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Committee Design with Endogenous Participation

February 25, 2016

Abstract

We analyze different committee designs in a model with the endogenous participation of experts who have private information about their own abilities. Each committee design involves a test of abilities whose accuracy influences experts' decisions to participate. We derive the following findings. First, higher wages lead to lower quality experts. Second, an increase in transparency improves the quality of experts on the committee. Third, larger committees attract less able experts than smaller ones, unless the committee operates under full transparency. Fourth, we derive the properties of optimal committees. They involve low wages and can be transparent or opaque.

Keywords: Committee decision-making, adverse selection, screening, efficiency wages, transparency, career concerns.

JEL: D71, D82, J45.

1 Introduction

Many decisions are taken by committees rather than individuals. Examples include boards of directors, monetary-policy committees, parliamentary committees, academic search committees, and juries. In this paper, we revisit the question of the optimal design of expert committees. While it has been recognized in the literature that the design of a committee may have important consequences for the amount of information collected by its members (see Mukhopadhaya (2003) and Persico (2004)), we focus on how the committee design affects potential members' decisions to join the committee and how this influences the committee's performance.

More specifically, we propose a two-period model of a principal ("she") who delegates a decision to an expert committee.¹ Each candidate ("he") has private information about his individual competence and decides whether to be available for a position on the committee.² If an expert works on the committee, he will earn the wage offered by the principal. In addition, his term on the committee can be viewed as a public test of his ability, which will affect his future wage. The committee design determines how much information outsiders learn about the experts' competence. As a result, different designs entail different future wage distributions and thereby affect experts' decisions to participate in the first place.

Our analysis generates the following findings. First, we show that every committee design attracts only experts with favorable private information about their abilities, provided that the lowest wage is chosen for which experts are willing to participate. Second, we show that the principal prefers the lowest possible wage for which experts are willing to participate. By selecting this wage, she can specifically hire experts of high competence and minimize the wage bill. Thus, our model might provide a rationale for the comparably modest financial

¹The literature on careerist experts can be traced back to Holmström (1999). Ottaviani and Sørensen (2001) build on Scharfstein and Stein (1990) to examine herding in sequential debate. Further analyses of expert committees are Gersbach and Hahn (2008), Hahn (2011), Levy (2007), Ottaviani and Sørensen (2006), Swank et al. (2008), and Visser and Swank (2007).

²Experts may possess private information about their own abilities because they have private non-verifiable information about their past performance in other tasks, for example.

incentives offered to members of some expert committees.^{3,4} For example, Frederic Mishkin was reported to have taken a pay cut, like most recent Federal Reserve governors, when he joined the central bank.⁵ Somewhat surprisingly, the amount of information about individual experts that is revealed during committee decision-making is irrelevant for the principal at the lowest possible wage. This is a consequence of our finding that the lowest wage for which experts apply is identical under all communication systems and, in all cases, it attracts only experts with favorable private information about their abilities.

Third, we show that, under relatively mild restrictions, higher wages continuously decrease the expected quality of experts on the committee. The intuition for this effect is the following: Experts who have private information about their high abilities always find working on the committee profitable as participating in this test of their abilities enables them to demonstrate their competence to the market. By contrast, experts who have unfavorable private information about their abilities expect to do badly in the test and only find working on the committee attractive if wages are high.

Fourth, we ask whether expert committees should operate under transparency or opacity, a question that has received renewed interest when the ECB decided to publish summary minutes of the ECB council's meetings.⁶ We show that more transparent committees typically attract more able experts than more opaque ones for fixed pay and committee size. This is intuitive because a more transparent committee constitutes a more rigorous test of one's ability, which deters experts with unfavorable signals about their competences because they expect to perform poorly in the test.

Fifth, we show that larger committees result in a lower quality of experts on the committee than smaller committees, unless the committee operates under full transparency. This

³An alternative reason for experts accepting low wages may be the personal contacts that they gain during their term on the committee.

⁴The remuneration of members of boards of directors may be rather generous. However, this does not necessarily contradict our analysis because other motives than the ones considered here may influence the size of these remuneration packages. It is also conceivable that observable experience rather than unobservable talent matters more in these cases.

⁵See *Bloomberg*, 05/28/2008, "Mishkin to Leave Fed in August, Return to Columbia".

⁶See *ECB press release*, 18 December 2014, "ECB to publish accounts of monetary policy discussions from January." Gersbach and Hahn (2009) argue that the transparency of decision-making procedures would be harmful in the case of the ECB because central bankers would face increased pressure from the governments to pursue their national interests.

finding stems from the fact that larger committees make it harder for outside observers to assess the individual competence of experts on the committee. As a result, more experts of low ability apply. While expert quality is unaffected by the number of seats under full transparency, full transparency may not be feasible in practice. Hence the harmful effect of a large number of seats identified in this paper may also be relevant for committees that are formally transparent.

Our paper contributes to the general literature on the optimal design of committees. This literature considers the impact of decision-making rules, committee size, and communication systems on performance when committees are used to aggregate preferences, information, or both.⁷ In contributions dealing with the impact of transparency on committee performance, transparency may distort committee members' decisions because the individual members' votes not only affect the outcome but can also be used to signal information about themselves to outsiders or the principal.⁸ In our paper, we focus on the effects of the communication system on the participation decisions of agents. For this reason, we treat the decision-making stage as a black box and do not model the strategic interaction of experts during committee decision-making explicitly.

Recent works on committees with endogenous information acquisition have studied the impact of committee design on members' incentives to acquire costly information.⁹ The present paper differs from this literature in that it considers the adverse-selection problem arising from the endogenous participation of experts with private information rather than the moral-hazard problem that occurs when agents' decisions to acquire costly information are unobservable. Interestingly, despite these differences both paradigms entail similar conclusions as they identify advantages of small and transparent committees over large and opaque ones.¹⁰

⁷The first formal analysis of the advantages of group decision-making goes back to Condorcet (1785). A classic book on committees is Black (1958). For a lucid review of papers on information aggregation by committees, see Austen-Smith and Feddersen (2009).

⁸See Prat (2005), Levy (2007), Gersbach and Hahn (2008, 2009), Visser and Swank (2007), and Seidmann (2011). Fox and Weelden (2012) analyze the impact of transparency on the performance of an individual expert.

⁹See Mukhopadhyaya (2003), Persico (2004), Martinelli (2007), Gerardi and Yariv (2008), Koriyama and Szentes (2009), Gershkov and Szentes (2009), and Gersbach and Hahn (2011) for analyses of committees where members' skills or accuracy of information are endogenous. See Gerling et al. (2005) for a survey.

¹⁰Transparency leads to better-informed experts under endogenous information acquisition (see Gersbach and Hahn (2011)); in the present paper it leads to more able experts. Smaller committees result in less severe

As our paper highlights a relationship between wages and experts' abilities, it contributes to the literature on efficiency wages (see Malcomson (1981) and Akerlof (1982)).¹¹ One approach to explaining such a relationship is self-selection in labor markets. In particular, Guasch and Weiss (1980, 1981) study models where firms use costly tests and application fees as self-selection devices for workers. Our model is related to these two contributions because working on the committee can be viewed as a test of experts' abilities. Mattozzi and Merlo (2008) analyze the effects of politicians' pay in an overlapping generations model. The opportunity to showcase their ability makes political office attractive for highly able candidates. High wages attract also worse candidates and thus lower the average quality of individuals who become politicians. In our paper, we identify a related effect in a committee setting.¹²

Finally, we discuss how our paper relates to the broad literature on screening. This literature analyzes the contract design problem of a principal when agents have private information about their types (see Bolton and Dewatripont (2005, ch. 2) for an overview). Our work differs from the existing literature on screening as we focus on agents who not only enter a contractual relationship with the principal but at the same time attempt to convince a third party of their high abilities. To the best of our knowledge, this case has not been studied in the screening literature as yet.

