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 his reputation for expertise. The state remains unobserved. In such environments, members' internal reputations are based on deliberation patterns, while members' external reputations are based on the observed group decision. We find that either form of reputation concerns creates strategic complementarity among members' effort levels. Internal reputations create stronger incentives to become informed than external reputations. Their strength grows in committee size; external reputations create no incentives in large committees. Finally, reputation concerns may relax participation constraints.

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

JEL codes: D71, D83

1. INTRODUCTION

Important decisions in the public sector are often made by teams or committees: health care consensus panels work out treatment protocols, monetary policy committees determine the overnight interbank interest rate target and teams of specialists in departments, ministries and agencies decide on the technicalities of public policy.

A well-known advantage of committee decision making is that two heads know more than one. A notorious downside is the scope for free-riding stemming from the public good character of information. Downs (1957) used this way of reasoning to argue that rational voters choose to be ignorant at large elections. Mukhopadhaya (2003) shows that this free-rider problem provides a rationale for small committees.

The members of many committees are experts for whom a reputation for being well-informed among one's fellow members in the committee, members' internal reputations, and in the eyes of the public or the market, members' external reputations, is a valuable asset. Committees of experts often

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operate in environments in which the consequences of the decisions made are often only fully experienced in the long run.[1] As a result, career-related decisions—retention, promotion etc.— cannot be based on a comparison of decision and state.[2]

This paper investigates how committee members' concerns with their internal and external reputations affect their incentives to acquire information and participate in committees when their reputations cannot be based on a comparison with the realized state. Our first results deal with internal reputations. We show that members who care about their internal reputations acquire more information, the larger the committee is. Moreover, members' effort levels are strategic complements. These results stand in sharp contrast to the consequences for the effort that would stem from a sole concern with the decision payoff. With decision-relevant information being a public good, an increase in group size would reduce individual effort levels. Members' information collection efforts would be strategic substitutes.

The second set of results deals with external reputations. External reputations also make members' effort levels strategic complements. However, they motivate less than internal reputations. Moreover, external reputations loose their power to motivate members to acquire information in large committees.

Reputations are updated beliefs about a member's ability. In equilibrium, these beliefs are obtained using Bayes' rule. As a result, the expected ex post reputation, internal and external, is equal to the prior belief that a member is smart—Bayesian beliefs from a martingale. This implies that acquiring information to improve one's expected reputation is to no avail. How, then, do reputation concerns affect a member's willingness to participate in the committee? In the absence of reputation concerns, free riding causes each member to acquire less information than is efficient. Reputation concerns raise the marginal benefits from acquiring information. As long as the weights that members put on their internal and external reputations are not too high, reputation concerns move acquisition levels closer to their efficient levels, relaxing the participation constraint.

We obtain our results in a model of committees in which 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 less competent member (or of two less competent members). Larger committees allow a fellow member to make sharper comparisons. As a result, the marginal benefits from acquiring information are larger. Hence the committees as *audiences* in the title: the larger committees are, the more prepared one wishes to be. On the other hand, external reputations are

[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."

[2] Internal and external reputation concerns may stem from members' ambitions within their organizations or outside their organizations.

based on the decision that the committee as a whole makes. In a large committee, the chance that a member's signal is pivotal in the decision goes to zero. As a result, the market loses its motivating power in large committees.

The rest of the paper is organized as follows. We discuss the related literature in the next section. We present the model in section 3. In section 4, we analyse symmetric equilibria in which reputation concerns do not lead to distorted decisions on the project. This allows us to focus on the consequences of reputation concerns on information acquisition. Section 5 studies the effect of group size on the incentives that reputation concerns generate to collect information. Proofs can be found in Appendix A; Appendix B studies an asymmetric equilibria in which members contribute unequally to the acquisition of information. Appendix C deals with equilibria in which reputation concerns do lead to distorted decisions on the project.

2. Related Literature

Our paper is related to various literatures.

Career concerns and effort. Holmström (1999), Milbourn, Shockley and Thakor (2001), Suurmond, Swank and Visser (2004) and Bar-Isaac (2012), among others, show that a reputation-concerned agent exerts costly effort and makes decisions to influence a principal's inferences about his ability. Such behavior may conflict with maximizing value for the principal. These papers study single-agent decision making. Of these papers, only Suurmond et al. (2004) consider effort to become informed about the underlying state, like we do. Given the absence of a second agent, attention is limited to an agent's external reputation (*i.e.*, in the eyes of a principal).

Like us, Bar-Isaac and Deb (2014) consider reputation formation with two different audiences. Different from us, they consider a single agent and audiences whose preferences over agent's actions are opposing. They show that if both actions are commonly observed by the audiences the agent benefits from reputation concerns; the opposite holds if audiences observe actions separately.

Like us, Gersbach and Hahn (2012) and Fehrler and Janas (forthcoming) study committees, but the questions that they ask and the informational environments that they use are different. Gersbach and Hahn (2012) studies the effect of the publication of members' votes on the quality of decision making in a two-period model. Fehrler and Janas (forthcoming) study how a principal's choice to approach experts individually for advice rather than ask for their collective advice affects information acquisition and information aggregation. In both papers, members are concerned with their reputation in the eyes of the principal only and the principal can observe the state before determining her belief about the members' competence. The principal's possibility to compare the true state with a member's vote or advice gives a member strong incentives to acquire information; it also makes a member's choice of effort independent of another member's choice. In our model, neither principal nor committee members know the state at the moment that they update their beliefs about a member's competence. As a result, an individual's internal reputation is based on the extent to which his signal concurs with those of his fellow members, whereas the external reputation is based on the degree of agreement that the principal *infers* from the group's decision. This implies, in turn, that either form of reputation concerns creates strategic complementarity between individual information acquisition efforts.[3]

Both internal and external concerns 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, as part of a team, concerned with the information generated about their decision-making ability in the internal and external labor market, like the experts that we study. Holmström (1999), originally published in 1982, was written in an attempt to understand Fama's claim about career concerns. Holmström studies a single-agent setting. Our paper appears to be the first to capture both the presence of management teams and the role played by both the internal and external labor market in providing incentives in Fama's paper. Our analysis suggests that career concerns thanks to internal labor markets provide stronger incentives to prepare a decision than the external labor market.

