpha - p_j^M\right)\left(D\left(p_j^M + \alpha - p_j^M\alpha\right) - d\left(p_j^M + \alpha - 1\right)\right)}{\left(1 - \Pr\left(s_i^g, s_j^g\right)\right)^2}.$$

Using again that $D > d \geq 0$, it follows that the derivative is negative if $p_j^M > 1 - \alpha$. This condition holds for $\alpha = 1/2$.■

Proof of Proposition 2: Suppose that $\mathbf{e}^*$ is a pair of equilibrium effort levels and the equilibrium voting strategy is a joint voting strategy. Then $\mathbf{e}^*$ and the voting strategy must satisfy conditions 1–3. This follows from our definition of equilibrium and a joint voting strategy. Suppose now instead that $\mathbf{e}^*$ and the voting strategy satisfy conditions 1–3. Then an individual's voting strategy is indeed a best reply and is a joint voting strategy. Moreover, e_i^* is a best reply. Thus $\mathbf{e}^*$ is a pair of equilibrium effort levels and the equilibrium voting strategy is a joint voting strategy. We conclude this proof with the derivation of (5). The *ex ante* expected project payoffs equal

$$\Pr\left(s_i^g, s_j^g; \mathbf{e}\right)\left(k + \mathbb{E}\left[\mu | s_i^g, s_j^g; \mathbf{e}\right]\right).$$

This can be rewritten as $\Pr\left(s_i^g, s_j^g\right) k + \frac{h}{2}\left(\Pr\left(s_i^g, s_j^g | h\right) - \Pr\left(s_i^g, s_j^g | -h\right)\right)$, where reference to e has been suppressed to save space. Moreover, $p\left(s_i^g, s_j^g\right) = \frac{1}{2} p_i^M p_j^M + \frac{1}{2}\left(1 - p_i^M\right)\left(1 - p_j^M\right)$, and so

$$\frac{\partial p\left(s_i^g, s_j^g\right)}{\partial e_i} = \frac{\partial p_i^M}{\partial e_i}\left(p_j^M - \frac{1}{2}\right).$$

As a result, the expected marginal increase in project value equals

$$\frac{\partial p_i^M}{\partial e_i}\left(\left(p_j^M - \frac{1}{2}\right) k + \frac{h}{2}\right).$$

Differentiating the expected utility of the external reputation $\lambda \mathbb{E}\left[\hat{\pi}_i^E\left(X; \mathbf{e}^*\right)\right]$ with respect to e_i yields

$$\lambda \frac{\partial p\left(s_i^g, s_j^g\right)}{\partial e_i}\left(\hat{\pi}^E\left(1; \mathbf{e}^*\right) - \hat{\pi}^E\left(0; \mathbf{e}^*\right)\right) = \lambda \frac{\partial p_i^M}{\partial e_i}\left(p_j^M - \frac{1}{2}\right) \Delta \hat{\pi}^E\left(X; \mathbf{e}^*\right).$$

Similarly, differentiating $\gamma \mathbb{E}\left[\hat{\pi}^I\left(s_i, s_j; \mathbf{e}^*\right)\right]$ with respect to e_i gives

$$\begin{aligned} &\gamma \frac{\partial \Pr\left(s_1^g, s_2^g\right)}{\partial e_i} \hat{\pi}_i^P\left(s_1^g, s_2^g; \mathbf{e}^*\right) + \gamma \frac{\partial \Pr\left(s_1^b, s_2^g\right)}{\partial e_i} \hat{\pi}_i^P\left(s_1^b, s_2^g; \mathbf{e}^*\right) + \\ &\gamma \frac{\partial \Pr\left(s_1^g, s_2^b\right)}{\partial e_i} \hat{\pi}_i^P\left(s_1^g, s_2^b; \mathbf{e}^*\right) + \gamma \frac{\partial \Pr\left(s_1^b, s_2^b\right)}{\partial e_i} \hat{\pi}_i^P\left(s_1^b, s_2^b; \mathbf{e}^*\right). \end{aligned} \tag{A.5}$$