The evaluation of experts by a third party has significant consequences for our outcomes: While the individual rationality constraint of the agents with a high type is not typically binding in screening models and these agents earn an informational rent under the optimal contract offered by the principal, this individual rationality constraint holds with equality in our framework and agents of a high type therefore do not earn an informational rent.

free-riding problems under endogenous information acquisition (see Mukhopadhaya (2003)); they attract experts of higher quality in this paper.

¹¹Besley (2004) and Messner and Polborn (2004) examine how politician's pay affects citizens' choice to run for office in citizen-candidate models.

¹²The mechanism that leads to the continuous and monotonically decreasing relationship between wages and expected quality is different in the present paper. In Mattozzi and Merlo (2008), this relationship arises because there is a continuum of politician's types. In the present paper, this effect occurs due to the mixing of less able candidates and the fact that the benefits of being on the committee depend on the expected quality of candidates applying for the committee. The precision of the information revealed about the competence of experts depends on the committee's design in our paper, whereas individual political skills are perfectly revealed in office in Mattozzi and Merlo (2008).

Moreover, whereas the principal can offer a menu of different options in screening models, we consider the case where only a single option can be offered to all agents. This contract must include a fixed, performance-independent wage.

Our paper is organized as follows. In Section 2 we outline the basic setup, introduce some abstract properties of committee designs, and define our notion of equilibrium. Section 3 presents general propositions about the existence and uniqueness of equilibria as well as the impact of committee size and the communication system on the quality of experts working on the committee. We study more specific committees in Section 4. In particular, we consider *Opacity*, where only the outcome of committee decision-making is observable, *Intermediate Transparency*, where information about the aggregate behavior of experts is released, and *Full Transparency*, where the individual behavior of experts is revealed. Section 5 discusses several extensions to our framework. In particular, we consider a finite pool of experts, the case where the correctness of the decision cannot be observed, observable expert quality as well as pre-vote communication. Section 6 concludes.

2 Model

2.1 General Setup

The model comprises two periods $t = 1, 2$. A principal wishes to form a committee consisting of N agents in order to solve a specific task. At the beginning of period 1, agents from a continuum can apply.¹³ The successful applicants work for the principal in period 1, whereas the other agents are employed from outside (by the “market”). In period 2, all agents are employed from outside.

Experts are risk-neutral and have a per-period utility function $u(c_t) = c_t$, where c_t denotes consumption in period t , which equals current labor income. Utility in period $t = 2$ is discounted by the factor δ ($\delta > 0$). We explicitly allow for $\delta > 1$, which would have the interpretation that the second period in our model captures a long-term future consisting of

¹³In practice, agents may not formally apply to the committee but agents may be invited by the principal. In this case the pool of candidates would correspond to the set of candidates invited by the principal and an agent’s application would be interpreted as his accepting the principal’s offer.

more than one period. It is important to note that, although in our formal model we assume that agents are only motivated by wage payments, our analysis readily applies to the case where agents derive direct utility from a reputation of high competence.

Each agent i in the pool of candidates is one of two types $\tau_i \in \{H, L\}$, where H stands for high and L for low ability. In the following, we will often omit the index i for the expert where this does not cause confusion. The commonly known prior of an agent being type H is $q \in (0, 1)$. At the beginning of period 1, each agent i receives a private signal $\mathcal{T} \in \{h, l\}$ about his type. Conditional on the agent's true ability $\tau \in \{H, L\}$, this signal is correct with probability $m_\tau \in (0, 1)$, where "correct" means that type H (L) receives signal h (l). Upon observing the signal h or l about his ability, the agent uses Bayes' law to estimate the probability of his being highly competent to be

$$q_h = \frac{qm_H}{qm_H + (1-q)(1-m_L)} \quad \text{or} \quad (1)$$

$$q_l = \frac{q(1-m_H)}{q(1-m_H) + (1-q)m_L}. \quad (2)$$

Our assumptions that $q \in (0, 1)$ and $m_\tau \in (0, 1)$, $\forall \tau \in \{H, L\}$, entail $q_h, q_l \in (0, 1)$, i.e. the expert's signal is never fully informative about his type. We make the additional assumption that $m_H + m_L > 1$, which implies $q_l < q < q_h$.¹⁴ Hence signal l makes an expert less confident in his ability, whereas h has the opposite effect.

After observing the signals about their abilities, all agents decide whether to apply. If more than N agents apply, each of the applicants has identical probability of being selected. If a number of applicants smaller than N applies, all applicants will be hired and the remaining positions will remain vacant. The number of vacant positions is common knowledge.¹⁵ Let \hat{N} be the number of experts actually working on the committee. We will show that $\hat{N} = N$ always holds in equilibrium and thus all vacancies are filled.

When an agent is not working for the principal, he receives a market wage that is given by $w + \kappa\Delta$, where κ is the endogenously determined probability that the market assigns to the eventuality of the agent being type H . Thus, w is the wage that an agent who is manifestly

¹⁴If $m_H + m_L < 1$ held, one would have to exchange the labels of signals h and l to ensure $q_l < q < q_h$.

¹⁵Our procedure of filling positions is equivalent to the one used by Besley (2004, Sec. 3.2).

type L would earn and $w + \Delta$ is the respective wage for type H . Beliefs κ will be updated as new information about an agent's competence becomes available. We assume that H -types receive higher wages, i.e. the exogenous skill premium Δ satisfies $\Delta > 0$. When an agent is working on the committee, he receives the wage $w + b$, i.e. b has the interpretation of a premium over w . We allow for b to be negative.

We assume that it is not commonly known which agents have applied. Moreover, as has been mentioned before, there is a continuum of agents. These two assumptions imply that not working for the principal in the first period is not informative of an agent's competence, i.e. $\kappa = q$ in this case.¹⁶ This feature of our model is meant to capture the fact that agents working for the principal are in a more exposed position than the agents working in the outside sector. Alternatively, ability in our model can also be interpreted as a specific talent as adviser or policy-maker that can only be revealed by working for the principal.^{17,18}

The committee takes a decision that can be either correct or wrong.^{19,20} The principal receives benefits B if the decision is correct and a utility of zero otherwise. Because we want to focus on the participation decisions of experts in this paper, we deliberately refrain from specifying an exact procedure how the committee reaches its decision. Instead, we consider abstract committee designs, where each design stipulates a maximum number N of agents that can work for the principal, a fixed wage b for the committee's members, a function that maps the abilities of experts into probabilities of a successful outcome of decision-making as well as a specification of the information that outsiders learn about the abilities of experts working on the committee. In Section 2.2, we will discuss different properties of the tests of individual abilities implied by different committee designs. More specific committee designs will be examined in Section 4.

¹⁶In Section 5.1, we consider an extension to our model where the fact that an agent is not working on the committee reveals information about his type.