Committee design and information acquisition Decision-relevant information is a public good. As individual members don't take into account the positive externalities of their information acquisition decisions, it is underprovided.[4] This literature studies the optimal provision of incentives to acquire information by comparing various design alternatives. Mukhopadhaya (2003) and Cai (2003) study the role played by group size. Li (2001), Persico (2004) and Gerardi and Yariv (2008), among others, analyse how voting rules affect incentives to acquire information. Dewatripont and Tirole (1999) and Kartik, Lee and Suen (2017) study information acquisition and concealment by advocates with conflicting interests. Gershkov and Szentes (2009) derive the optimal decision-making process when members can acquire information simultaneously or sequentially and in a fixed or random order. Although we also investigate a feature of the decision-making process, group size, our main interest is in the consequences for information acquisition of member preferences that naturally arise in a group.[5]

Group decisions and information acquisition over time In a dynamic context, when information can be acquired over time, moral hazard, besides leading to free-riding, also leads to procrastination and delay (Bonatti and Hörner, 2011; Campbell, Ederer and Spinnewijn, 2014). Strulovici (2010) shows that, when the payoffs of a risky action can only be learned by experimenting with that action for a period of time, groups with heterogeneous members who collectively decide whether to experiment do so too little. This is not because of free riding, but because of the sharing of control. As a result, losers may get trapped if a majority finds out to benefit from the risky action. Vice versa,

[3]Visser and Swank (2007) study a committee of experts who care about project value and their external reputation. Like in the current paper, the market does not observe the state. Different from the current paper, private signals are exogenously given and the focus is on information manipulation and distortions due to heterogeneity of preferences.

[4]Gersbach (1995) is among the first to study the underprovision of information in committees.

[5]Clearly, members' preferences can be influenced by an organizational designer through, *e.g.*, selection and personnel policies. That is, members' preferences are to some degree a design variable. 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.

winners may remain frustrated if a majority were to decide to revert to the safe action. Either possibility makes experimentation, and thus information acquisition, less attractive. A similar inefficiency arises in models of collective search, *e.g.*, in Albrecht, Anderson and Vroman (2010). In our model, the sharing of control induces both free riding and, through a concern with internal reputations, pressures to acquire information that are growing in the size of the committee.

3. A MODEL OF COMMITTEE DECISION MAKING WITH INTERNAL AND EXTERNAL REPUTATION CONCERNS

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 $\Pr(\mu = h) = \frac{1}{2}$.[6] 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 consists of three stages.

1. Information acquisition stage. In this stage, each member privately 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

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

for $a_i \in \{L, H\}$. For $a_i \in \{L, H\}$, $p^{a_i}(\cdot)$ is an increasing, strictly concave function with $p^{a_i}(0) \geq 1/2$, $p^{a_i\prime}(0) = \infty$, $\lim_{e_i \to \infty} p^{a_i}(e_i) \leq 1$, and $\lim_{e_i \to \infty} p^{a_i\prime}(e_i) = 0$.

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 $\Pr(a_i = H) = \pi$.[7] Define the *ex ante* likelihood that a signal is correct as

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

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.

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

[7] 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).

2. Deliberation stage. In this stage, members simultaneously send a message to the other member. We focus on situations in which private information is truthfully revealed, for example because committee members have the knowledge and the time to ask probing questions to verify claims made in the meeting.[8]

3. Voting stage. In this 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 $v_i(s_i, s_j, e_i) = \Pr(v_i = v^1 \mid s_i, s_j, e_i)$ of i equals the probability that i votes v^1 in information set (s_i, s_j, e_i). 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 effort levels, nor their deliberation and voting, nor the state of the world. Let $\hat{\pi}_i^E(X) = \Pr(a_i = H \mid X)$ denote i's external reputation, conditional on 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, but neither member observes the state.[9] Let $\hat{\pi}_i^I(s_i, s_j) = \Pr(a_i = H \mid s_i, s_j)$ denote i's internal reputation if his fellow member observes the signal pair (s_i, s_j). 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

$$X \cdot (k + \mu) + \gamma \hat{\pi}_i^I(s_i, s_j) + \lambda \hat{\pi}_i^E(X) - c(e_i). \tag{1}$$

The parameters γ and λ are the weights that members attach to their internal 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;

[8]As we note in the conclusion, truthful revelation is in fact part of an equilibrium in this model. See Visser and Swank (2007) for a discussion of the incentives to misrepresent information in committees of experts.

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

(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. Whenever they exist, we focus on weakly dominant voting strategies;

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

4. Analysis

4.1. **Voting.** When casting their votes, members have exchanged information. Member i knows s_1, s_2 and e_i. Based on s_1, s_2, and conjectured effort levels, both members have formed beliefs about each others' abilities. Consequently, members' internal reputations are determined before the voting stage and do not affect members' vote decisions.

For every information set (s_i, s_j, e_i) of member i, let $\Delta U_i(s_i, s_j, e_i)$ denote the difference in expected payoffs that i experiences from the committee implementing the project and rejecting it,

$$\Delta U_i(s_i, s_j, e_i) = k + \mathbb{E}\left[\mu \mid s_i, s_j, e_i\right] + \lambda \Delta \hat{\pi}_i^E \tag{2}$$

$$\text{where } \Delta \hat{\pi}_i^E = \hat{\pi}_i^E(1) - \hat{\pi}_i^E(0). \tag{3}$$

We refer to $\Delta \hat{\pi}_i^E$ as i's **external reputation gap**. It equals the difference in member i's external reputation from the committee implementing or rejecting the project.

Consider the following voting strategy of member i:

$$v_i^*(s_i, s_j, e_i) = \begin{cases} 1 & \text{if } \Delta U_i(s_i, s_j, e_i) > 0 \\ \beta_i & \text{if } \Delta U_i(s_i, s_j, e_i) = 0 \\ 0 & \text{if } \Delta U_i(s_i, s_j, e_i) < 0, \end{cases} \tag{4}$$

with $\beta_i \in [0, 1]$. This voting strategy ensures that if i's vote changes the decision, he votes in favor of the decision that gives him the larger payoff. If he is indifferent between either decision, he can vote in favor with any probability. That is, it is a weakly dominant voting strategy. It is the equilibrium voting strategy that we employ in the paper. The asterisk indicates that the voting strategy is an equilibrium strategy. We denote the pair of equilibrium strategies by $\mathbf{v}^*$.

