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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 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.

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 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-

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[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.

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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 probabilities about a member's ability. In equilibrium, these probabilities are obtained using Bayes' rule. As a result, the expected ex post reputation, internal and external, is equal to the prior probability 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 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, while Section 6 numerically illustrates the effect of committee size on reputation-induced incentives. The Appendices contain proofs, some lengthy expressions, and two discussions of other equilibria.

2. Related literature

Our paper is related to various literatures.

Career concerns and effort. Holmström (1999),Milbourn et al. (2001), Suurmond et al. (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 Sebastian 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. Sebastian 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.[4]

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.[5] 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

[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] The gain in internal reputation from a conformity of views is one of the drivers of information acquisition in the current model. It can also drive information distortion, see *e.g.* Prendergast (1993),Orphanides (2001) and Gentzkow and Shapiro (2006), and distorted decisions, see *e.g.* Holmström (1999),Scharfstein and Stein (1990) and Visser and Swank (2007).

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

Kartik et al. (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.[6]

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 et al., 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, 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 et al. (2010). In our model, the sharing of control induces both free riding and, through a concern with internal reputations, pressure to acquire information that is 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 $\Pr(\mu = h) = \frac{1}{2}$.[7] 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 $e_i \geqslant 0$ to receive a signal $s_i \in \{b, g\}$about the state μ. The costs of exerting effort are increasing and strictly convex, with $c(e_i) > 0, c(0) = c'(0) = 0$ and $\lim_{e_i \to \infty} c'(e_i) = \infty$. 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 e_i and 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

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

For $a_i \in \{L, H\}, p_i^{a_i}(\cdot)$is an increasing, strictly concave function with $p_i^{a_i}(0) \geqslant 1/2, p_i^{a_i\prime}(0) = \infty$, $\lim_{e_i \to \infty} p_i^{a_i}(e_i) \leqslant 1$, and $\lim_{e_i \to \infty} p_i^{a_i\prime}(e_i) = 0$. We assume that higher ability means a higher likelihood of receiving the right signal, for all $e_i > 0, p_i^H(e_i) > p_i^L(e_i)$. Only pure strategies are allowed in this stage.

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

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

The other member (call her j) does not observe i's effort choice.

As the main interest of the paper is in effort provision by reputation-concerned committee members, we simplify the next two stages.

2. Deliberation stage. In this stage, members simultaneously send a message to the other member. To simplify the analysis, 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.

3. Choice stage. In this stage, the committee decides whether to implement the project or not. To simplify the analysis, we focus in the main part of the paper on a committee that implements the project when members have received two positive signals and maintains the status quo in case of conflicting signals or two negative signals. The simplification consists in the avoidance of individual voting strategies and a voting rule, and a focus on a specific relationship between signals on the one hand and decision on the other.[9]

Objectives of committee members. Each member cares about the value of the project, his cost of effort, his internal reputation and his external reputation. For an effort pair (e_i, e_j), member i's expected utility equals

$$\begin{aligned} U_i(e_i, e_j) &= \Pr(g, g, e_i, e_j)\left(k + \mathbb{E}[\mu|g, g, e_i, e_j]\right) - c(e_i) \\ &+ \gamma \sum_{(s_i, s_j)} \Pr(s_i, s_j, e_i, e_j) r_i^I(s_i, s_j) \\ &+ \lambda \sum_X \Pr(X, e_i, e_j) r_i^E(X), \end{aligned} \qquad (1)$$

where we have used that the project is only implemented in case of two positive signals. The parameters $\gamma$and $\lambda$are the weights i attaches to his internal reputation r_i^I and external reputation r_i^E, respectively. The values of these reputations are determined in equilibrium. An equilibrium consists of a pair of effort levels (e_1^*, e_2^*) and reputation functions $r_i^I(s_i, s_j)$and $r_i^E(X)$ such that

1. (e_1^*, e_2^*) is a Nash equilibrium for given $r_i^I(s_i, s_j)$and $r_i^E(X)$;
2. reputation functions satisfy $r_i^I(s_i, s_j) = \Pr\left(a_i = H|s_i, s_j, e_i^*, e_j^*, \pi\right)$ and $r_i^E(X) = \Pr\left(a_i = H|X, e_i^*, e_j^*, \pi\right)$.

That is, in equilibrium effort levels form a Nash equilibrium given the reputation functions; and the reputation functions equal the posterior probability that a member is of high ability for the various signal pairs (in the case of the internal reputation) or decisions (in the case of the external reputation) and given the equilibrium effort levels and prior probability π. The reason that r_i^I is called the internal reputation is because only members inside the committee observe the realized signal pair, while the outside world—the market, the public—only observes the decision.[10]

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[6] 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.

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

[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] We thank an anonymous referee for suggesting this approach.

[10] Note that neither reputation depends on the realized state of the world μ. In some sense, we are dealing here with decisions that take a long time before it becomes known whether they were good or bad.

In the main body of the paper we focus on symmetric equilibria. We discuss asymmetric equilibria in Appendix C. In a symmetric equilibrium, $e_i^* = e_j^* = e^*$. As a result, one can drop the subscripts from the reputation functions, $r_i^I(s_i, s_j) = r^I(s_i, s_j)$ and $r_i^E(X) = r^E(X)$; moreover, the expected project value conditional on conflicting signals is negative, $k + \mathbb{E}[\mu|g, b, e^*] = k < 0$. From a project-value perspective, the committee should then maintain the status quo. In the main body of the paper we study equilibria in which in case of conflicting signals the committee chooses to maintain the status quo, see the description of the choice stage. In Appendix D, we discuss equilibria in which the committee chooses for project implementation with positive probability in case of conflicting signals.