¹⁷Under this interpretation, agents should be viewed as valuing prestige in itself.

¹⁸One might ask whether outside experts could not form a shadow committee like the shadow open market committee to signal their types. However, revealing one's high ability may require information that is only available to members of the official committee such as confidential data, analysis from staff, or detailed instructions by the principal about the task.

¹⁹All propositions in Section 3 do not depend on the assumption of only two possible outcomes.

²⁰Our analysis could also be applied to advisory committees that transmit information to the principal but do not take a decision themselves. In this case, an additional advantage of transparent committees would be that they reveal more detailed information and thereby may enable the principal to make better decisions.

Given a committee design D , the probability of a correct overall outcome is given by a function $\pi_{\hat{N}}^D(n)$, where variable $\hat{N} \in \{0, 1, 2, \dots, N\}$ denotes the number of agents who work for the principal and n ($0 \leq n \leq \hat{N}$) is the number of highly able experts in this group. Henceforth we will sometimes omit the superscript D for the design, where this does not cause confusion. We assume that, for all \hat{N} with $\hat{N} \geq 1$, $\pi_{\hat{N}}^D(n)$ increases with n weakly everywhere and strictly at least at one point.

The principal has to pay the agents' wage bill. Hence, the principal's expected overall payoffs are $B\pi_{\hat{N}}^D(n) - \hat{N}(w + b)$, given that \hat{N} experts serve on the committee, among which n are highly able.²¹ We restrict the principal's choice of b to values at least as large as $\underline{b} := q\Delta - \delta(q_h - q)\Delta$. It is easy to see that for lower levels of b , agents would never be willing to work for the principal. For the moment, we consider the design as given; later we will consider the principal's optimal choice of design at an ex-ante stage.

In the following, we summarize the sequence of events.

1. At the beginning of period 1, Nature determines the types $\tau_i \in \{H, L\}$ for all agents i .
2. Each agent i receives a signal $\mathcal{T}_i \in \{h, l\}$ about his type.
3. Given the design D of the committee and his individual ability signal $\mathcal{T}_i \in \{h, l\}$, each agent i decides whether to apply for the committee.
4. Out of the group of applicants, \hat{N} candidates are selected. Each applicant has equal probability of being selected.
5. Agents working for the principal receive a wage $w + b$. The other agents receive $w + q\Delta$.
6. Information about the abilities of agent working on the committee is revealed (more on this in Section 2.2).
7. In period 2, agents who did not work for the principal in the first period continue to earn a market wage of $w + q\Delta$. Agents who worked for the principal in the first period obtain the wage $w + \kappa_i\Delta$, where in this case κ_i is the Bayesian update of the probability of agent i being type H .

²¹The assumptions in this paragraph are irrelevant for Propositions 1-3.

2.2 Tests of individual abilities implied by committee designs

As has been mentioned before, working for the principal typically reveals information about the abilities of agents to the market. The market will apply Bayes' law and use all publicly available information about the outcomes of the committee decision-making process to form expectations about the abilities of agents. These expectations will determine experts' wages in the second period. For example, under a transparent procedure, information about individuals' votes or statements in discussions may be released and can be used in the market's evaluation of experts' abilities. Under an opaque procedure, information about the success of the committee decision may be available, which is revealing about the abilities of individual experts to some extent.

Let ϕ be the probability of agents applying for the committee to be type H .²² We note that ϕ must lie in the interval $[q_l, q_h]$ because q_l would materialize if only experts with signals l applied and $\phi = q_h$ would hold if only experts with signals h were willing to work for the principal. We introduce $k_{\mathcal{T}}^D(\phi)$ as an expert's expectation of the probability that the market will assign to the event of his being type H , conditional on his signal being $\mathcal{T} \in \{h, l\}$ and the given design D . We will only consider designs for which $k_{\mathcal{T}}^D(\phi)$, $\forall \mathcal{T} \in \{h, l\}$, is a continuous and differentiable function.

In principle, a test implied by a specific design generates two distributions of posterior assessments of experts' abilities: one for experts with ability H and one for ability L . There are two reasons why we do not need to describe these distributions explicitly. First, we concentrate on the agents' expectations about the market's beliefs, as only the latter are relevant for the agents' decisions to apply. Second, because all agents are risk-neutral, we only consider the means of these distributions, $k_h(\phi)$ and $k_l(\phi)$. It is important to note that the test induced by the committee design may also reveal information about the agents' abilities that is unknown to the agents when they apply. However, because agents are risk-neutral, their application decisions are unaffected by the extent to which additional information may be generated by the test.

²²We will consider symmetric equilibria. As a result, ϕ is identical for all agents.

The law of iterated expectations implies that all tests must satisfy

$$\eta k_h(\phi) + (1 - \eta)k_l(\phi) = \phi, \quad (3)$$

where η is defined as the probability of an applicant having observed signal h . Rational expectations have to be unbiased and therefore imply

$$q_h \geq k_h(\phi) \geq k_l(\phi) \geq q_l, \quad \forall \phi \in [q_l, q_h]. \quad (4)$$

It will be instructive to introduce two polar examples of tests, a completely informative and a completely uninformative test. A completely informative test yields $k_h(\phi) = q_h$ and $k_l(\phi) = q_l$ irrespective of the value of ϕ . A completely uninformative test implies $k_h(\phi) = k_l(\phi) = \phi$, i.e. the probability that is assigned to the event of an expert having high ability is equal to the corresponding prior for both signals of expert ability $\mathcal{T} \in \{h, l\}$.

We observe that “completely informative” means that all information contained in the private signal \mathcal{T} is made public by the test. By contrast, a test is “completely uninformative” if it reveals none of the information contained in the agents’ ability signals, although it may reveal information about experts’ abilities that is unknown to the agents when they apply.

We define

$$\alpha(\phi) := \frac{k_h(\phi) - k_l(\phi)}{q_h - q_l} \quad (5)$$

as a test’s accuracy. It is easy to see that $\alpha(\phi) \in [0, 1]$ must hold for all $\phi \in [q_l, q_h]$. Obviously, the accuracy of a completely informative test is 1 and that of a completely uninformative test is 0. We note that with the above definition, $k_h(\phi)$ and $k_l(\phi)$ can be rewritten as follows:

$$k_h(\phi) = \alpha(\phi)q_h + (1 - \alpha(\phi))\phi, \quad (6)$$

$$k_l(\phi) = \alpha(\phi)q_l + (1 - \alpha(\phi))\phi. \quad (7)$$

Hence an arbitrary test can be viewed as a combination of a completely informative test and a fully uninformative test with $\alpha(\phi)$ being the corresponding weight of the fully informative test and $1 - \alpha(\phi)$ the weight of the fully uninformative test. We would like to stress that we explicitly allow for the possibility that the accuracy of the test depends on the average quality of the experts being tested, which is measured by ϕ .

The following property will be useful for our analysis:

Definition 1

A design is *globally, partially informative* if the implied test involves $\alpha(\phi) > 0, \forall \phi \in [q_l, q_h]$.

Intuitively, the property implies that the test may always reveal at least some information that is contained in the private ability signals of the agents. Clearly, $\alpha(\phi) > 0$ is equivalent to $k_h(\phi) > k_l(\phi)$. We note that a completely uninformative test is not *globally, partially informative*, while a fully informative one obviously is.