We organize the rest of the analysis as follows. In the main body of the paper we focus on symmetric equilibria. We discuss asymmetric equilibria in Appendix B. In a symmetric equilibrium, $e_i = e_j = e^*$, and the expected project value conditional on conflicting signals is negative, $k + \mathbb{E}[\mu \mid s^g, s^b, e^*] = k < 0$. From a project-value perspective, a member should then vote against project implementation. In the main body of the paper we study equilibria in which in case of conflicting signals members indeed vote against implementation. In Appendix C we discuss equilibria in which members vote for project implementation with positive probability in case of conflicting signals. Thus, in the main body of the paper we focus on symmetric equilibria in which, on the equilibrium path:

- a member votes against implementation when the committee has received conflicting signals:

$$k + \lambda \Delta \hat{\pi}_i^E < 0; \tag{5}$$

- a member votes for implementation when the committee has received two positive signals (as otherwise the project would never be implemented):

$$k + \mathbb{E}[\mu \mid s^g, s^g, e^*] + \lambda \Delta \hat{\pi}_i^E > 0. \tag{6}$$

We denote the resulting voting strategy (4) on the equilibrium path (EP) by v_i^{EP}:

$$v_i^{EP}\left(s_i, s_j, e^*\right) = \begin{cases} 1 & \text{if } \left(s_i, s_j\right) = \left(s^g, s^g\right) \\ 0 & \text{if } \left(s_i, s_j\right) \in \left\{\left(s^g, s^b\right), \left(s^b, s^g\right), \left(s^b, s^b\right)\right\}. \end{cases} \tag{7}$$

Let $\mathbf{v}^{EP}$ denote the pair of such voting strategies.

4.2. **Information Acquisition.** In the information acquisition stage, member i chooses e_i so as to maximize his expected payoff, given voting strategies (7), given his conjecture of effort exerted by j, denoted by $\hat{e}_j$, and given his internal and external reputations .

With the project implemented only when the committee receives two positive signals, see (7), the expected payoff to member i when choosing effort e_i equals

$$\begin{aligned} & \Pr\left(s_i^g, s_j^g; e_i, \hat{e}_j\right)\left(k + \mathbb{E}\left[\mu \mid s_i^g, s_j^g, e_i, \hat{e}_j\right]\right) - c\left(e_i\right) \\ & + \gamma \sum_{\left(s_i, s_j\right)} \Pr\left(s_i, s_j; e_i, \hat{e}_j\right) \hat{\pi}_i^I\left(s_i, s_j\right) \\ & + \lambda \sum_X \Pr\left(X; e_i, \hat{e}_j\right) \hat{\pi}_i^E\left(X\right). \end{aligned} \tag{8}$$

As a result, the marginal benefits from exerting effort equal[10]

$$\begin{aligned} MB_i\left(e_i, \hat{e}_j\right) = & \frac{\partial p_i^M}{\partial e_i}\left(\left(p_j^M\left(\hat{e}_j\right) - \frac{1}{2}\right) k + \frac{h}{2}\right) \\ & + 2\gamma \frac{\partial p_i^M}{\partial e_i}\left(p_j^M\left(\hat{e}_j\right) - \frac{1}{2}\right) \Delta \hat{\pi}_i^I\left(s_i, s_j\right) \\ & + \lambda \frac{\partial p_i^M}{\partial e_i}\left(p_j^M\left(\hat{e}_j\right) - \frac{1}{2}\right) \Delta \hat{\pi}_i^E\left(X\right). \end{aligned} \tag{9}$$

We call $\Delta \hat{\pi}_i^I\left(s_i, s_j\right) = \hat{\pi}_i^I\left(s, s\right) - \hat{\pi}_i^I\left(s', s\right)$, with $s, s' \in \left\{s^g, s^b\right\}$ and $s \neq s'$, i's **internal reputation gap**. It captures the difference in member i's internal reputation from holding the same view as j about the state rather than a conflicting view. Member i's best reply is determined by equating his marginal benefits in (9) to $C'\left(e_i\right)$. The first line of (9) represents the marginal benefits of effort from the project perspective. It shows the well-known result that the marginal benefit of e_i decreases in $\hat{e}_j$ (recall that $p_j^M\left(\hat{e}_j\right) > \frac{1}{2}$ and $k < 0$). The second and third lines show that whether reputation

[10] For the derivation, see the proof of Proposition 1.

concerns strengthen or weaken incentives to exert effort depends on the sign of the reputation gaps. In the next section, we study the reputation gaps in more detail.

4.3. **Internal and External Reputations.** Member i's internal reputation is defined as j's belief that i is of high ability. That belief depends on the observed signal pair (s_i, s_j), on j's own effort e_j and on j's conjecture about i's effort. We write $\hat{\pi}_i^I\left(s_i, s_j; \hat{e}_i, e_j\right)$ to denote i's internal reputation consistent with (s_i, s_j) and $(\hat{e}_i, e_j)$.

Lemma 1 (Internal reputation gap)**.** *Consider internal reputations of member i consistent with $(\hat{e}_i, e_j)$. The internal reputation gap is (i) positive and (ii) increasing in e_j.*

As the signals of high ability members are correlated more strongly than those of low ability members, holding the same view as a fellow member raises one's internal reputation above the prior belief π_i, while holding a conflicting view lowers it below that level; a positive internal reputation gap follows. Moreover, the better informed j is, the more probable it becomes that j holds the correct view. This raises the internal reputation from agreeing with j and reduces the reputation from differing from her. As a result, the internal reputation gap of i increases in e_j.

Member i's external reputation is defined as the market's belief that i is of high ability. That belief depends on the committee's decision that the market observes and on the market's conjecture of members' effort levels and voting strategies. Let $\bar{e}_i$ denote the market's conjecture of e_i and write $\bar{\mathbf{e}} = (\bar{e}_i, \bar{e}_j)$ for the pair of conjectured effort levels. Throughout this section we assume that the market conjectures that voting on the equilibrium path satisfies (7). We write $\hat{\pi}_i^E\left(X; \bar{\mathbf{e}}, \mathbf{v}^{EP}\right)$ to denote i's external reputation consistent with $(\bar{\mathbf{e}}, \mathbf{v}^{EP})$.

Lemma 2 (External reputation gap)**.** *Consider external reputations of member i consistent with $(\bar{\mathbf{e}}, \mathbf{v}^{EP})$. The external reputation gap is (i) positive and (ii) increasing in $\bar{e}_j$.*

As the market conjectures that implementation only takes place after two positive, and thus equal signals, while maintaining the status quo can also result from two conflicting signals, $X = 1$ raises a member's external reputation above his prior reputation π_i, while $X = 0$ lowers it below that level; a positive external reputation gap follows. Moreover, with the market inferring from implementation that both members received the same signals, the better informed the market conjectures that j is, the stronger the external reputation that i commands from project implementation, and the weaker it becomes after maintaining the status quo.