4. Analysis

4.1. Internal and external reputations

We begin by determining internal and external reputations in equilibrium.

Lemma 1. The internal reputations that member i can achieve in equilibrium are

$$r^I(g,g) = r^I(b,b) = \frac{p_i^H(e^*)p_j^M(e^*) + (1 - p_i^H(e^*))\left(1 - p_j^M(e^*)\right)}{p_i^M(e^*)p_j^M(e^*) + (1 - p_i^M(e^*))\left(1 - p_j^M(e^*)\right)}\pi, \quad (2)$$

$$r^I(g,b) = r^I(b,g) = \frac{p_i^H(e^*)\left(1 - p_j^M(e^*)\right) + (1 - p_i^H(e^*))p_j^M(e^*)}{p_i^M(e^*)\left(1 - p_j^M(e^*)\right) + (1 - p_i^M(e^*))p_j^M(e^*)}\pi. \quad (3)$$

Internal reputations satisfy, for $s, s\prime \in \{g, b\}$ and $s \neq s\prime, r^I(s,s) > \pi > r^I(s,s\prime)$.

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 probability π, while holding a conflicting view lowers it below that level.

Lemma 2. The external reputations that member i can achieve in equilibrium are

$$r^E(1) = \frac{p_i^H(e^*)p_j^M(e^*) + (1 - p_i^H(e^*))\left(1 - p_j^M(e^*)\right)}{p_i^M(e^*)p_j^M(e^*) + (1 - p_i^M(e^*))\left(1 - p_j^M(e^*)\right)}\pi, \quad (4)$$

$$r^E(0) = \frac{p_i^H(e^*) + p_j^M(e^*)}{p_i^M(e^*) + p_j^M(e^*) - 2p_i^M(e^*)p_j^M(e^*)}. \quad (5)$$

External reputations satisfy $r^E(1) > \pi > r^E(0)$.

As the market knows 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 probability π, while $X = 0$ lowers it below that level.

4.2. Information acquisition

In the information acquisition stage, member i chooses e_i so as to maximize his expected utility given equilibrium internal and external reputations as determined in Lemmas 1 and 2 As a result, in the symmetric equilibrium, e^* satisfies[11]

$$c'(e^*) = \frac{\partial p_i^M}{\partial e_i}\left(\left(p_j^M(e^*) - \frac{1}{2}\right)k + \frac{h}{2}\right) \quad (6)$$
$$+2\gamma \tfrac{\partial p_i^M}{\partial e_i}\left(p_j^M(e^*) - \tfrac{1}{2}\right)\left(r^I(g,g) - r^I(b,g)\right)$$
$$+\lambda \tfrac{\partial p_i^M}{\partial e_i}\left(p_j^M(e^*) - \tfrac{1}{2}\right)\left(r^E(1) - r^E(0)\right).$$

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

Proposition 1. In a symmetric equilibrium, 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 $(s_i, s_j) = (b, b)$, 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, $r^I(s\prime, s) < r^E(0) < r^I(s, s) = r^E(1)$. 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) in Proposition 1 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, the larger i conjectures $e_j$to be, the larger he expects to be the difference between his internal reputation in case of two concurring signals and in case of conflicting signals, and thus the stronger are the incentive effects. Similarly, the larger the market conjectures e_j to be, the larger the difference in i's external reputation between project implementation and maintaining the status quo. That is, internal and external reputation concerns affect how members motivate each other. As (6) 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.[12]

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.

4.3. 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, 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

$$\Pr(s_1^g, s_2^g, e^*, e^*)(k + \mathbb{E}[\mu|g, g, e^*, e^*]) + \gamma\pi + \lambda\pi - c(e^*) \quad (7)$$

Thus, on the one hand, reputation concerns, by adding incentives, induce a member to acquire more information than he would with-

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

[12] We cannot exclude the presence of multiple equilibria, see also Echenique (2004, 2017). However, in a numerical simulation we found a unique equilibrium.

out reputation concerns. On the other, from an ex ante reputation perspective information acquisition does not pay off. 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.

4.3.1. Participation constraints without reputation concerns

Consider the equilibrium in which 1 acquires information (as does member 2). The resulting effort level for members 1 and 2, denoted by $e^*(0)$, satisfies (6) for $i = 1, 2$ with $\gamma = \lambda = 0$. Member 1's equilibrium expected utility equals

$$\Pr(g, g, e^*(0), e^*(0))(k + \mathbb{E}[\mu|g, g, e^*(0), e^*(0)]) - c(e^*(0)). \tag{8}$$

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 $\breve{e}_2$. Assume that member 2 implements the project only if $s_2 = g$. Her optimal effort level then satisfies

$$\breve{e}_2 = \arg\max_e \Pr(g, e)(k + \mathbb{E}[\mu|g, ; e]) - c(e). \tag{9}$$

As member 2 cannot free-ride on member 1, she will exert more effort $\breve{e}_2 > e_2^*(0)$. The expected utility that results for member 1 is $\frac{1}{2}(k + \mathbb{E}[\mu|g, \breve{e}_2])$. Thus, the equilibrium condition for the extensive margin is

$$\Pr(g, g, e^*(0), e^*(0))(k + \mathbb{E}[\mu|g, g, e^*(0), e^*(0)]) - c(e^*(0)) > \frac{1}{2}(k + \mathbb{E}[\mu|g, \breve{e}_2]). \tag{10}$$

Intensive margin. What is member 1's expected utility 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

$$\Pr(g, g, e^*(0), e^*(0))(k + \mathbb{E}[\mu|g, g, e^*(0), e^*(0)]) - c(e^*(0)) > \frac{1}{2}\left(k + \mathbb{E}\left[\mu|g, e_2^*(0)\right]\right). \tag{11}$$

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 g if member 1 deviates and acquires no information.