As we explain now, the sign of the derivative of $k_l(\phi)$ will be crucial for the description of equilibria. We will typically consider *globally, partially informative* designs, which imply that experts with favorable signals find it more attractive to apply than experts with unfavorable signals. As a result, if the design attracts any experts at all, it will induce experts with favorable signals about their abilities to apply. This makes it important to study whether the experts with unfavorable signals apply as well and thus to examine the magnitude of $k_l(\phi)$, which influences how attractive working for the principal is for agents with signal l . Recall that ϕ is the fraction of applicants who are of high ability, and that this is negatively related to the number of applicants with unfavorable signals. According to this observation, a negative sign of the derivative of $k_l(\phi)$ makes the participation decisions of experts with unfavorable signals strategic complements, a positive sign makes these decisions strategic substitutes.

Which sign of the derivative of $k_l(\phi)$ would we typically expect? Consider, for example, a test whose accuracy is constant and smaller than one. Then Equation (7) indicates that $k_l(\phi)$ is a monotonically increasing function of ϕ . Intuitively, an agent with signal l benefits from a better pool of agents working for the principal, i.e. an increase in ϕ , because the test is not fully informative and hence the expected market assessment of his ability will be a weighted average of the market's prior ϕ and the agent's own private assessment of his ability q_l . By contrast, suppose that the accuracy of the test would increase strongly as the quality of applicants improves, i.e. as ϕ rises. The increase in accuracy resulting from increases in ϕ would tend to harm agents with signal l . If the increase in accuracy was sufficiently strong, then $k_l(\phi)$ might decrease for some range of ϕ as ϕ rises.

As can be readily verified, the following property, which imposes an upper bound on the potential increases in accuracy induced by improvements in the quality of applicants, ensures that $k_l(\phi)$ is a strictly increasing function:

Definition 2

A design satisfies the stable accuracy property if the accuracy implied by its test satisfies $\alpha(q_l) < 1$ and

$$\alpha'(\phi) < \frac{1 - \alpha(\phi)}{\phi - q_l}, \quad \forall \phi \in (q_l, q_h]. \quad (8)$$

Later we will also analyze the principal's choice of committee design. Here the following concept that allows for comparing the amounts of information revealed by two designs will be useful:

Definition 3

Design D is globally more informative than D' if the corresponding accuracy $\alpha^D(\phi)$ is globally larger than D' 's accuracy $\alpha^{D'}(\phi)$, i.e. $\alpha^D(\phi) > \alpha^{D'}(\phi) \forall \phi \in [q_l, q_h]$.

2.3 Equilibrium concept

The equilibrium concept we apply is a straightforward extension of a perfect Bayesian equilibrium with two additional refinements. More precisely, an equilibrium consists of a rule determining how beliefs κ about the competence of individual agents are formed as well as the strategies of agents. These strategies prescribe an application probability for both ability signals $\mathcal{T} \in \{h, l\}$. The strategies and beliefs have to satisfy the following standard conditions:

1. Agents' beliefs about their own abilities are adjusted in accordance with Bayes' law. In particular, the agents' expectations about the market's beliefs about their abilities are adjusted with the help of $k_h^D(\phi)$ and $k_l^D(\phi)$.²³ The beliefs initially correspond to the prior q .

²³Later we will specify different committee designs. Then $k_h^D(\phi)$ and $k_l^D(\phi)$ will be explicitly derived using Bayes' law.

2. An agent with signal \mathcal{T} will apply for the committee with certainty if his utility, conditional on being hired by the principal, is strictly higher than otherwise, given the strategies of the other agents and beliefs κ .²⁴ He will never apply if his utility, conditional on being hired, is strictly lower. Agents who are indifferent regarding working for the principal or not may choose a mixed strategy and apply with a probability in the interval $[0, 1]$.

Next we have to specify the two additional restrictions mentioned above. First, we focus on equilibria in which agents' strategies are identical. Second, we introduce a restriction in the spirit of trembling-hand perfection. We define an ε -perturbation of our game as a modification where all signal- h agents apply for the committee with a minimum probability $\varepsilon \in (0, 1)$, i.e. their choice of application probability is restricted to $[\varepsilon, 1]$.²⁵ We only consider equilibria of the unperturbed game for which the agents' strategies and the resulting expected payoffs for the principal are the limits of equilibrium strategies and resulting payoffs for some sequence of ε -perturbed games with $\varepsilon \rightarrow 0$.

A few words are in order regarding the second restriction. As will become clear, it rules out equilibria where pessimistic out-of-equilibrium beliefs about the abilities of agents who apply for the committee lead all agents to refrain from applying in the first place. Alternatively, we could obtain the same results as in this paper by assuming, as is frequently done in the mechanism-design literature, that the equilibrium preferred by the principal or mechanism designer is chosen (for a survey of this literature, see Jackson (2001)).

3 General Results

Having introduced the basic setup and different properties of tests and designs, we are in a position to formulate several general findings. The first finding concerns designs with the lowest possible wage \underline{b} :

²⁴We state this explicitly because the probability of being hired by the principal goes to zero as the number of candidates who apply becomes large.

²⁵Note that we only consider trembles that induce signal- h agents to apply. This can be justified by the observation that these agents always benefit more from working on the committee than the agents with signal l , provided that the design under consideration is *globally, partially informative*. Introducing trembles where agents can apply for the committee only with a maximum probability $1 - \varepsilon$ would not affect our results.

Proposition 1

Consider a design with $b = \underline{b}$. Then multiple equilibria exist. In all of them, experts with signal h apply with positive probability and experts with signal l never apply. All positions are filled, i.e. $\hat{N} = N$. Hence all equilibria imply the same overall payoffs for the principal.

The proof, which is given in Appendix A, demonstrates that at wage \underline{b} , experts with favorable signals about their abilities are indifferent between applying and not applying, provided that $\phi = q_h$. In this case, experts with signal l strictly prefer not to apply, unless $\alpha(q_h) = 0$, which would render them indifferent. Equilibria where experts with unfavorable signals apply with positive probability cannot exist because $\phi < q_h$ would hold in this case, which would imply that the possible gain in reputation that could be achieved by working on the committee would be so low such that all experts would strictly prefer not to apply. Equilibria where pessimistic out-of-equilibrium beliefs prevent all experts from applying are ruled out by the restriction in the spirit of trembling-hand perfection introduced in Section 2.3. It is noteworthy that the proof does not rely on the design being *globally, partially informative*. Hence the statement of the proposition also holds for completely uninformative committee designs, where no information about experts' abilities is revealed.²⁶

Because the lowest possible wage implies the best possible composition of experts, we immediately obtain

Corollary 1

Consider a design with a wage $b > \underline{b}$. Then a design that involves the lowest admissible wage $b = \underline{b}$ but is otherwise identical makes the principal strictly better off.

Another implication of Proposition 1 is that the principal is indifferent between any two designs D and D' that stipulate the lowest possible wage, $b = \underline{b}$, as well as an identical number of seats N and involve $\sum_{n=0}^N \binom{N}{n} q_h^n (1 - q_h)^{N-n} \pi_N^D(n) = \sum_{n=0}^N \binom{N}{n} q_h^n (1 - q_h)^{N-n} \pi_N^{D'}(n)$, i.e. an identical probability of a correct outcome when only experts with signal h apply. Hence the amount of information revealed about the experts' abilities is immaterial at the lowest admissible wage \underline{b} .