4.4. **Characteristics of the symmetric equilibrium.** In equilibrium, conjectured effort levels equal chosen effort levels. Thus, in a symmetric equilibrium in which conditions (6) and (5) hold, such that a member votes for implementation only in case of two positive signals,

$$
\begin{aligned}
(10) \qquad C'(e_i^*) &= \frac{\partial p_i^M}{\partial e_i}\left(\left(p_j^M\left(e_j^*\right)-\frac{1}{2}\right)k+\frac{h}{2}\right) \\
&\quad +2\gamma\frac{\partial p_i^M}{\partial e_i}\left(p_j^M\left(e_j^*\right)-\frac{1}{2}\right)\Delta\hat{\pi}_i^I\left(s_i,s_j;\mathbf{e}^*\right) \\
&\quad +\lambda\frac{\partial p_i^M}{\partial e_i}\left(p_j^M\left(e_j^*\right)-\frac{1}{2}\right)\Delta\hat{\pi}_i^E\left(X;\mathbf{e}^*,\mathbf{v}^{EP}\right).
\end{aligned}
$$

must hold. Proposition 1 presents the main consequences of internal and external reputations in equilibrium.

Proposition 1. *In a symmetric equilibrium that satisfies conditions (5) and (6) such that a member votes for implementation only in case of two positive signals, the following holds:*
(1) for $\lambda=\gamma$, a concern with internal reputations creates stronger incentives to acquire information than a concern with external reputations;
(2) the concern with reputations, internal or external, creates strategic complementarity among members' effort levels;
(3) if $\left(s_i,s_j\right)=\left(s^b,s^b\right)$, then a member's internal reputation is strengthened whereas his external reputation is hurt.

That internal reputations create stronger incentives to acquire information than external reputations (for $\lambda=\gamma$) is for two reasons. 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, $\hat{\pi}_i^I\left(s_i^g,s_j^b;\mathbf{e}^*\right)<\hat{\pi}_i^E\left(0;\mathbf{e}^*,\mathbf{v}^{EP}\right)<\hat{\pi}_i^I\left(s_i^g,s_j^g;\mathbf{e}^*\right)=\hat{\pi}_i^E\left(1;\mathbf{e}^*,\mathbf{v}^{EP}\right)$. 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.

Point (2) says that internal and external reputations create strategic complementarity between effort levels. If i conjectures that j acquires more information, then additional effort of i is more likely to prevent conflicting signals and the status quo. This is beneficial from an internal and external reputation point of view, respectively. Besides, e_j determines the internal reputation gap; the larger i conjectures e_j to be, the larger he expects this gap to be, and the stronger are the incentive effects. Similarly, the larger the market conjectures e_j to be, the larger the external reputation gap of member i. That is, internal and external reputation concerns affect how members motivate each other. As (10) shows, if members were only to care about project value, their effort levels would be strategic substitutes as decision-relevant information is a public good.

Point (3) shows that if both members found evidence that the status quo should be maintained, internal and external reputations are updated in opposite directions: their external reputations drop while their internal reputations rise. This divergence is possible as internal reputations contain more information about members' abilities than external reputations.

4.5. **Do reputation concerns stimulate participation in a committee?** So far, we have assumed that both members participate in the meeting. In this section, we study whether reputation concerns relax or tighten the conditions to participate.

In equilibrium, a member's internal and external reputation are updated probabilities obtained using Bayes rule. As a result, in equilibrium, the expected ex post reputation, internal or external, is equal to the prior belief that a member is of high ability, π. Indeed, in equilibrium, a member's expected payoff equals

$$\Pr\left(s_1^g, s_2^g; \mathbf{e}^*\right)\left(k + \mathbb{E}[\mu \mid s^g, s^g; \mathbf{e}^*]\right) + \gamma\pi + \lambda\pi - c\left(e_1^*\right) \tag{11}$$

Thus, on the one hand, reputation concerns, by adding incentives, induce a member to acquire more information than he would without reputation concerns. On the other, from an ex ante reputation perspective information acquisition does not payoff. Does this mean that reputation concerns make it harder to motivate a member to participate in the meeting? To answer this question, we consider the extensive margin (attendance) and the intensive margin (preparation). For sake of concreteness, we assume that it is member 1 who considers deviating from participation.

For the analysis of the extensive margin, we assume that member 1's decision to attend the meeting or not is publicly observed *before* member 2 acquires information. For the analysis of the intensive margin, we assume that at the beginning of the deliberation stage, before signals are exchanged, a member can make cheap talk 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. But given that the claim is made *after* the information acquisition stage, member 2 cannot adapt her effort level to the claim. We assume that if member 1 states that he did not collect any information, the project is implemented if member 2's signal is positive.

4.5.1. *Participation constraints without reputation concerns.* Consider the equilibrium in which 1 acquires information (as does member 2). The resulting effort levels for members 1 and 2, denoted by $\mathbf{e}^*(0)$, satisfy (10) for $i = 1, 2$ with $\gamma = \lambda = 0$. Member 1's equilibrium payoff equals

$$\Pr\left(s_1^g, s_2^g; \mathbf{e}^*(0)\right)\left(k + \mathbb{E}[\mu \mid s^g, s^g; \mathbf{e}^*(0)]\right) - c\left(e_1^*(0)\right). \tag{12}$$

Extensive margin. What is member 1's payoff if he deviates and does not attend the meeting? Member 2 observes this deviation and next chooses her optimal level of effort, denoted by $\check{e}_2$. Assume that member 2 implements the project only if $s_2 = s^g$. Her optimal effort level then satisfies

$$\check{e}_2 = \arg\max_e \Pr\left(s_2^g; e\right)\left(k + \mathbb{E}\left[\mu \mid s_2^g; e\right]\right) - c\left(e\right). \tag{13}$$

As member 2 cannot free-ride on member 1, she will exert more effort herself then in equilibrium, $\check{e}_2 > e_2^*(0)$. The payoff that results for member 1 is $\frac{1}{2}\left(k + \mathbb{E}\left[\mu \mid s_2^g; \check{e}_2\right]\right)$. Thus, the equilibrium condition for the extensive margin is

$$\Pr\left(s^g, s^g; \mathbf{e}^*(0)\right)\left(k + \mathbb{E}[\mu \mid s^g, s^g; \mathbf{e}^*(0)]\right) - c\left(e_0^*\right) > \frac{1}{2}\left(k + \mathbb{E}\left[\mu \mid s_2^g; \check{e}_2\right]\right). \tag{14}$$

Intensive margin. What are member 1's payoffs if he deviates and comes to the meeting unprepared? As member 2 only finds out 1's unpreparedness at the start of the deliberation stage, she does not re-optimize her own information acquisition decision. Thus, the equilibrium condition for the intensive margin is

$$\Pr\left(s_1^g, s_2^g; \mathbf{e}^*(0)\right)\left(k + \mathbb{E}[\mu \mid s^g, s^g; \mathbf{e}^*(0)]\right) - c\left(e_1^*(0)\right) > \frac{1}{2}\left(k + \mathbb{E}[\mu \mid s^g; e_2^*(0)]\right). \tag{15}$$

On the right-hand side we have assumed, as in the analysis of the extensive margin, that member 2 implements the project in case of s_2^g if member 1 deviates and acquires no information.