Note that

$$\frac{\partial \Pr\left(s_1^g, s_2^g\right)}{\partial e_i} = -\frac{\partial \Pr\left(s_1^b, s_2^g\right)}{\partial e_i} \text{ and } \frac{\partial \Pr\left(s_1^g, s_2^b\right)}{\partial e_i} = -\frac{\partial \Pr\left(s_1^b, s_2^b\right)}{\partial e_i} \text{ for all } \mathbf{e}$$

and therefore (A.5) reduces to

$$\gamma\frac{\partial\Pr\left(s_1^g,s_2^g\right)}{\partial e_i}\left[\hat{\pi}^I\left(s_1^g,s_2^g;\mathbf{e}^*\right)-\hat{\pi}^I\left(s_1^b,s_2^g;\mathbf{e}^*\right)\right]+\gamma\frac{\partial\Pr\left(s_1^b,s_2^b\right)}{\partial e_i}\left[\hat{\pi}^I\left(s_1^b,s_2^b;\mathbf{e}^*\right)-\hat{\pi}^I\left(s_1^g,s_2^b;\mathbf{e}^*\right)\right]. \tag{A.6}$$

Finally, as $\hat{\pi}^I\left(s_1^g,s_2^g;\mathbf{e}^*\right)-\hat{\pi}^I\left(s_1^b,s_2^g;\mathbf{e}^*\right)=\hat{\pi}^I\left(s_1^b,s_2^b;\mathbf{e}^*\right)-\hat{\pi}^I\left(s_1^g,s_2^b;\mathbf{e}^*\right)$ for $\alpha=1/2$, see (A.1) and (A.2), this expression reduces to $2\gamma\frac{\partial p_i^M}{\partial e_i}\left(p_j^M\left(e_j\right)-\frac{1}{2}\right)\Delta\hat{\pi}^I\left(s_i,s_j;\mathbf{e}^*\right)$. Putting these three parts together gives (5).■

Proof of Proposition 3: We show here that the marginal benefits of exerting effort are higher in a large committee than in a two-person committee. The rest was shown in the text following the proposition. Assume a given effort level, the same for the $n=2$–case and $n\to\infty$–case. We suppress reference to this level in the expressions that follow. For $n=2$, the marginal benefits of e_i are

$$\frac{\partial\Pr\left(s_i^g,s_j^g\right)}{\partial e_i}\left[\hat{\pi}_i^I\left(s_i^g,s_j^g\right)-\hat{\pi}_i^I\left(s_i^b,s_j^g\right)\right]+\frac{\partial\Pr\left(s_i^b,s_j^b\right)}{\partial e_i}\left[\hat{\pi}_i^I\left(s_i^b,s_j^b\right)-\hat{\pi}_i^I\left(s_i^g,s_j^b\right)\right].$$

For $n\to\infty$, we invoke the Condorcet Jury Theorem, see the main text. Thus, if the majority of signals of i's fellow members is s^g, then we write i's internal reputation as $\hat{\pi}_i^I\left(s_i,h\right)$, while if the majority is s^b, we write $\hat{\pi}_i^I\left(s_i,-h\right)$. Notice that

$$\hat{\pi}_i^I\left(s_i^g,h\right)=\hat{\pi}_i^I\left(s_i^b,-h\right)=\frac{p_i^H}{p_i^M}\pi>\hat{\pi}_i^I\left(s_i^g,-h\right)=\hat{\pi}_i^I\left(s_i^b,h\right)=\frac{1-p_i^H}{1-p_i^M}\pi. \tag{A.7}$$