²⁶However, the restriction in the spirit of trembling-hand perfection, which was used to rule out additional equilibria where no expert applies, was motivated by the fact that we typically consider *globally, partially informative* designs (see footnote 25).

While a wage of $b = \underline{b}$ is an interesting benchmark, it may not be possible for the principal to select this wage. For example, making agents exactly indifferent between participating or not participating might require a negative wage which may not be feasible, e.g. due to borrowing constraints.²⁷ Moreover, legal constraints or social norms may render very low wages impossible. Finally, it is possible that the principal does not exactly know the outside wage or the intensity of the agents' intrinsic motivation to work on the committee. Therefore we will also consider wages different from \underline{b} in the rest of the paper. The equilibria for general values of b are described in the following proposition, which is proved in Appendix B.

Proposition 2

Consider a fixed wage b with $b > \underline{b}$ and a design of the committee D that is *globally, partially informative* and that satisfies the *stable accuracy property*. Then a unique equilibrium exists. In particular, there are unique values b^{*D} and \bar{b}^D with $\underline{b} < b^{*D} < \bar{b}^D$ such that

1. for $b \in (\underline{b}, b^{*D})$, agents with signal h apply with certainty, while agents with signal l never apply;
2. for $b \in [b^{*D}, \bar{b}^D)$, agents with signal h apply with certainty, while agents with signal l apply with a probability that is zero for $b = b^*$, one when b goes to $b = \bar{b}^D$, and increases strictly in between;
3. for $b \geq \bar{b}^D$, both groups of agents apply with certainty.

One implication of Propositions 1 and 2 is that in all equilibria all vacancies on the committee are filled, provided that the committee designs are *globally, partially informative* and satisfy the *stable accuracy property*. In line with this observation, we will not distinguish between N and \hat{N} for the remainder of this paper.

In addition, Proposition 2 has the noteworthy implication that a higher wage tends to lead to a lower ability of agents working for the principal. This has the following interpretation: Agents with favorable signals about their abilities find it generally more attractive to apply than agents with less favorable signals because the test implied by a *globally, partially informative* design makes some information about the agents' competence levels publicly available. This

²⁷Type H 's reservation wage will also be negative if agents draw direct utility from working on the committee.

tends to enable highly able agents to earn a high wage in the future. Hence for all wages of at least \underline{b} , agents who expect their ability to be high are willing to work on the committee. As the wage increases above \underline{b} , working for the principal becomes more attractive, even to agents with unfavorable signals about their abilities. However, up to wage b^{*D} , agents with signal l would be strictly harmed by applying because working on the committee would likely reveal disadvantageous information about their abilities to the market.

At wages higher than b^{*D} , the wage is, in principle, sufficiently generous for agents with signal l to apply. However, a second, indirect effect reduces the number of agents with signal l who apply: As more less efficient agents apply (and thus the overall quality of applicants, ϕ , drops), the gain in reputation that an agent can achieve by working for the principal is diminished, which is a consequence of the *stable accuracy property* that ensures $k'_i(\phi) > 0$. This effect lowers the expected future wages for these applicants and thereby reduces the incentive to apply. In fact, when $b \in (b^{*D}, \bar{b}^D)$, the direct effect of a wage increase on the signal- l agents' incentive to apply is exactly offset by the indirect effect that works through the deterioration of the committee composition. Under these circumstances, agents with signal l are always indifferent between applying or not applying. For $b \geq \bar{b}^D$, the remuneration is so high such that both groups of agents apply with certainty.

We have already seen that the accuracy of the test implied by the committee's design does not affect the composition of the committee when the lowest admissible wage is selected. The next proposition analyzes how expert quality is affected by the accuracy of the test in the general case where $b > \underline{b}$.

Proposition 3

*Consider two designs D and D' that involve the same wage b , are globally, partially informative, and satisfy the stable accuracy property. Moreover, suppose that D' is globally more informative than D . Let b^{*D} be the value of b^* implied by Proposition 2 for design D and $\bar{b}^{D'}$ the value of \bar{b} implied for design D' . Then the following statements hold:*

1. *For $b \in (b^{*D}, \bar{b}^{D'})$, D' leads to a strictly higher probability of an individual committee member being highly competent, ϕ .*

2. For $b \in [\underline{b}, b^{*D}]$ or $b \geq \bar{b}^{D'}$, the probability of an individual committee member being highly competent remains constant at q_h or q respectively.

See Appendix C for the proof.

The Proposition implies that more informative designs improve the quality of experts working for the principal. This is intuitive as a more accurate test makes working for the principal more attractive to experts with favorable signals but less attractive to the experts with unfavorable signals. The proposition is a first indication that more transparent decision-making procedures typically have the advantage of attracting experts with higher abilities, unless the lowest possible wage \underline{b} is selected.

4 More Specific Scenarios

As the *stable accuracy property* is crucial for our findings in cases where $b > \underline{b}$, it is worth asking whether this property is plausible to hold in committee settings. For this purpose, we will define three scenarios, *Full Transparency*, *Intermediate Transparency*, and *Opacity*. We will show that the *stable accuracy property* holds in all these cases. Moreover, we will prove that the respective designs are *globally*, *partially informative* and that they can be ranked by the *globally more informative* criterion.

Under *Opacity*, only the correctness of the committee's decision becomes publicly available, where the probability of a correct decision is given by the function $\pi_N(n)$ introduced earlier. Under *Full Transparency*, information about the individual contributions to the outcome are publicized as well. Therefore we have to introduce assumptions about individual behaviors in this case, which are unnecessary under *Opacity*.

We assume that there are two possible behaviors of individuals: a correct behavior and a wrong one. By assumption, an expert of ability $\tau \in \{H, L\}$ chooses the correct action with probability p_τ , where $1/2 \leq p_L < p_H \leq 1$. The correctness of individual decisions can be observed by the market. In addition, we make the assumption that the probability of a correct overall decision can be written as a function $f_N(c)$ if there are N experts working on

the committee, out of which $c \leq N$ have made a correct decision. We assume that $f_N(c)$ increases with c weakly everywhere and strictly at least at one point, for all given N . It is straightforward to see that $f_N(c)$ can be used to construct an increasing function $\pi_N(n)$ for the success probability for different numbers n of highly able experts. *Intermediate Transparency* is almost identical to *Full Transparency*. The only difference is that only the total numbers of correct and wrong individual decisions but not the correctness of individual decisions are revealed.

At this point, it is important to note that we directly make assumptions on experts' choices on committees operating under *Full Transparency* and *Intermediate Transparency*, whereas application decisions are always derived from agents' optimization problems. This approach allows us to focus on the endogenous formation of committees and to abstract from the details of committee decision-making. Experts' choices on the committee could also be determined endogenously. For example, we could assume that both types of agents receive signals about which of two *a priori* equally plausible actions is correct, where the signals of experts with ability τ are correct with probability p_τ . In this case, choosing the options suggested by their signals is in the experts' own interests, given that this behavior leads to the highest attainable expected reputation.²⁸

The three scenarios capture some features of monetary-policy committees, for example. *Opacity* can be thought of as describing traditional approaches to communication by central banks, where the monetary-policy decisions were revealed to outside observers but the details of the decision-making process were kept secret. *Intermediate Transparency* can be interpreted as a procedure where summary minutes are released, which corresponds to the ECB's current practice. *Full Transparency* can be seen as a case where the committee publishes attributed minutes and voting records, which is currently done by the Federal Reserve and the Bank of England.