As $\breve{e}_2 > e_2^*(0)$, a comparison of the right-hand sides of Eqs. (10) and (11) shows that in the absence of reputation concerns, condition (10) is the relevant one.

4.3.2. Participation constraints with reputation concerns

Member 1's equilibrium payoff equals (7).

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 $\breve{e}_2$, see (9). The equilibrium condition for the extensive margin is that

$$\Pr(g, g, e^*, e^*)(k + \mathbb{E}[\mu|g, g, e^*, e^*]) + \gamma\pi + \lambda\pi - c(e^*) > \frac{1}{2}(k + \mathbb{E}[\mu|g, \breve{e}_2]) + \gamma\pi + \lambda\pi$$

holds, or, more compactly, that

$$\Pr(g, g, e^*, e^*)(k + \mathbb{E}[\mu|g, g, e^*, e^*]) - c(e^*) > \frac{1}{2}(k + \mathbb{E}[\mu|g, \breve{e}_2]) \tag{12}$$

holds.

Intensive margin. What is member 1's expected utillty 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

$$\Pr(g, g, e^*, e^*)(k + \mathbb{E}[\mu|g, g, e^*, e^*]) + \gamma\pi + \lambda\pi - c(e^*) > \tfrac{1}{2}\left(k + \mathbb{E}\left[\mu|g, e_2^*\right]\right) + \gamma\pi + \lambda\tfrac{1}{2}\left[r^E(1) + r^E(0)\right]$$

or, more compactly,

$$\Pr(g, g, e^*, e^*)(k + \mathbb{E}[\mu|g, g, e^*, e^*]) + \lambda\pi - c\left(e_1^*\right) > \frac{1}{2}\left(k + \mathbb{E}\left[\mu|g, e_2^*\right]\right) + \lambda\frac{1}{2}\left[r^E(1) + r^E(0)\right]. \tag{13}$$

The question whether reputation concerns facilitate or hinder participation can be answered by comparing condition (10) in the absence of reputation concerns with conditions (12) and (13) in the presence of reputation concerns.

Intuitively, reputation concerns of moderate strength increase incentives to participate in the committee. In the absence of reputation concerns, free riding causes each member to acquire less information than is first-best—that is, less than the acquisition level that maximizes the sum of members' payoffs net of the total costs of effort provision. 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; this relaxes the participation constraint. Too strong concerns move acquisition levels further away from their efficient levels, making the participation constraint tighter or not met.

More formally, due to free riding, the equilibrium effort level $e^*(0)$ in (10) *in the absence of reputation concerns* falls short of first-best effort level. In a committee, the effort incentives provided by reputation concerns can make up for this shortfall. As a result, the left-hand side of (12) will be larger than the left-hand side of (10) 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 (10) is larger than the right-hand side of (13) thanks to member 2's optimal acquisition decision following 1's absence from the committee (and thus $\frac{1}{2}(k + \mathbb{E}[\mu|g, \breve{e}_2]) > \frac{1}{2}\left(k + \mathbb{E}\left[\mu|g, e_2^*\right]\right)$). If condition (10) holds without reputation concerns, then for weights γ and λ that are not too high, condition (13) also holds. That is, 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 (10) holds, then conditions (12) and (13) hold. The next proposition sums up.

Proposition 2 (*Participation, extensive and intensive margin*). Suppose that (10) 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 (10) 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 $\lambda = \gamma = 0$, (10) 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 μobservable. 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 μunobservable. 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 μbefore 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. Numerical illustration of effect of committee size on reputation-induced incentives to exert effort

Proposition 3 compares the incentives that internal and external reputations give for a one-person, a two-person and a large committee (with $n \to \infty$). To shed light on these incentives in moderately large committees we conduct a numerical analysis. For this analysis, we make some further simplifying assumptions. We consider a situation where each committee member either exerts effort or not $e_i \in \{0, 1\}$. Regardless of his effort, a low-ability member receives a correct signal with probability one-half, $p^L(e_i) = \frac{1}{2}$. By exerting effort, a high-ability member increases the probability that he receives a correct signal from $p^H(0) = \frac{1}{2}$ to $p^H(1) = 1$. We assume that $X = 1$ requires that all n members vote for $X = 1$.

We numerically determine the effects of reputation concerns on a member's incentives to choose $e_i = 1$. Point of departure is an equilibrium in which all members exert effort, $\mathbf{e}^* = (1, 1, \ldots, 1)$. In equilibrium, a member's expected reputation, whether internal or external, equals π. We derive the loss in reputation when a member deviates by choosing $e_i = 0$. The bigger this loss is, the more a concern with reputation motivates to exert effort.

First, consider internal reputations. In equilibrium, i's internal reputation depends on the distribution of the signals of the other members in the committee. Without loss of generality, suppose that member i received a positive signal. Let $r^I(k; \mathbf{e}^*)$denote the equilibrium internal reputation of i when k out of n signals are positive, including i's, conditional on $\mathbf{e}^*$. By deviating to $e_i = 0, i$ reduces the probability that s_i corresponds to the other signals. Consequently, a deviation damages i's reputation in expected terms. Therefore, i's expected reputation becomes lower than π. Let $\Pr(k; \mathbf{e}_0^*)$ denote the probability that the committee receives k positive signals, including $s_i = g$, when only member i deviates to $e_i = 0$. Thus, the expected loss in internal reputation L^I due to the deviation equals

$$L^I(n) = \pi - \sum_{k=1}^{n} \Pr(k; \mathbf{e}_0^*) r^I(k; \mathbf{e}^*). \tag{14}$$

The expressions for $\Pr(k; \mathbf{e}_0^*)$ and $r^I(k; \mathbf{e}^*)$ are given in the Appendix, Section B. Fig. 1 plots this expected loss for $\pi = 0.7$. The figure shows that the larger the committee is, the stronger is the effect of internal reputations on the incentives to exert effort. By deviating in a large committee i's reputation drops sharply.