As $\check{e}_2 > e_2^*(0)$, a comparison of the right-hand sides of (14) and (15) shows that in the absence of reputation concerns, condition (14) is the relevant one.

4.5.2. *Participation constraints with reputation concerns.* Member 1's equilibrium payoff equals (11).
Extensive margin. If 1 deviates and does not attend the meeting, the decision is made by 2 in isolation. Reputation concerns do not induce 2 to exert more effort. Thus, she chooses $\check{e}_2$, see (13). The equilibrium condition for the extensive margin is that

$$\Pr\left(s_1^g, s_2^g; \mathbf{e}^*\right)\left(k + \mathbb{E}[\mu \mid s^g, s^g; \mathbf{e}^*]\right) + \gamma\pi + \lambda\pi - c\left(e_1^*\right) > \frac{1}{2}\left(k + \mathbb{E}[\mu \mid s^g; \check{e}_2]\right) + \gamma\pi + \lambda\pi$$

holds, or, more compactly, that

$$\Pr\left(s_1^g, s_2^g; \mathbf{e}^*\right)\left(k + \mathbb{E}[\mu \mid s^g, s^g; \mathbf{e}^*]\right) - c\left(e_1^*\right) > \frac{1}{2}\left(k + \mathbb{E}[\mu \mid s^g; \check{e}_2]\right) \tag{16}$$

holds.
Intensive margin. What are member 1's payoffs if he deviates and comes to the meeting unprepared? His expected internal reputation equals π. This is so as his announcement not to have acquired information leads member 2 to take this into account in her assessment of 1's ability. The market, however, does not observe 1's deviation. The market's beliefs after the deviation equal those in equilibrium. As a result, member 1's *expected* external reputation benefits from coming unprepared. By deviating and coming unprepared, member 1 ensures that the decision on the project depends only on 2's signal. This maximizes the likelihood of implementation and thus of a boost to his external reputation. The equilibrium condition for the intensive margin is

$$\begin{aligned}
&\Pr\left(s_1^g, s_2^g; \mathbf{e}^*\right)\left(k + \mathbb{E}[\mu \mid s^g, s^g; \mathbf{e}^*]\right) + \gamma\pi + \lambda\pi - c\left(e_1^*\right) \\
>\ &\frac{1}{2}\left(k + \mathbb{E}[\mu \mid s^g; e_2^*]\right) + \gamma\pi + \lambda\frac{1}{2}\left[\hat{\pi}^E\left(1; \mathbf{e}^*, \mathbf{v}^{EP}\right) + \hat{\pi}^E\left(0; \mathbf{e}^*, \mathbf{v}^{EP}\right)\right]
\end{aligned}$$

or, more compactly,

$$\begin{aligned}(17)\qquad & \Pr\left(s_1^g, s_2^g; \mathbf{e}^*\right)\left(k + \mathbb{E}[\mu \mid s^g, s^g; \mathbf{e}^*]\right) + \lambda\pi - c\left(e_1^*\right) \\ > \; & \frac{1}{2}\left(k + \mathbb{E}[\mu \mid s^g; e_2^*]\right) + \lambda\frac{1}{2}\left[\hat{\pi}^E\left(1; \mathbf{e}^*, \mathbf{v}^{EP}\right) + \hat{\pi}^E\left(0; \mathbf{e}^*, \mathbf{v}^{EP}\right)\right].\end{aligned}$$

The question whether reputation concerns facilitate or hinder participation can be answered by comparing condition (14) in the absence of reputation concerns with conditions (16) and (17) in the presence of reputation concerns.

Due to free riding, the equilibrium effort levels $\mathbf{e}^*(0)$ in (14) *in the absence of reputation concerns* fall short of the first-best effort levels that maximize the sum of members' payoffs net of the total costs of effort provision. In a committee, the effort incentives provided by reputation concerns can make up for this shortfall. As a result, the left-hand side of (16) will be larger than the left-hand side of (14) if the weights γ and λ are not too high (while the right-hand sides are identical). Reputation concerns relax the constraint. For high weights, the opposite holds. Furthermore, for λ and γ close to zero, the right-hand side of (14) is larger than the right-hand side of (17) thanks to member 2's optimal acquisition decision following 1's absence from the committee (and thus $\frac{1}{2}\left(k + \mathbb{E}[\mu \mid s^g; \check{e}_2]\right) > \frac{1}{2}\left(k + \mathbb{E}[\mu \mid s^g; e_2^*]\right)$). If condition (14) holds without reputation concerns, then for weights γ and λ that are not too high, condition (17) also holds.

Formally, there is a number $\overline{\gamma} > 0$ and a decreasing function $\overline{\lambda}(\gamma)$ defined on $[0, \overline{\gamma}]$ and satisfying $\overline{\lambda}(\overline{\gamma}) = 0$ such that for $(\gamma, \lambda) \in \Theta$, where $\Theta = (0, \overline{\gamma}) \times (0, \overline{\lambda}(\gamma))$, the following holds: if condition (14) holds, then conditions (16) and (17) hold. The next proposition sums up.

Proposition 2 (Participation, extensive and intensive margin)**.** *Suppose that* (14) *is met such that in the absence of reputation concerns both members participate in the meeting. Participation in the meeting is then also guaranteed when reputation concerns are weak,* $(\gamma, \lambda) \in \Theta$*. Strong (i.e., non-weak) reputation concerns hinder participation.*

This proposition has as a corollary that reputation concerns may make committee decision making possible in the first place. This would be the case if without reputation concerns a member does not want to participate, as (14) is not met, while with reputation concerns of moderate strength the member is willing to participate. For example, for $p^H(e) = \frac{1}{2} + e$, $p^L(e) = \frac{1}{2} + \frac{1}{2}e$, $c(e) = \frac{9}{8}e^2$, $\pi = \frac{1}{2}$, $k = -\frac{3}{4}$, $h = 2$ and $\lambda = \gamma = 0$, (14) is not met. But for $\lambda = \frac{3}{2}$ and γ just above 2, the participation constraints are met.

5. 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 acquire information. To put this discussion in context, notice that if a member only cares about project value and not about his reputation, the amount of information that a member acquires 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 symmetric equilibrium of a two-member committee, member i's signal is only decisive if member j's signal is positive. As a result, the marginal benefits from acquiring information 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 acquire information 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 apply a result from statistics: if the size of the committee tends to infinity, then the probability that the majority of signals that members receive reveals the true state goes to one. Thus, in a large committee, a comparison of the view that member i expresses with those of the majority of the other members amounts to a comparison of s_i with the true state μ. As a result, a member's marginal benefits from acquiring information to improve his internal reputation are larger in a large committee than in a two-person committee. We prove this formally in the Appendix. Intuitively, with a member's ability influencing the quality of his signal, and a signal's quality meaning whether it corresponds with the state, observing μ is the best evidence available to establish member i's reputation. As a result, 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 in a two-member committee. Besides, the change in probability of commanding the better reputation thanks to an increase in information acquisition is larger for a large committee than for 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 a symmetric equilibrium, 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 acquire information.