Thus, the marginal benefits of e_i equal

$$\begin{aligned}
&\frac{\partial\Pr\left(s_i^g,h\right)}{\partial e_i}\hat{\pi}_i^I\left(s_i^g,h\right)+\frac{\partial\Pr\left(s_i^g,-h\right)}{\partial e_i}\hat{\pi}_i^I\left(s_i^g,-h\right)+\\
&\frac{\partial\Pr\left(s_i^b,h;e\right)}{\partial e_i}\hat{\pi}_i^I\left(s_i^b,h\right)+\frac{\partial\Pr\left(s_i^b,-h;e\right)}{\partial e_i}\hat{\pi}_i^I\left(s_i^b,-h\right)\\
=&\left(\frac{\partial\Pr\left(s_i^g,h\right)}{\partial e_i}+\frac{\partial\Pr\left(s_i^b,-h\right)}{\partial e_i}\right)\left[\hat{\pi}_i^I\left(s_i^g,h\right)-\hat{\pi}_i^I\left(s_i^b,h\right)\right].
\end{aligned}$$

It can be checked using Eq. (A.7), (A.2) and (A.3) that $\hat{\pi}_i^I\left(s_i^g,h\right)>\max\left\{\hat{\pi}_i^I\left(s_i^g,s_j^g\right),\hat{\pi}_i^I\left(s_i^b,s_j^b\right)\right\}$

and $\hat{\pi}_i^I\left(s_i^b, h\right) < \min\left\{\hat{\pi}_i^I\left(s_i^b, s_j^g\right), \hat{\pi}_i^I\left(s_i^g, s_j^b\right)\right\}$ for any α. This implies that, for the same effort levels, the internal reputation premiums are larger in the large committee than in the 2-person committee. Furthermore,

$$\begin{aligned}
\frac{\partial \Pr\left(s_i^g, h\right)}{\partial e_i} &= \frac{\partial p_i^M}{\partial e_i}\alpha > \frac{\partial p_i^M}{\partial e_i}\left(p_j^M + \alpha - 1\right) = \frac{\partial \Pr\left(s_i^g, s_j^g\right)}{\partial e_i} \\
\frac{\partial \Pr\left(s_i^b, -h\right)}{\partial e_i} &= \frac{\partial p_i^M}{\partial e_i}(1-\alpha) > \frac{\partial p_i^M}{\partial e_i}\left(p_j^M - \alpha\right) = \frac{\partial \Pr\left(s_i^b, s_j^b\right)}{\partial e_i}.
\end{aligned}$$

As a result, the marginal benefits are larger in a large committee for the same level of effort.■

Proof of Lemma 3: This was shown in the proof of Lemma 1.■

Proof of Proposition 5: For $n \to \infty$, the truth telling conditions for s_i^g and s_i^b are

$$\begin{aligned}
\Pr\left(h|s_i^g\right)\left[\hat{\pi}_i^I\left(s_i^g, h\right) - \hat{\pi}_i^I\left(s_i^b, h\right)\right] &\geq \Pr\left(-h|s_i^g\right)\left[\hat{\pi}_i^I\left(s_i^b, -h\right) - \hat{\pi}_i^I\left(s_i^g, -h\right)\right] \\
\Pr\left(-h|s_i^b\right)\left[\hat{\pi}_i^I\left(s_i^b, -h\right) - \hat{\pi}_i^I\left(s_i^g, -h\right)\right] &\geq \Pr\left(h|s_i^b\right)\left[\hat{\pi}_i^I\left(s_i^g, h\right) - \hat{\pi}_i^I\left(s_i^b, h\right)\right]
\end{aligned}$$

respectively, where we have suppressed reference to $\mathbf{e}$. The internal reputation terms are defined in (A.7). These inequalities reduce to $1-\alpha \leq p_i^M$ and $\alpha \leq p_i^M$, respectively. A comparison with the inequalities in section 4.1 shows that, for the same levels of effort e, truthtelling in a large committee is incentive compatible for a superset of parameters for which it is compatible in a two-member committee: the two diagonally sloped, dashed lines in Figure 2 are precisely $p_i^M = \alpha$ and $p_i^M = 1-\alpha$.■

Proof of Proposition 7: Suppose that $\mathbf{e}_C^*$ is a pair of equilibrium effort levels and the equilibrium voting strategy is a chicken voting strategy. Then $\mathbf{e}^*$ and the voting strategy must satisfy conditions 1–5. This follows from our definition of equilibrium and a chicken voting strategy. Suppose now instead that $\mathbf{e}_C^*$ and the voting strategy satisfy conditions 1–5. Then an individual's voting strategy is indeed a best reply and is a chicken voting strategy. Moreover, e_{iC}^* is a best reply. Thus $\mathbf{e}_C^*$ is a pair of equilibrium effort levels and the equilibrium voting strategy is a chicken voting strategy.