Next, consider external reputations. The expected loss in external reputation by deviating from $e_i^* = 1$ to $e_i = 0$ equals

$$L^E(n) = \pi - \left(\Pr(1; \mathbf{e}_0^*) r^E(1) + \Pr(0; \mathbf{e}_0^*) r^E(0)\right), \tag{15}$$

where $\Pr(X; \mathbf{e}_0^*)$ denotes the probability that the committee chooses X when member i deviates to $e_i = 0$. As $\pi = \Pr(1; \mathbf{e}^*) r^E(1) + \Pr(0; \mathbf{e}^*) r^E(0)$, this expression can be rewritten as

$$L^E(n) = \left(r^E(1) - r^E(0)\right)\left(\Pr(1; \mathbf{e}^*) - \Pr(1; \mathbf{e}_0^*)\right). \tag{16}$$

Let $q^+(n-1)$ denote the probability that the other $n-1$ members all receive a positive signal given that $\mu = h$ and $q^-(n-1)$ the probability that they do so given that $\mu = -h$. Then,

$$\begin{aligned} \Pr(1; \mathbf{e}^*) - \Pr(1; \mathbf{e}_0^*) &= \tfrac{q^+(n-1)}{2}(\Pr(g|\mu = h; 1) - \Pr(g|\mu = h; 0)) \\ &\quad + \tfrac{q^-(n-1)}{2}(\Pr(g|\mu = -h; 1) - \Pr(g|\mu = -h; 0)). \end{aligned}$$

As $\Pr(g|\mu = h; 1) = (1+\pi)/2$ and $\Pr(g|\mu = -h; 1) = (1-\pi)/2, L^E(n)$ can be written as

$$L^E(n) = \left(r^E(1) - r^E(0)\right)\frac{\pi}{4}(q^+(n-1) - q^-(n-1)), \tag{17}$$

Fig. 2 plots the expected loss in external reputation L^E as a function of n, again for $\pi = 0.7$. It shows that a concern with one's external reputation gives stronger incentives when the committee consists of three rather than two members. For larger committees, an increase in size weakens members' incentives to acquire information. To understand this pattern, three forces should be distinguished. First, the larger a committee is, the more information $X = 1$ contains about members' abilities. For sufficiently high values of $\pi, X = 1$ is already convincing evidence that $\mu = h$ in relatively small committees. As a consequence, this force might be strong for small committees. Second, the larger the committee, the less information $X = 0$ contains about a member's ability. The first force might dominate the second one for (very) small committees, but not for larger committees. The last force is the probabilty that a member's signal is pivotal. This force weakens members' incentives to acquire effort for $n > 2$, and dominates the other forces in larger committees.

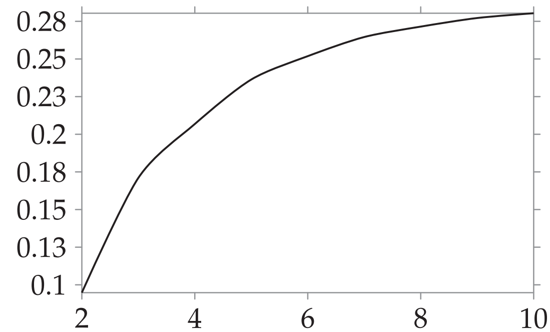

Fig. 1. The incentive to exert effort because of a concern with internal reputations grows in n. Note: The figure plots the expected loss in a member's internal reputation L^I stemming from a deviation from $e_i^* = 1$ to $e_i = 0$ as a function of n, the size of the committee. For $n = 20$, its value equals 0.28804 and for $n \to \infty$it equals 0.28824.

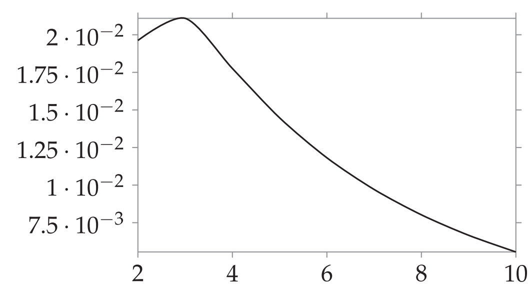

Fig. 2. The incentive to exert effort because of a concern with external reputations peaks for $n = 3$ and then declines quickly. Note: The figure plots the expected loss in a member's external reputation L^E stemming from a deviation from $e_i^* = 1$ to $e_i = 0$ as a function of n, the size of the committee. For $n = 20$, its value equals 1.0052×10^{-3}, for $n = 30$ 1.9481×10^{-4} and for $n = 100$ it equals 2.2248×10^{-9}.

A comparison of Figs. 1 and 2 confirms our earlier result that for the same weights, internal reputations provide stronger incentives to gather information than external reputations. The figures show that this is especially true for large committees.

7. 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 in the deliberation stage, 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.

In our model, committee members are concerned with their reputation for being able. In practice, other reputations might also be relevant. One possibility is that a committee member cares about his perceived effort level (not shirking, being diligent).[13] In that case, we could model committee members' types through the cost-of-effort function. For example, we could assume that the cost of effort for a more diligent agent is generally lower than for a less diligent agent. Another important feature of our model is that agents do not know their abilities. In a model with committee members who care about their perceived effort levels, the assumption that members do not know their types seems implausible. However, if they were not to know their types, a concern with the perception of one's effort would not motivate committee members to exert effort. To understand why suppose that agents are concerned with their reputations for being diligent and that these concerns encourage agents to exert effort. In equilibrium, committee members infer each others' effort levels from their strategies. Reputations for being diligent depend on these equilibrium effort levels. As a result, a deviation to a lower effort level is profitable, as it leaves one's reputation unaffected but reduces the cost of effort. Reputations for being able do motivate members to exert effort because a higher effort level increases the probability of signal congruence, which boosts reputations for being able.