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 gap. Larger audiences create larger incentives. A member's external reputation gap depends on the size of the committee and on the number of good signals about the state needed for implementation. For $k \to 0$, implementation requires that more than half of the signals are good. Visser and Swank (2007) show that in this case, no external reputation gap exists if the committee consists of an odd number of members. The reason for this result is that in this situation, the average agreement among members is the same when $X = 0$ and $X = 1$. As a result, the decision on X does not contain information about members' abilities. When the number of members is even the decision on X does contain information about members' abilities. Implementation requires at least two more positive signals than negative signals. For $k \to 0$ and an even number of committee members, this requirement is independent of the size of the committee. As a result, for larger committees the external reputation gap narrows.

Remark about μ observable. If μ were observed such that conclusive evidence about the correctness of the decision were available, a member's internal reputation would be determined by comparing the state with 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.

6. CONCLUSION

Members of committees can be concerned with their reputation for expertise in the eyes of fellow committee members and the outside labor market. When the state that these members need to assess 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 made by the committee as a whole. We find that, nevertheless, reputation concerns—both internal and external—do motivate information acquisition. As a result, they counteract the underprovision of effort stemming from the public good nature of information. We also find that internal reputations provide stronger incentives to acquire information than external reputations.

The absence of conclusive evidence means that a member's internal reputation is based on deliberation patterns; members' external reputation is based on what outside observers infer from the observed decision about the degree of congruence among individual signals. We find that, as a result, reputation concerns create strategic complementarity among individual effort levels. Also, 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.

We have assumed that committee members share their private information in the deliberation stage. This assumption is without loss of generality given our assumption that uncertainty about the state is maximal. When one state is a priori much more likely than another, a member may want to misrepresent his private information to command a strong internal reputation; this would reduce the incentives to collect information in the first place. Whether a member is more inclined to misrepresent his private information in a small committee than in a large one is an interesting topic for further research.

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APPENDIX

APPENDIX A. PROOFS

Proof of Lemma 1: In what follows we suppress $\hat{e}_i$ and e_j in the expressions and write $p_i^{a_i}$ instead of $p^{a_i}(e_i)$ etc.

1. We use Bayes rule to obtain

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

Similarly,

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

It follows that

$$\hat{\pi}_i^I\left(s_i^g, s_j^g\right) = \hat{\pi}_i^I\left(s_i^b, s_j^b\right) > \pi \text{ and } \hat{\pi}_i^I\left(s_i^g, s_j^b\right) = \hat{\pi}_i^I\left(s_i^b, s_j^g\right) < \pi \qquad \text{(A.3)}$$

Thus, $\hat{\pi}_i^I(s,s) - \hat{\pi}_i^I(s',s) > 0$ with $s \neq s'$, which is part (i) of the lemma. We now show that this difference is increasing in 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 $s \neq s'$,

$$\begin{aligned}
\frac{\partial\hat{\pi}_i^I(s,s)}{\partial p_j^M} &= \frac{\pi}{2}\frac{p_i^H - p_i^M}{\Pr(s,s)^2} > 0 \\
\frac{\partial\hat{\pi}_i^I(s',s)}{\partial p_j^M} &= \frac{\pi}{4}\frac{p_i^H - p_i^M}{\Pr(s',s)^2} < 0,
\end{aligned}$$

and this proves part (ii).

Proof of Lemma 2: Write

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

where we have suppressed reference to $\bar{\mathbf{e}}$ and $\mathbf{v}^{EP}$. Note that $\hat{\pi}_i^E(1) > \hat{\pi}_i^E(0) \Leftrightarrow \Pr\left(s_i^g, s_j^g \mid H\right) > \Pr\left(s_i^g, s_j^g\right) \Leftrightarrow \left(p_j^M - \frac{1}{2}\right)\left(p_i^H - p_i^M\right) > 0$. As the latter inequality holds, we have shown part (i) of the lemma. We now show that $\hat{\pi}_i^E(1) - \hat{\pi}_i^E(0)$ increases in $\bar{e}_j$. Note that $\partial\hat{\pi}_i^E(\cdot)/\partial\bar{e}_j = \left(\partial\hat{\pi}_i^E(\cdot)/\partial p_j^M\right)\left(\partial p_j^M(\cdot)/\partial\bar{e}_j\right)$ and $\partial p_j^M/\partial\bar{e}_j > 0$. Thus, $sign\left(\partial\hat{\pi}_i^E(\cdot)/\partial\bar{e}_j\right) = sign\left(\partial\hat{\pi}_i^E(\cdot)/\partial p_j^M\right)$. 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 $\partial\hat{\pi}_i^I\left(s_i^g, s_j^g\right)/\partial p_j^M > 0$ and thus $\partial\hat{\pi}_i^E(1)/\partial e_j > 0$. Moreover,

$$\frac{\partial\hat{\pi}_i^E(0)}{\partial p_j^M} = -\frac{3}{4}\frac{\left(p_i^H - p_i^M\right)}{\left(1-\Pr\left(s_i^g, \bar{s}_j^g\right)\right)^2}\pi < 0.$$

This proves part (ii).

Proof of Proposition 1: We begin by deriving the expression for the marginal benefits of effort, (9). The *ex ante* expected project payoffs equal

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

This can be rewritten as $\Pr\left(s_i^g, s_j^g\right)k + \frac{h}{2}\left(\Pr\left(s_i^g, s_j^g \mid h\right) - \Pr\left(s_i^g, s_j^g \mid -h\right)\right)$, 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 $\lambda\sum_X \Pr\left(X; e_i, \hat{e}_j\right)\hat{\pi}_i^E(X)$ with respect to e_i yields

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

Similarly, differentiating the expected utility of the internal reputation $\gamma\sum_{(s_i,s_j)}\Pr\left(s_i, s_j; e_i, \hat{e}_j\right)\hat{\pi}_i^I\left(s_i, s_j\right)$ with respect to e_i gives

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

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

$$\text{(A.6)}\qquad \gamma\frac{\partial \Pr\left(s_1^g,s_2^g\right)}{\partial e_i}\Delta\hat{\pi}^I\left(s_i,s_j\right)+\gamma\frac{\partial \Pr\left(s_1^b,s_2^b\right)}{\partial e_i}\Delta\hat{\pi}^I\left(s_i,s_j\right)=2\gamma\frac{\partial p_i^M}{\partial e_i}\left(p_j^M-\frac{1}{2}\right)\Delta\hat{\pi}^I\left(s_i,s_j\right),$$

where we used (A.3) to derive the last equality. Putting the three parts (project payoff, external reputation, internal reputation) together gives (9).