The next proposition, which is proved in Appendix D, confirms that in all three scenarios the crucial properties used in Proposition 2 hold:

²⁸This modeling approach was pursued in a previous version of this paper.

Proposition 4

Full Transparency, Intermediate Transparency, and Opacity are globally, partially informative and satisfy the stable accuracy property.

As a result, Proposition 2 holds for all three scenarios. Thus expert quality is typically a decreasing function of the wage. As a next step, it would be interesting to compare the accuracies implied by the three scenarios to verify whether Proposition 3 can be applied, which states that more transparent committees attract more able experts than more opaque ones. The following proposition, which is proved in Appendix E, compares *Full Transparency* and *Intermediate Transparency*.

Proposition 5

*Consider a fixed total number N of experts working for the principal with $N \geq 2$. Suppose that the probabilities p_H and p_L of an individual committee member making a correct decision are identical under *Full Transparency* and *Intermediate Transparency*. Then *Full Transparency* is globally more informative than *Intermediate Transparency*.*

As has been mentioned before, we abstract from potential changes of behavior in the decision-making stage induced by the communication system, *Full Transparency* or *Intermediate Transparency*, and therefore assume that the probabilities of correct individual decisions are invariant.²⁹ It may be worth noting that the proposition also holds if the probabilities of correct overall decisions $f_N(c)$ are different across both communication systems.

In order to be able to rank *Intermediate Transparency* and *Opacity* by the *globally more informative* criterion, we have to impose more structure on the decision-making procedure. For this purpose, we introduce the following probability of a correct outcome of the decision-making process for odd numbers of seats N

$$f_N^{MR}(c) := \begin{cases} 1 & \text{if } c > N/2 \\ 0 & \text{if } c < N/2, \end{cases} \quad (9)$$

where c is the total number of correct actions by all experts. The particular functional form in (9) can be motivated in the following way. Suppose that there are two states of the

²⁹Our results would continue to hold if p_H and p_L depended on the communication system, unless *Full Transparency* aligned p_H and p_L to a large extent. See Gersbach and Hahn (2011), who discuss a related effect.

world, which are a priori equally likely, and two actions, where the first action is correct in the first state of the world and the second one in the second state. Moreover, assume that experts receive private signals about the state of the world, which are correct with probabilities p_H or p_L respectively. If experts vote their signals and the simple majority rule is used, then the resulting probability of a correct decision will be given by (9).³⁰ In line with this interpretation, the superscript MR stands for “majority rule.” $f_N^{MR}(c)$ can be used to construct an increasing function for the success probability for different numbers n of highly able experts. We label this function $\pi_N^{MR}(n)$. With the help of these definitions, we can show

Proposition 6

*Consider an odd, fixed total number N of experts working for the principal with $N \geq 3$ as well as fixed probabilities p_H and p_L of individual experts making correct decisions with $1/2 \leq p_L < p_H \leq 1$. If the simple majority rule is applied, i.e. the probabilities of successful decisions are given by $f_N^{MR}(c)$ and $\pi_N^{MR}(n)$ under *Intermediate Transparency* and *Opacity*, then *Intermediate Transparency* is globally more informative than *Opacity*.*

The proof is stated in Appendix F.

Hence *Opacity* reveals less information about the abilities of experts than *Intermediate Transparency*, which in turn is less informative about experts’ abilities than *Full Transparency*. This is plausible because the correctness of individual decisions is observable under *Full Transparency*, which is a rather accurate signal about an individual’s ability. By contrast, only the total number of correct decisions is released under *Intermediate Transparency*, which is a noisier signal of the correctness of an individual’s decision and thus also a less precise signal of individual ability. Under *Opacity*, even less information about experts’ abilities becomes publicly known because the market only learns whether a majority of experts made a correct choice or not, which is only loosely informative about the correctness of an individual’s decision and thereby about an individual’s ability. Combined with Proposition 3, Propositions 5 and 6 establish that more transparent committees typically attract more competent experts than opaque ones. As a result, the principal tends to prefer *Full Transparency* to *Intermediate*

³⁰Note that we only consider odd values N because this obviates the need to specify a tie-breaking rule and thereby simplifies the analysis considerably.

Transparency and *Intermediate Transparency* to *Opacity* for fixed wage $b > \underline{b}$ and committee size.³¹

Propositions 5 and 6 exclude the case of a single expert ($N = 1$). For a single expert, it is obvious that *Intermediate Transparency* and *Full Transparency* would lead to tests with identical accuracies. Under the additional assumption that the overall decision is correct iff the individual's decision is correct, *Opacity* also involves the same accuracy in this case because the correctness of an individual expert's decision can be perfectly inferred.

As a next step, we assess the consequences that committee size has for the quality of experts on the committee. Under *Full Transparency*, the abilities of the experts working on the committee are unaffected by the size of the committee, provided that the probabilities of their making a correct decision individually, p_H and p_L , are unaffected by committee size. This follows from the fact that individual behavior can be observed directly in this scenario. It appears plausible that committees that are not fully transparent reveal the less information about an expert's individual ability, the larger the committee is. The following proposition confirms this conjecture for *Intermediate Transparency*:

Proposition 7

Consider two committee designs under Intermediate Transparency with different numbers of seats but identical probabilities p_H and p_L of experts making correct choices. Then the smaller committee is globally more informative than the larger one.

The proof is an immediate consequence of the proof of Proposition 4 in Appendix D, where the accuracy under *Intermediate Transparency* has been derived in Equation (27). In Appendix G, a related claim about the relationship between committee size and accuracy is proved for *Opacity* under the assumption that the correct outcome is adopted iff a majority of experts pursues the correct action.³²

³¹This obviously assumes that the probabilities of correct decisions, $\pi_N(n)$, do not differ strongly across scenarios.

³²We have confirmed that the statement of the proposition also holds for even values of N and fair coin tosses in the case of draws by evaluating the corresponding accuracies numerically.

Proposition 8

Consider a committee under *Opacity* with an odd size $N = 1, 3, 5, \dots$. Each individual may contribute to the overall outcome by a correct action or a wrong one. An expert of ability $\tau \in \{H, L\}$ chooses the correct action with probability p_τ , where $1/2 \leq p_L < p_H \leq 1$. The probability of a correct overall decision is given by $f_N^{MR}(c)$. Then a smaller committee is *globally more informative* than a larger one.

Finally, we observe that it would be straightforward to construct new committee designs by combining the three designs discussed in this section. For example, one could examine opaque committees with the possibility of leaks, i.e. a certain fixed probability of the details of decision-making becoming public (see Ghosh and Roy (2015)). It is possible to show that such committees would also be *globally, partially informative* and satisfy the *stable accuracy property*. Moreover, it would be true that larger committees would lead to less accurate tests of members' abilities and therefore would attract less able experts.

5 Discussion

We now discuss several extensions in more detail. More specifically, we consider a variant of our basic framework with a finite pool of experts, a version where the market cannot observe the correctness of the overall decision, the possibility that the quality of some experts is publicly observable, and the consequences of pre-vote communication as a means of circumventing transparency requirements.