Committees are audiences for their members. The presence of fellow members creates incentives to come prepared, especially because fellow members are active themselves and gather decision-relevant information. This complementarity is at the heart of our analysis. This complementarity does not have to mean that the contribution of each member to the decision-making process is equally large. In fact, a committee can be made up of a dominant member and other members with little apparent influence. Strikingly, our analysis suggests that because of a concern with one's internal reputation, these other members could still continue acquiring information.[14] This is reminiscent of former Federal Reserve Board governor Meyer's description of decision making at the Federal Open Market Committee (FOMC), the monetary policy committee of the Federal Reserve. 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 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. Our analysis suggests that the audience of Board governors and Fed presidents also strengthened Greenspans' incentives.

Some committees, including the FOMC and its counterpart in the Euro zone, the Governing Council of the European Central Bank, are made up of permanent members and rotating members. Interestingly, on both committees, the voting right rotation is without exclusion: whether they have the right to vote or not they receive the same information to prepare for the meeting, they attend the meeting, can contribute to the discussion etc.[15] This paper suggests that, to the extent that these committee members care about their internal reputation, the inclusive nature of such a process stimulates decision-making preparation of all present.

[13] We thank an anonymous referee for suggesting this kind of reputation.
[14] See Appendix C.
[15] See Ehrmann et al. (2022).

Visser and Swank (2007) show, in a model with private signals of exogenous quality and members who put zero weight on their internal reputations, that as long as members' interests are sufficiently aligned with each other an equilibrium exists in which members share their private signals. In this paper, we have assumed that both states are equally likely a priori. As a result, a member's internal reputation depends on how his signal compares to the signal of the other member (and equilibrium effort levels). Even if they could misrepresent their private information, an equilibrium in which they share their private signals would still exist. But if the two states differ in prior probability, a member's internal reputation depends also on a comparison with the a priori more likely state. The incentive compatibility constraints for truth telling may then fail to hold. This would reduce the incentives to acquire 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.

Data availability

No data was used for the research described in the article.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Proofs

Proof of Lemma 1 We suppress e^* in the expressions that follow. We use Bayes rule to obtain

$$\begin{aligned} r^I(g,g) = &\ \Pr(a_i = H|g,g) = \tfrac{\Pr(g,g|H)}{\Pr(g,g)}\Pr(a_i = H) \\ = &\ \tfrac{\Pr(g,g|H,\mu=h)\Pr(\mu=h)+\Pr(g,g|H,\mu=-h)\Pr(\mu=-h)}{\Pr(g,g|\mu=h)\Pr(\mu=h)+\Pr(g,g|\mu=-h)\Pr(\mu=-h)}\pi \\ = &\ \frac{p_i^H p_j^M + \left(1-p_i^H\right)\left(1-p_j^M\right)}{p_i^M p_j^M + \left(1-p_i^M\right)\left(1-p_j^M\right)}\pi. \end{aligned} \tag{A.1}$$

Similarly,

$$r^I(g,b) = \frac{p_i^H\left(1-p_j^M\right) + (1-p_i^H)p_j^M}{p_i^M\left(1-p_j^M\right) + (1-p_i^M)p_j^M}\pi. \tag{A.2}$$

Because of symmetry,

$$r^I(b,b) = r^I(g,g) \text{ and } r^I(b,g) = r^I(g,b). \tag{A.3}$$

It is straightforward to check that

$$r^I(s,s) > \pi > r^I(s\prime,s), \text{ with } s \neq s\prime. \tag{A.4}$$

Proof of Lemma 2 As $X = 1$ requires two positive signals,

$$r^E(1) = r^I(g,g) = \frac{\Pr(g,g|H)}{\Pr(g,g)}\pi, \tag{A.5}$$

where we have suppressed reference to e^*. The expression for $r^E(0)$ then follows easily from writing it as

$$r_i^E(0) = \frac{1-\Pr(g,g|H)}{1-\Pr(g,g)}\pi \tag{A.6}$$

Note that $r^E(1) > r^E(0)$ holds because $\left(p_j^M - \frac{1}{2}\right)(p_i^H - p_i^M) > 0$ holds and this implies $\Pr(g,g|H) > \Pr(g,g)$.

Proof of Proposition 1: We begin by deriving the expression for the marginal benefits of effort, (6). The *ex ante* expected project payoffs equal

$$\Pr(g,g,e_i,e_j)\left(k+\mathbb{E}[\mu|g,g,e_i,e_j]\right).$$

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

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

As a result, the expected marginal benefit 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 derived from the external reputation $\lambda\sum_X\Pr(X,e_i,e_j)r_i^E(X)$with respect to e_i yields

$$\lambda\frac{\partial p(g,g)}{\partial e_i}\Delta r^E(X)=\lambda\frac{\partial p_i^M}{\partial e_i}\left(p_j^M-\frac{1}{2}\right)\left(r^E(1)-r^E(0)\right).$$