A.2 Mixed decision-making process

It follows from Proposition 2, condition 1, that for $\lambda > -k/\Delta\hat{\pi}^E(X; \mathbf{e}^*)$, a joint decision-making process cannot be part of an equilibrium. To boost their external reputations, members have incentives to choose $X = 1$ even if they received conflicting signals. However, an equilibrium in which the project is implemented with probability one in case of conflicting signals does not exist either. To see this, assume it does. Then, $X = 0$ would command a higher external reputation than $X = 1$ as the public market would deduce from $X = 0$ that members received the same (negative) signals, while $X = 1$ could now result from conflicting signals. But if members were then to receive conflicting signals, both members would prefer to deviate from the hypothesized equilibrium strategy and maintain the status quo as this decision would both command a higher external reputation and avoid the expected loss following from project implementation.

A mixed strategy equilibrium in which the committee chooses $X = 1$ with a positive probability less than one in case of conflicting signals does exist. In the context of identical agents, such equilibria can be of two types. In the first type, conditional on a pair of conflicting signals, both members follow a mixed strategy. This type is, however, knife-edge as it does not survive the slightest heterogeneity among members. Heterogeneous members cannot both be indifferent between $X = 1$ and $X = 0$ conditional on a given pair of signals. In the second type, one member mixes while the other member plays a pure strategy. This type of equilibrium continues to exist with heterogeneous members and will therefore be used to characterize behavior.

With homogenous members who exert the same level of effort, $E\left[\mu|s_1^g, s_2^b; e, e\right] = E\left[\mu|s_1^b, s_2^g; e, e\right]$ holds. As a result, a homogenous committee has two possibilities to implement the project in case of conflicting signals. First, it can decide to implement the project with positive probabilities for *both* signal pairs. Second, the committee implements the project with positive probability for only one of these signal pairs, while for the other pair it maintains the status quo. The first possibility is knife-edge and would not survive the slightest heterogeneity among members. With heterogeneous members, $e_1^* \neq e_2^*$ holds, and the conditional expected values would differ, say, $E\left[\mu|s_1^g, s_2^b; \mathbf{e}^*\right] > E\left[\mu|s_1^b, s_2^g; \mathbf{e}^*\right]$. As a result, the committee would choose $X = 1$ with positive probability for $\left(s_1^g, s_2^b\right)$, and choose $X = 0$ for sure for $\left(s_1^b, s_2^g\right)$. This is precisely the second possibility. We therefore use it to characterize behavior. We assume that the committee chooses $X = 1$ with positive probability for $\left(s_1^g, s_2^b\right)$, and chooses $X = 0$ for $\left(s_1^b, s_2^g\right)$. As a bad signal of member 2 is no longer a reason to choose $X = 0$ for sure, while member 1's signal becomes more useful, members' incentives to exert effort diverge, $e_1 > e_2$.

We thus arrive at two asymmetries between the members to ensure equilibrium behavior that is qualitatively the same as in the heterogeneous members' case: (i) $\left(s_1^g, s_2^b\right)$ makes one member vote in favor with probability one and the other member vote in favor with probability β and (ii) $\left(s_1^g, s_2^b\right)$ leads to implementation with probability $\beta > 0$, while $\left(s_1^b, s_2^g\right)$ leads to the status quo for sure. Only the second asymmetry causes differences in the incentive to exert effort.