5.1 Finite pool of experts

In our basic framework, we consider an infinite pool of experts. This has two convenient consequences. First, no information about experts' abilities is revealed unless they work on the committee. Second, the assumption of an infinite pool of experts makes the model tractable because all vacancies are filled with certainty.

However, one might ask how our results would change if not working on the committee reflected badly on an expert's reputation. In this section, we consider a version of our

framework where this is the case. More specifically, we assume that the numbers of highly efficient and less efficient experts are known, whereas the identities of these experts are not. For simplicity, we focus on the case where the principal hires a single expert from a pool of experts comprising two experts, one expert being type H and one type L . With probability p_τ , the decision of an expert with ability $\tau \in \{H, L\}$ is correct, where $p_H > p_L \geq 1/2$. This special case is instructive because it allows for a maximum spillover from the reputation of the expert hired by the principal to that of the other expert. For example, if the ability of the expert on the committee is known to be high, this will automatically imply that the outside expert's competence is low. We also make the simplifying assumption that experts know their own abilities perfectly.

In Appendix H, we derive the utility gain $G_L^{FP}(\phi, b)$ of an expert with low ability if he works for the principal compared to the case where he does not. This gain is a function of the wage premium b as well as the probability ϕ that the market assigns to the possibility of the expert hired by the principal being type H before the results of his performance are known.

Clearly, $G_L^{FP}(\phi, b)$ monotonically increases with b , i.e. the wage paid by the principal. Moreover, we show in the appendix that $G_L^{FP}(\phi, b)$ is an increasing function of ϕ . This is due to two effects. First, a higher value of ϕ leads, on average, to higher second-period wages for the expert working for the principal in the first period. This effect is also present in the basic model under the assumption of a design satisfying the *stable accuracy property*. Second, a high value of ϕ reduces the wage that the other expert earns because his probability of being highly competent is $1 - \phi$. Both effects make working for the principal more attractive for higher levels of ϕ .

By analogy with our basic model, we consider equilibria where experts of type H apply with certainty and experts of type L apply with probability $\lambda_L \in [0, 1)$. Thus the equilibrium value of $\phi = 1/(1 + \lambda_L)$ as a function of b is implicitly given by the function $\phi(b)$ solving

$$G_L^{FP}(\phi(b), b) = 0. \tag{10}$$

The implicit function theorem readily implies that $\phi(b)$ is a monotonically decreasing function of b . As a consequence, a low wage is also optimal for the principal in this model variant. The

optimal wage $w + b$ is implicitly given by $G_L^{FP}(1, b) = 0$. At this wage, the expert working for the principal is of type H with certainty. Accordingly, the abilities of both experts are revealed completely. To sum up, the negative relationship between the wage and the ability of the expert working for the principal is not restricted to our model with an infinitely large pool of experts.

5.2 Correctness of the overall decision unobservable

In this section, we discuss variants of the specific committee designs introduced in Section 4 where the market cannot directly observe the correctness of individual behaviors or the overall decision. In such a framework, an opaque committee would not deliver any information about the competence of experts and therefore would constitute a perfectly uninformative test. By contrast, transparent voting records would reveal some information in this regard.

Under *Full Transparency*, i.e., if the individual actions were published, experts choosing the minority position would suffer a loss in reputation whereas experts who support the ultimately implemented decision would gain prestige.³³ Hence, this scenario would result in a *globally, partially informative* design. Numerical simulations reveal that these committee designs satisfy the *stable accuracy property* and become *globally more informative* if the committee size is increased. The latter finding plausible because the competence of a single expert is unobservable in this case, whereas large committees implement the correct decision with high probability and thus tend to reveal the correctness of individual actions. Under *Intermediate Transparency*, a small number of dissenters would signal a larger average competence of experts because experts with high ability are more likely to make aligned choices. Such a scenario would therefore lead to *globally, partially informative* designs.

5.3 Observable expert quality

In the following discussion, we distinguish between two reasons why expert quality may be observable when the principal appoints committee members. First, experts' competence may improve with experience, which is observable. In this case, it would be beneficial for the

³³Swank et al. (2008) investigate the effect that concealing disagreement may be desirable for experts.

principal to condition experts' pay on their experience. However, increasing the wage paid to experts with a specific level of experience will plausibly lower the quality of experts because of the mechanism identified in this paper.

Second, even if experience was of minor importance for the issue at hand, public information about some experts' abilities may be available when these experts have a long track record of working on other committees and have thereby revealed their abilities. More specifically, suppose that there were three groups of experts: Experts whose ability is their private information, experts who are commonly known to be type L , and experts who are commonly known to be type H . Suppose also that $\underline{b} < 0$, which always holds if experts work for a sufficiently long time after their term on the committee or if the fraction of highly competent experts in the pool q is rather low. Condition $\underline{b} < 0$ ensures that the wage $w + \underline{b}$, which is sufficient to attract H -types from the group of experts with unknown ability, is lower than the wage w necessary to attract L -types from the group of experts of known ability. Under these circumstances, it is clearly optimal for the principal to offer $b = \underline{b}$. This will only attract highly competent experts at the lowest possible cost. Hence this property of optimal committees also holds in this variant of our model.

5.4 Pre-vote communication

In a committee where voting records are published, pre-vote communication behind closed doors, which has been analyzed by Swank et al. (2008), may enable committee members to circumvent transparency requirements by coordinating on a joint voting behavior. In this case, our finding that larger committees attract less competent experts will even hold for committees that are formally operating under *Full Transparency*.

6 Conclusions

In this paper, we have examined the impact of committee design on the committee's performance when members' decisions to participate are endogenous. More specifically, we have studied three determinants of committee performance: the remuneration of its members, the

committee's size, and the communication system: *Full Transparency*, *Intermediate Transparency* or *Opacity*.

Experts' incentives to work on the committee are determined not only by the remuneration offered by the principal but also by the reputation they can gain from working on the committee. The potential gain or loss in reputation is affected by the committee design. In particular, we have derived the following results. First, while one would usually expect the quality of experts to increase with remuneration, we obtain the exact opposite: Higher wages attract a larger number of mediocre experts. Second, we have shown that more transparent committees typically attract more able experts because these committees make more information about experts' competence publicly available than less transparent ones. Third, when decision-making is not completely transparent, larger committees attract less able experts than smaller ones. Fourth, we have derived properties of optimal committee designs. They stipulate low wages and the communication system is immaterial in this case.

Finally, we would like to mention that some of our findings may not be restricted to committee settings but may apply to other team problems as well.³⁴ In particular, our finding that larger opaque committees may attract less able members might also have implications for other teams where aggregate output is observable but individual input is not. Moreover, our paper may also have implications for other tests of abilities that individuals take voluntarily. For example, university education can be viewed as a test of inherent abilities to some extent. The prediction of our theory would be that, for given observable indicators of student ability, more costly programs would tend to attract more able students. The quality of students applying to very expensive programs would not depend on the informativeness of the degree certificates. In this sense, grade compression resulting from grade inflation would not affect the participation decisions of potential students and would be irrelevant for the suppliers of such programs.

³⁴The economic theory of teams goes back to Marschak and Radner (1972).