Similarly, differentiating with respect to e_i the expected utility $\gamma\sum_{(s_i,s_j)}\Pr(s_i,s_j,e_i,e_j)r^I(s_i,s_j)$derived from the internal reputation gives

$$\gamma\frac{\partial\Pr(s_1^g,s_2^g)}{\partial e_i}r^I(g,g)+\gamma\frac{\partial\Pr(b,g)}{\partial e_i}r^I(b,g)+ \tag{A.7}$$
$$\gamma\frac{\partial\Pr(g,b)}{\partial e_i}r^I(g,b)+\gamma\frac{\partial\Pr(s_1^b,s_2^b)}{\partial e_i}r_i^I(b,b).$$

Note that

$$\frac{\partial\Pr(g,g)}{\partial e_i}=-\frac{\partial\Pr(b,g)}{\partial e_i}\text{and}\frac{\partial\Pr(g,b)}{\partial e_i}=-\frac{\partial\Pr(b,b)}{\partial e_i}$$

for given effort levels, and therefore (A.7) reduces to

$$\gamma\frac{\partial\Pr(g,g)}{\partial e_i}\left(r^I(g,g)-r^I(b,g)\right)+\gamma\frac{\partial\Pr(b,b)}{\partial e_i}\left(r^I(b,b)-r^I(g,b)\right) \tag{A.8}$$
$$=2\gamma\frac{\partial p_i^M}{\partial e_i}\left(p_j^M-\frac{1}{2}\right)\left(r^I(g,g)-r^I(b,g)\right), \tag{A.9}$$

where we used (A.3) to derive the last equality. Putting the three parts (project payoff, external reputation, internal reputation) together gives (6).

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

$$\gamma\frac{\partial p_i^M}{\partial e_i}\left(p_j^M\left(e_j^*\right)-\frac{1}{2}\right)\left(\left(r^I(g,g)-r^I(b,g)\right)-\left(r^E(1)-r^E(0)\right)\right). \tag{A.10}$$

As $r^I(b,g)<r^E(0)<r^I(g,g)=r^E(1)$, this difference is positive. This proves part (1).

(2). We begin by showing that a concern with internal reputations creates strategic complementarity. Differentiate the second line in (6) with respect to e_j^* to obtain

$$2\gamma\frac{\partial p_i^M}{\partial e_i}\left[\left(\frac{\partial p_j^M}{\partial e_j}\right)\left(r^I(g,g)-r^I(b,g)\right)+\left(p_j^M-\frac{1}{2}\right)\left(\frac{\partial r^I(g,g)}{\partial e_j}-\frac{\partial r^I(b,g)}{\partial e_j}\right)\right], \tag{A.11}$$

evaluated in $\left(e_i^*,e_j^*\right)$. Note that

$$\partial r^I(\cdot)/\partial e_j=\left(\partial r^I(\cdot)/\partial p_j^M\right)\left(\partial p_j^M(\cdot)/\partial e_j\right)$$

and $\partial p_j^M/\partial e_j>0$. Thus, $sign(\partial r_i^I(\cdot)/\partial e_j)=sign\left(\partial r^I(\cdot)/\partial p_j^M\right)$. Straightforward derivations show that for $s,s'\in\{g,b\}$with $s\neq s'$,

$$\frac{\partial r^I(s,s)}{\partial p_j^M}=\pi\frac{p_i^H-p_i^M}{\Pr(s,s)^2}>0 \tag{A.12}$$
$$\frac{\partial r^I(s',s)}{\partial p_j^M}=\pi\frac{p_i^H-p_i^M}{\Pr(s',s)^2}<0. \tag{A.13}$$

Thus, member i's marginal utility from internal reputations increases in e_j^*. As a result, the expression in (A.11) is positive and the concern with internal reputations indeed creates strategic complementarity.

Along the same lines one can show that also a concern with external reputations creates strategic complementarity. Differentiate the third line in (6) with respect to e_j^* to obtain

$$\lambda\frac{\partial p_i^M}{\partial e_i}\left[\left(\frac{\partial p_j^M}{\partial e_j}\right)\left(r^E(1)-r^E(0)\right)+\left(p_j^M-\frac{1}{2}\right)\left(\frac{\partial r^E(1)}{\partial e_j}-\frac{\partial r^E(0)}{\partial e_j}\right)\right], \tag{A.14}$$

evaluated in $\left(e_i^*,e_j^*\right)$. Note that $\partial r^E(\cdot)/\partial e_j=\left(\partial r^E(\cdot)/\partial p_j^M\right)\left(\partial p_j^M(\cdot)/\partial e_j\right)$and $\partial p_j^M/\partial e_j>0$. Thus, $sign(\partial r^E(\cdot)/\partial e_j)=sign\left(\partial r^E(\cdot)/\partial p_j^M\right)$. As $r^E(1)=r^I(g,g)$, it follows from (A.12) that $\partial r^E(1)/\partial e_j>0$. Moreover,

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

Thus, member i's marginal utility from external reputations increases in e_j^*. As a result, the expression in (A.14) is positive and the concern with external reputations indeed creates strategic complementarity. This completes the proof of part (2).

(3). In equilibrium, $(s_i,s_j)=(b,b)$ implies an internal reputation equal to $r^I(b,b)>\pi$, and a committee decision $X=0$ and thus an external reputation equal to $r^E(0)<\pi$. This proves part (3).