Let $\mathbf{e}_M^* = (e_{1M}^*, e_{2M}^*)$ be the equilibrium level of effort, with $e_{1M}^* > e_{2M}^*$. Since effort levels differ, both external and internal reputations differ across members. As a result, the member with the higher external reputation premium is the one who votes for $X = 1$ with probability one in case of $\left(s_1^g, s_2^b\right)$, while the other member votes for $X = 1$ with probability $\beta^* \in (0, 1)$. Assume, again for definitiness-sake, that $\hat{\pi}_1^E (X; \mathbf{e}_M^*, \beta^*) > \hat{\pi}_2^E (X; \mathbf{e}_M^*, \beta^*)$ such that

$$k + \mathbb{E}\left[\mu | s_1^g, s_2^b; \mathbf{e}_M^*\right] + \lambda \Delta \hat{\pi}_2^E (X; \mathbf{e}_M^*, \beta^*) = 0 \tag{A.8}$$

must hold for member 2 to mix in the voting stage conditional on the committee having received $\left(s_1^g, s_2^b\right)$. Thus, we characterize an equilibrium in which the committee chooses $X = 1$ with probability β for $\left(s_1^g, s_2^b\right)$

$$(v_1, v_2) = \begin{cases} (1, 1) & \text{for } \left(s_1^g, s_2^g\right) \\ (1, \beta^*) & \text{for } \left(s_1^g, s_2^b\right) \\ (0, 0) & \text{for } \left(s_1^b, s_2^g\right) \text{ and } \left(s_1^b, s_2^b\right), \end{cases} \tag{A.9}$$

with $\beta^* \in (0, 1)$. As $\beta^* < 1$, parameter values must be such that $k + \mathbb{E}\left[\mu | s_1^g, s_2^b; \mathbf{e}_M^*\right] < 0$. That is, effort levels should not diverge so much that the quality of member 1's good signal overwhelms the quality of member 2's bad signal (as in the chicken decision-making process in section 4.2). When choosing effort, member i's expected payoff equals

$$
\begin{aligned}
& p\left(s_i^g, s_j^g; \mathbf{e}\right)\left(k+\mathbb{E}\left[\mu | s_i^g, s_j^g; \mathbf{e}\right]\right)+\beta p\left(s_1^g, s_2^b; \mathbf{e}\right)\left(k+\mathbb{E}\left[\mu | s_1^g, s_2^b; \mathbf{e}\right]\right) \\
& +\gamma \mathbb{E}\left[\hat{\pi}_i^I\left(s_i, s_j; \mathbf{e}_M^*\right)\right]+\lambda \mathbb{E}\left[\hat{\pi}_i^E\left(X; \mathbf{e}_M^*, \beta^*\right)\right]-c\left(e_i\right).
\end{aligned}
$$

The derivative of this expression with respect to e_i becomes

$$
\begin{aligned}
& \frac{\partial p_i^M}{\partial e_i}\left(\left(p_j^M\left(e_j\right)-\frac{1}{2}\right)\left(1+\beta^*\right) k+\frac{h}{2}\left(1-\beta^*+2 \beta^* I_1(i)\right)\right) \\
& +2 \gamma \frac{\partial p_i^M}{\partial e_i}\left(p_j^M\left(e_j\right)-\frac{1}{2}\right) \Delta \hat{\pi}_i^I\left(s_i, s_j; \mathbf{e}_M^*\right) \\
& +\lambda \frac{\partial p_i^M}{\partial e_i}\left(p_j^M\left(e_j\right)-\frac{1}{2}\right)\left(1+\beta^*\right) \Delta \hat{\pi}_i^E\left(X; \mathbf{e}_M^*, \beta^*\right) \\
= \; & c^{\prime}\left(e_i\right) \text { for } i=1,2,
\end{aligned} \tag{A.10}
$$

where $I_1(i)$ is an indicator function such that $I_1(i)=1$ if $i=1$ and $I_1(i)=0$ if $i=2$. The above discussion can be summarized as follows.

Proposition A.1 *For $\lambda > -k/\Delta\hat{\pi}^E(X;\mathbf{e}^*)$, a mixed decision-making process is characterized by voting strategies (A.9) and mixing probability and effort levels that are determined by (A.8) and (A.10).*