We now proceed by proving parts (1)–(3) of the proposition.

(1). In equilibrium, and under the assumption that $\lambda=\gamma$, the difference in marginal benefits from internal and external reputation concerns equals

$$\text{(A.7)}\qquad \gamma\frac{\partial p_i^M}{\partial e_i}\left(p_j^M\left(e_j^*\right)-\frac{1}{2}\right)\left(\Delta\hat{\pi}_i^I\left(s_i,s_j;\mathbf{e}^*\right)-\Delta\hat{\pi}_i^E\left(X;\mathbf{e}^*,\mathbf{v}^{EP}\right)\right).$$

As $\Delta\hat{\pi}_i^I\left(s_i,s_j;\mathbf{e}^*\right)=\hat{\pi}_i^I\left(s_i^g,s_j^g;\mathbf{e}^*\right)-\hat{\pi}_i^I\left(s_i^g,s_j^b;\mathbf{e}^*\right)$ and $\Delta\hat{\pi}_i^E\left(X;\mathbf{e}^*,\mathbf{v}^{EP}\right)=\hat{\pi}_i^E\left(1;\mathbf{e}^*,\mathbf{v}^{EP}\right)-\hat{\pi}_i^E\left(0;\mathbf{e}^*,\mathbf{v}^{EP}\right)$ and $\hat{\pi}_i^I\left(s_i^g,s_j^b;\mathbf{e}^*\right)<\hat{\pi}_i^E\left(0;\mathbf{e}^*,\mathbf{v}^{EP}\right)<\hat{\pi}_i^I\left(s_i^g,s_j^g;\mathbf{e}^*\right)=\hat{\pi}_i^E\left(1;\mathbf{e}^*,\mathbf{v}^{EP}\right)$, this difference is positive. This proves part (1).

(2). To prove the strategic complementarity, we differentiate the marginal benefits of member i, the right-hand side of (10), with respect to e_j^*. As both $\Delta\hat{\pi}_i^I\left(s_i,s_j;\mathbf{e}^*\right)$ and $\Delta\hat{\pi}_i^E\left(X;\mathbf{e}^*,\mathbf{v}^{EP}\right)$ are increasing in e_j^*, see Lemmas (1) and (2), it follows that the marginal benefits of member i are increasing in e_j^*. This completes the proof of part (2).

(3). In equilibrium, $(s_i,s_j)=(s^b,s^b)$ implies an internal reputation equal to $\hat{\pi}_i^I\left(s_i^b,s_j^b;\mathbf{e}^*\right)>\pi$, and a committee decision $X=0$ and thus an external reputation equal to $\hat{\pi}_i^E\left(0;\mathbf{e}^*,\mathbf{v}^{EP}\right)<\pi$. This proves part (3).

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 use a result from statistics: if the size of the committee tends to infinity, then the probability that the majority of signals that members receive reveals the true state goes to one. Thus, if the majority of signals of i's fellow members is s^g, 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

$$\text{(A.8)}\qquad \hat{\pi}_i^I\left(s_i^g,h\right)=\hat{\pi}_i^I\left(s_i^b,-h\right)=\frac{p_i^H}{p_i^M}\pi>\hat{\pi}_i^I\left(s_i^g,-h\right)=\hat{\pi}_i^I\left(s_i^b,h\right)=\frac{1-p_i^H}{1-p_i^M}\pi.$$

Thus, the marginal benefits of e_i for $n \to \infty$ equal

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

It can be checked using (A.8), (A.2) and (A.3) that $\hat{\pi}_i^I\left(s_i^g, h\right) > \hat{\pi}_i^I\left(s, s\right)$ and $\hat{\pi}_i^I\left(s_i^b, h\right) < \min \hat{\pi}_i^I\left(s, s'\right)$. This implies that, for the same effort levels, the internal reputation gaps are larger in the large committee than in the 2-person committee. Furthermore,

$$\frac{\partial \Pr\left(s, h\right)}{\partial e_i} = \frac{\partial p_i^M}{\partial e_i} \frac{1}{2} > \frac{\partial p_i^M}{\partial e_i}\left(p_j^M - \frac{1}{2}\right) = \frac{\partial \Pr\left(s, s\right)}{\partial e_i} \tag{A.9}$$

for $s \in \{s_i^g, s_i^b\}$ As a result, the marginal benefits are larger in a large committee for the same level of effort.

APPENDIX B. ASYMMETRIC EQUILIBRIA

In the main text, we discussed symmetric equilibria in which both members contribute equally to the provision of information. In this appendix, we turn to asymmetric equilibria in which effort levels between members differ to such an extent that the signal of one member, member 2 for the sake of concreteness, is ignored, while the signal of member 1 is decisive. As a result, both members vote for implementation if the signal of member 1 is positive and vote against if his signal is negative,

$$v_1^{EP}\left(s_1, s_2, e_{1U}^*\right) = v_2^{EP}\left(s_1, s_2, e_{2U}^*\right) = \begin{cases} 1 & \text{if } s_1 = s^g \\ 0 & \text{if } s_1 = s^b. \end{cases} \tag{B.1}$$

The subscript U stands for unequal contributions (and EP continues to stand for equilibrium path).

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 do not motivate members to acquire information. With her 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 her internal reputation. Thus, the expected payoffs to members 1 and 2 when choosing effort equal

$$\text{(B.2)} \qquad \text{member 1} \quad : \quad \Pr\left(s_1^g; e_1\right)\left(k + \mathbb{E}\left[\mu \mid s_1^g; e_1\right]\right) + \gamma \mathbb{E}\left[\hat{\pi}_1^I\left(s_i, s_j; \mathbf{e}_U^*\right)\right] + \lambda \pi - c\left(e_1\right)$$

$$\text{(B.3)} \qquad \text{member 2} \quad : \quad \gamma \mathbb{E}\left[\hat{\pi}_2^I\left(s_i, s_j; \mathbf{e}_U^*\right)\right] + \lambda \pi - c\left(e_2\right),$$

Notice that the $\hat{\pi}^I$ carry member-subscripts as effort levels differ across members. The first-order conditions for optimality are

$$\text{(B.4)} \qquad \text{member 1} \quad : \quad h\frac{\partial p_1^M}{\partial e_1} + 2\gamma \frac{\partial p_1^M}{\partial e_1}\left(p_2^M\left(e_2\right) - \frac{1}{2}\right)\Delta \hat{\pi}_1^I\left(s_1, s_2\right) = c'\left(e_1\right)$$

$$\text{(B.5)} \qquad \text{member 2} \quad : \quad 2\gamma \frac{\partial p_2^M}{\partial e_2}\left(p_1^M\left(e_1\right) - \frac{1}{2}\right)\Delta \hat{\pi}_2^I\left(s_1, s_2\right) = c'\left(e_2\right).$$

Compared with a symmetric equilbrium with equal contributions, member 1's signal now matters for the decision on the project *irrespective* of the signal of member 2, strengthening 1's incentives to acquire information. On the other hand, member 2's incentives to become informed become weaker as these incentives 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 symmetric equilibrium with equal contributions 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 B.1 presents a number of characteristics of this equilibrium.