Proof of Proposition 3: We show here that the marginal utility that a member derives from his expected internal reputation is 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

$$\frac{\partial\Pr(g,g)}{\partial e_i}\left[r^I(g,g)-r^I(b,g)\right]+\frac{\partial\Pr(b,b)}{\partial e_i}\left[r^I(b,b)-r^I(g,b)\right].$$

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 g, we write i's internal reputation as $r^I(s_i,h)$, while if the majority is b, we write $r^I(s_i,-h)$. Notice that

$$r^I(g,h)=r^I(b,-h)=\frac{p_i^H}{p_i^M}\pi>r^I(g,-h)=r^I(b,h)$$
$$=\frac{1-p_i^H}{1-p_i^M}\pi. \tag{A.15}$$

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

$$\frac{\partial\Pr(g,h)}{\partial e_i}r^I(g,h)+\frac{\partial\Pr(g,-h)}{\partial e_i}r^I(g,-h)+$$
$$\frac{\partial\Pr(b,h)}{\partial e_i}r^I(b,h)+\frac{\partial\Pr(b,-h)}{\partial e_i}r^I(b,-h)$$
$$=\left(\frac{\partial\Pr(g,h)}{\partial e_i}+\frac{\partial\Pr(b,-h)}{\partial e_i}\right)\left[r^I(g,h)-r^I(b,h)\right].$$

It can be checked using (A.15), (A.2) and (A.4) that $r^I(g,h) > r^I(s,s)$and $r^I_i(b,h) < \min r^I(s\prime,s)$. This implies that, for the same effort levels, the difference in internal reputation is larger in a large committee than in a 2-person committee, $r^I(g,h) - r^I(b,h) > r^I(s,s) - r^I(s\prime,s)$. Furthermore,

$$\frac{\partial \Pr(s,h)}{\partial e_i} = \frac{\partial p_i^M}{\partial e_i}\frac{1}{2} > \frac{\partial p_i^M}{\partial e_i}\left(p_j^M - \frac{1}{2}\right) = \frac{\partial \Pr(s,s)}{\partial e_i} \tag{A.16}$$

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

Appendix B. Expressions used in Section 6

In Section 6, we define $L^I(n)$ as

$$L^I(n) = \pi - \sum_{k=1}^{n} \Pr(k;\mathbf{e}_0^*) r^I(k;\mathbf{e}^*).$$

In this expression,

$$\begin{aligned}\Pr(k;\mathbf{e}_0^*) =& \frac{1}{2}\sum_{t=0}^{k-1}\left(\frac{(k-1)!}{(k-t-1)!t!}\pi^t \frac{1}{-}2^{k-1-t}(1-\pi)^{k-1-t}\right.\\ &\left.\frac{(n-1)!}{(k-1)!(n-k)!}\left(\frac{1}{-}2^{n-k}(1-\pi)^{n-k}\right)\right)\\ &+\frac{1}{2}\sum_{t=0}^{n-k}\left(\frac{(n-k)!}{(n-k-t)!t!}p^t \frac{1}{-}2^{n-k-t}(1-\pi)^{n-k-t}\right.\\ &\left.\frac{(n-1)!}{(k-1)!(n-k)!}\left(\frac{1}{-}2^{k-1}(1-\pi)^{k-1}\right)\right)\end{aligned}$$

equals the probability that k out of n members, including member i, receive a positive signal in case of effort choices $\mathbf{e}_0^*$, and

$$\begin{aligned} r^I(k;\mathbf{e}^*) =& \frac{A}{A+B}\\ \text{with } A =& \frac{1}{2}p\sum_{t=0}^{k-1}\left(\frac{(k-1)!}{(k-t-1)!t!}p^t \frac{1}{} 2^{k-1-t}(1-p)^{k-1-t}\right.\\ &\left.\frac{(n-1)!}{(k-1)!(n-k)!}\left(\frac{1}{}2^{n-k}(1-p)^{n-k}\right)\right)\\ \text{and } B =& \frac{1}{4}(1-p)\sum_{t=0}^{n-k}\left(\frac{(n-k)!}{(n-k-t)!r!}p^t \frac{1}{}2^{n-k-t}(1-p)^{n-k-t}\right.\\ &\left.\frac{(n-1)!}{(k-1)!(n-k)!}\left(\frac{1}{}2^{k-1}(1-p)^{k-1}\right)\right)\end{aligned}$$

equals i's internal reputation in case k out of n members, including member i, receive a positive signal with effort choices $\mathbf{e}^*$.

In that section, we also derive an expression for $L^E(n)$,

$$L^E(n) = \left(r^E(1) - r^E(0)\right)\frac{\pi}{4}\left(q^+(n-1) - q^-(n-1)\right).$$

Here, we write out the variables $r^E(1), r^E(0), q^+(n-1)$ and $q^-(n-1)$:

$$r^E(1) = \frac{\frac{1}{2}\sum_{t=0}^{n-1}\left(\frac{(n-1)!}{(n-t-1)!t!}\pi^t \frac{1}{}2^{n-1-t}(1-\pi)^{n-1-t}\right)}{\frac{1}{2}\sum_{t=0}^{n}\left(\frac{(n)!}{(n-t)!t!}\pi^t \frac{1}{}2^{n-t}(1-\pi)^{n-t}\right) + \frac{1}{2}(1-\pi)^n \frac{1}{}2^n}\pi$$

$$r^E(0) = \frac{1-\frac{1}{2}\sum_{t=0}^{n-1}\left(\frac{(n-1)!}{(n-t-1)!t!}\pi^t \frac{1}{}2^{n-1-t}(1-\pi)^{n-1-t}\right)}{1-\frac{1}{2}\sum_{t=0}^{n}\left(\frac{(n)!}{(n-t)!t!}\pi^t \frac{1}{}2^{n-t}(1-\pi)^{n-t}\right) + \frac{1}{2}(1-\pi)^n \frac{1}{}2^n}\pi$$

$$q^+(n-1) = \sum_{t=0}^{n-1}\left(\frac{(n-1)!}{(n-t-1)!t!}\pi^t \frac{1}{-}2^{n-1-t}(1-\pi)^{n-1-t}\right)$$

$$q^-(n-1) = (1-\pi)^{n-1}\frac{1}{-}2^{n-1} \tag{B.4}$$

Appendix C. Implementation determined by signal of member 1 only

In the main text, we have investigated committee members' effort decisions when the project is implemented only if both members received a positive signal. We now consider a situation where the project decision is solely based on member 1's signal. Thus, member 2's signal is irrelevant. The main point of this section is to show that although member 2's signal is ignored in the choice stage, it may still be useful to have her in the committee. Thanks to her presence, member 1 acquires more information than in her absence because of his concern with his internal reputation.