Proposition B.1. *In an asymmetric equilibrium with unequal contributions, characterized by voting as in* (B.1)*,*
(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 decision-making process characterized by voting as in (7)*;*
(4) member 1's incentives to become informed may be weaker or stronger than in a decision-making process characterized by voting as in (7)

We noted 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.

The presence of a dominant member, like member 1, in combination with other members with little apparent influence but who continue to acquire information is reminiscent of former Federal Reserve Board governor Meyer's description of decision making at the Federal Open Market Committee (FOMC). Meyer was appointed to serve on the Federal Reserve Board in 1996 when Alan Greenspan was the chairman of the Federal Reserve Board. 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, Swank and Visser, 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.

APPENDIX C. STRONG EXTERNAL REPUTATION CONCERNS

In the main text we have focused on symmetric equilibria in which

$$k + \Delta\hat{\pi}_i^E\left(X; \mathbf{e}^*, \mathbf{v}^{EP}\right) < 0, \tag{C.1}$$

with $\mathbf{v}^{EP}$ as in (7) and $\mathbf{e}^*$ determined in (10). As a result, in equilibrium both members vote against project implementation in case of conflicting signals. In this appendix, we assume that condition (C.1) does not hold. Thus, λ is that high that members have incentives to vote in favor of $X = 1$ even if they received conflicting signals. However, a symmetric equilibrium in which both members vote for implementation with probability one in case of conflicting signals does not exist. To see this, assume it does. Then, $X = 0$ would command a higher external reputation than $X = 1$ as the public 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 voting strategy and maintain the status quo as this decision would both command a higher external reputation and avoid the expected loss associated with project implementation (recall that $k + \mathbb{E}[\mu \mid s^g, s^b; e, e] < 0$ in a symmetric equilibrium).

What does exist, is a mixed-strategy equilibrium in which the committee chooses $X = 1$ with a positive probability less than one in case of conflicting signals. With homogenous members, such equilibria can be of two types. In the first type, conditional on a pair of conflicting signals, both members follow a mixed voting 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 the same pair of signals. In the second type, one member uses a mixed voting strategy while the other member plays a pure voting 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, the equality $E\left[\mu \mid s_1^g, s_2^b; e, e\right] = E\left[\mu \mid s_1^b, s_2^g; e, e\right]$ 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, either $e_1^* > e_2^*$ or the reverse holds. Assume for concreteness sake that $e_1^* > e_2^*$. Then, the conditional expected values would differ, $E\left[\mu \mid s_1^g, s_2^b; \mathbf{e}^*\right] > E\left[\mu \mid s_1^b, s_2^g; \mathbf{e}^*\right]$. 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.

As a bad signal of member 2 is no longer a reason to vote for status quo with probability one, 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:

- $\left(s_1^g, s_2^b\right)$ makes one member vote in favor with probability one and the other member vote in favor with probability β
- $\left(s_1^g, s_2^b\right)$ 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 $\mathbf{e}_M^* = \left(e_{1M}^*, e_{2M}^*\right)$ be the equilibrium level of effort, with $e_{1M}^* > e_{2M}^*$ (the M stands for mixed strategy). Since effort levels differ, both external and internal reputations differ across members. As a result, the member with the higher external reputation gap 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 $\hat{\pi}_1^E\left(X; \mathbf{e}_M^*, \beta^*\right) > \hat{\pi}_2^E\left(X; \mathbf{e}_M^*, \beta^*\right)$ such that

$$k + \mathbb{E}\left[\mu \mid s_1^g, s_2^b; \mathbf{e}_M^*\right] + \lambda \Delta \hat{\pi}_2^E\left(X; \beta^*\right) = 0 \tag{C.2}$$

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 $\left(s_1^g, s_2^b\right)$

$$(v_1, v_2) = \begin{cases} (1,1) & \text{for } \left(s_1^g, s_2^g\right) \\ (1, \beta^*) & \text{for } \left(s_1^g, s_2^b\right) \\ (0,0) & \text{for } \left(s_1^b, s_2^g\right) \text{ and } \left(s_1^b, s_2^b\right), \end{cases} \tag{C.3}$$

with $\beta^* \in (0, 1)$. As $\beta^* < 1$, parameter values must be such that $k + \mathbb{E}\left[\mu \mid s_1^g, s_2^b; \mathbf{e}_M^*\right] < 0$. 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 is the case in the asymmetric equilibrium discussed in Appendix B). When choosing effort, member i's expected payoff equals

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

The derivative of this expression with respect to e_i becomes

$$\begin{aligned} & \frac{\partial p_i^M}{\partial e_i}\left(\left(p_j^M\left(e_j\right) - \frac{1}{2}\right)\left(1 + \beta^*\right) k + \frac{h}{2}\left(1 - \beta^* + 2\beta^* I_1(i)\right)\right) \\ & + 2\gamma \frac{\partial p_i^M}{\partial e_i}\left(p_j^M\left(e_j\right) - \frac{1}{2}\right) \Delta \hat{\pi}_i^I\left(s_i, s_j, \mathbf{e}_M^*\right) \\ & + \lambda \frac{\partial p_i^M}{\partial e_i}\left(p_j^M\left(e_j\right) - \frac{1}{2}\right)\left(1 + \beta^*\right) \Delta \hat{\pi}_i^E\left(X; \mathbf{e}_M^*, \beta^*\right) \\ = \; & c'\left(e_i\right) \text{ for } i = 1, 2, \end{aligned} \tag{C.4}$$

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 C.1. *For $k + \Delta\hat{\pi}_i^E\left(X; \mathbf{e}^*, \mathbf{v}^{EP}\right) > 0$, a mixed-strategy equilibrium is characterized by voting strategies (C.3) on the equilibrium path and mixing probability and effort levels that are determined by (C.2) and (C.4).*