Suppose that in the choice stage, the committee chooses $X = 1$ if member 1's signal is positive, and $X = 0$ otherwise. 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. The expected payoff to members 1 and 2 when choosing effort equals

$$\begin{aligned}\text{member } 1: &\Pr(g,e_1)(k + \mathbb{E}[\mu|g,e_1])\\ &+\gamma\sum_{(s_1,s_2)}\Pr(s_1,s_2,e_1,e_2)r_1^I(s_1,s_2) + \lambda\pi - c(e_1)\end{aligned} \tag{C.1}$$

$$\text{member } 2: \gamma\sum_{(s_1,s_2)}\Pr(s_1,s_2,e_1,e_2)r_2^I(s_1,s_2) + \lambda\pi - c(e_2), \tag{C.2}$$

Notice that the r^I carry member-subscripts as effort levels differ across members. The first-order conditions for optimality are

$$\text{member } 1: h\frac{\partial p_1^M}{\partial e_1} + 2\gamma\frac{\partial p_1^M}{\partial e_1}\left(p_2^M(e_2) - \frac{1}{2}\right)\left[r_1^I(s,s) - r_1^I(s\prime,s)\right] = c'(e_1) \tag{C.3}$$

$$\text{member } 2: 2\gamma\frac{\partial p_2^M}{\partial e_2}\left(p_1^M(e_1) - \frac{1}{2}\right)\left[r_2^I(s,s) - r_2^I(s\prime,s)\right] = c'(e_2). \tag{C.4}$$

Compared with *member 2 being absent* from the meeting, her presence adds the marginal returns from a strong internal reputation to the first-order condition of member 1. Her presence thus raises member 1's efforts. Compared with a *joint decision-making process*, which we examined in the main text, 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. Moreover, in the present setting, member 1's concern with his external reputation does not give an incentive to him to exert effort. The net effect on member 1's incentives is ambiguous.

Proposition 4. Suppose that the committee chooses $X = 1$ if $s_1 = g$ and $X = 0$ if $s_1 = b$. Then,

(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 1's incentives to become informed are stronger with member 2 present on the committee rather than her being absent;

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

(5) 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. Finally, note that member 1 exerts more effort than member 2. This result may support the assumption that in the choice stage the committee bases its decision on X solely on member 1's signal.

Appendix D. Mixed decision-making process

In the main text, we have focused on a committee that implements the project only if both members received positive signals. Lemma 2 shows that in this environment, $r^E(1) > r^E(0)$. The implication is that for $\lambda > \bar{\lambda} = -k/[r^E(1) - r^E(0)]$, our assumption about the implementation decision is highly implausible. For $\lambda > \bar{\lambda}$, both members prefer implementation in case of conflicting signals. However, assuming that in this case the committee implements the project unless both members received negative signals does not make sense either. In that case, we would get an equilibrium in which $r^E(0) > r^E(1)$, so that high values of λwould give an incentive to choose implementation in case of conflicting signals. Visser and Swank (2007) show that for high values of λ, regarding the implementation decision an equilibrium in mixed strategies exists.

We now examine effort provision in an equilibrium in which the committee chooses $X = 1$ if both members receive a positive signal, and chooses $X = 1$ with probability β^*if the members receive conflicting signals. In this equilibrium of mixed strategies, both members are indifferent between $X = 0$ and $X = 1$ if $s_1 \neq s_2$:

$$k + \mathbb{E}[\mu|g, b] + \lambda r^E(1) = \lambda r^E(0).$$

The equilibrium values of $r^E(1)$ and $r^E(0)$ depend on β^*. When choosing effort, member i's expected payoff equals

$$\Pr(g, g, e_i, e_j)\left(k + \mathbb{E}[\mu|g, g, e_i, e_j]\right) + \beta\left[\Pr(g, b, e_i, e_j) + \Pr(b, g, e_i, e_j)\right]k$$
$$+\gamma \sum_{(s_i, s_j)} \Pr(s_i, s_j, e_i, e_j) r^I(s_i, s_j) + \lambda \sum_X \Pr(X, e_i, e_j) r^E(X) - c(e_i).$$

The equilibrium effort level satisfies:

$$c'(e) = \frac{\partial p_i^M}{\partial e_i}\left(\left(p_j^M(e^*) - \frac{1}{2}\right)(1 - 2\beta^*)k + \frac{h}{2}\right) \tag{D.1}$$
$$+2\gamma \frac{\partial p_i^M}{\partial e_i}\left(p_j^M(e^*) - \frac{1}{2}\right)\left[r^I(s, s) - r^I(s, s')\right]$$
$$+\lambda \frac{\partial p_i^M}{\partial e_i}\left(p_j^M(e^*) - \frac{1}{2}\right)(1 - 2\beta^*)\left[r^E(1) - r^E(0)\right]$$

Eq. (D.1) reveals three novel effects. First, the first line shows that to reduce the likelihood of conflicting signals, and thereby the implementation of a project with a negative expected value $k < 0$, mixing in the choice stage increases effort. Second, a higher effort level reduces the probability of conflicting signals, and thereby decreases the probability of having a good external reputation. Finally, in an equilibrium with mixing $r^E(1) - r^E(0)$is lower than in the symmetric equilibrium of the main text. This weakens members' incentives to exert effort.

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