A Proof of Proposition 1

Consider an expert with signal $\mathcal{T} \in \{h, l\}$. The expert will find it strictly profitable to apply if

$$G_{\mathcal{T}}(\phi, b) := w + b + \delta(w + k_{\mathcal{T}}(\phi)\Delta) - (w + q\Delta)(1 + \delta) > 0. \quad (11)$$

Here we have taken into account that the expert receives an outside wage of $w + q\Delta$ in both periods when not working for the principal. If the expert works for the principal, his wage in period 1 will be $w + b$. In the second period, he will earn the market wage, whose expected value is $w + k_{\mathcal{T}}(\phi)\Delta$. In the following, we check all candidate equilibria in ε -perturbations of our game, i.e. we impose the restriction that the application probability of experts with signal h must not be smaller than some fixed $\varepsilon \in (0, 1)$.

First, we examine whether an equilibrium exists where the equilibrium value of ϕ would satisfy $\phi < q_h$. Suppose that, in addition, $\alpha(\phi) < 1$. Then it is easy to see from (6), (7), and (11) that $G_{\mathcal{T}}(\phi, \underline{b}) < 0$ for both signals $\mathcal{T} \in \{h, l\}$. As a consequence, we obtain a contradiction, as the application probability of experts with signal h is zero. Suppose by contrast that $\alpha(\phi) = 1$ at the equilibrium value of ϕ with $\phi < q_h$. This implies $G_l(\phi, \underline{b}) < 0$ and $G_h(\phi, \underline{b}) = 0$. Because experts with signal h apply with positive probability, ϕ has to be equal to q_h , which entails a contradiction. Hence, we can conclude $\phi = q_h$ must hold.

Second, we consider the case $\phi = q_h$, which results in $G_h(q_h, \underline{b}) = 0$ and $G_l(q_h, \underline{b}) \leq 0$, which means that experts with favorable signals are indifferent between applying and not applying and that experts with unfavorable signals about their abilities are either indifferent or prefer strictly not to apply. $\phi = q_h$ can only hold if experts with signal l apply with probability zero. This implies that equilibria exist where experts with signal h apply with positive probability and experts with signal l apply with probability zero. While the application probability of experts with signal h cannot be uniquely pinned down, all strictly positive values of this probability lead to the same composition of agents working for the principal.

At this point, it is important to mention that our refinement in the spirit of trembling-hand perfection enables us to eliminate the equilibrium of the unperturbed game in which all experts refrain from applying with certainty. This is so because it is impossible to find a

sequence of equilibria of ε -perturbed games with $\varepsilon \rightarrow 0$ such that the respective strategies of experts and the resulting payoffs for the principal converge to the strategies and the principal's implied payoffs in the aforementioned equilibrium of the unperturbed game. To see this, note that all seats on the committee are filled for all strictly positive probabilities of individual experts with signal h applying, whereas all seats would remain vacant in the equilibrium of the unperturbed game. As a result, we are left with equilibria of the unperturbed game in which experts who are optimistic about their abilities apply with strictly positive probability. \square

B Proof of Proposition 2

Step 1: Critical values of b To characterize the equilibria, it will be useful to define different critical levels of b . First, recall $G_h(q_h, \underline{b}) = 0$. Intuitively, \underline{b} is the level of b that makes experts with signal h indifferent between applying and not applying when only signal- h experts apply, i.e. $\phi = q_h$. Second, we introduce b^* implicitly with $G_l(q_h, b^*) = 0$. At this level of b , experts with unfavorable signals regarding their individual abilities are indifferent between applying and not applying, provided that $\phi = q_h$, i.e., only experts with favorable signals are expected to apply. Third, \bar{b} is the level of b that satisfies $G_l(q, \bar{b}) = 0$. Intuitively, \bar{b} is the wage premium which makes experts with adverse signals about their types indifferent between applying and not applying, conditional on both groups of experts applying for the committee with certainty.

Next we have to show $\underline{b} < b^* < \bar{b}$. The assumption of a *globally, partially informative* design implies $0 = G_h(q_h, \underline{b}) > G_l(q_h, \underline{b})$. Moreover, because $G_l(q_h, b)$ increases monotonically with b , b^* , which is implicitly defined by $G_l(q_h, b^*) = 0$, is strictly larger than \underline{b} . Because $q < q_h$ and the design satisfies the *stable accuracy property*, $0 = G_l(q_h, b^*) > G_l(q, b^*)$. As a consequence, \bar{b} , which is defined by $G_l(q, \bar{b}) = 0$ is strictly larger than b^* .

Step 2: Candidate equilibria In the following, we check all candidate equilibria in ε -perturbations of our game, i.e. we impose the restriction that the application probability of

experts with signal h must not be smaller than some fixed $\varepsilon \in (0, 1)$. In the following, we distinguish between different ranges for b .

(a) $b \in (\underline{b}, b^*)$ Because of $G_l(q_h, b^*) = 0$ and the monotonicity of $G_l(\phi, b)$ as a function of b and ϕ , which in the second case is implied by the *stable accuracy property*, we can conclude that $G_l(\phi, b) < 0 \forall \phi \in [q_l, q_h], b \in [\underline{b}, b^*)$. As a consequence, no expert with signal l applies for $b \in (\underline{b}, b^*)$. Because experts with signal h apply with positive probability, we can conclude $\phi = q_h$. As a next step, we note that $G_h(q_h, b) > 0 \forall b > \underline{b}$. This implies a unique equilibrium for $b \in (\underline{b}, b^*)$, in which all experts with signal h apply and no expert with signal l applies.

(b) $b \in [b^*, \bar{b}]$ We distinguish between three cases:

(i) Suppose ϕ is such that $G_l(\phi, b) < 0$. As a result, no expert with a low-ability signal applies and hence $\phi = q_h$. However, this leads to a contradiction as $G_l(q_h) \geq 0$ for $b \geq b^*$.

(ii) Suppose ϕ is such that $G_l(\phi, b) > 0$. Because of $G_h(\phi, b) > G_l(\phi, b)$, which is a consequence of the design being *globally, partially informative*, this implies $G_h(\phi, b) > 0$ as well. As both groups of experts apply with certainty, $\phi = q$. However, $G_l(q, b) \leq 0 \forall b \leq \bar{b}$, which results in a contradiction.

(iii) Suppose ϕ is such that $G_l(\phi, b) = 0$. As the design is *globally, partially informative*, $G_h(\phi, b) > G_l(\phi, b)$ and therefore $G_h(\phi, b) > 0$. Hence, all experts with favorable signals about their abilities apply, which implies $\phi \in [q, q_h]$. Because in line with the *stable accuracy property* $G_l(\phi, b)$ is a strictly monotonically increasing function of ϕ with $G_l(q, b) \leq 0$ and $G_l(q_h, b) \geq 0 \forall b \in [b^*, \bar{b}]$, a unique solution for $\phi \in [q, q_h]$ satisfying $G_l(\phi, b) = 0$ always exists. Experts with unfavorable signals about their competences apply with some probability $\psi \in [0, 1]$. For given ϕ , which is pinned down by $G_l(\phi, b) = 0$, ψ can be readily computed from

$$\phi = \frac{qm_H + q(1-m_H)\psi}{qm_H + q(1-m_H)\psi + (1-q)m_L\psi + (1-q)(1-m_L)}.$$

(c) $b > \bar{b}$ First, suppose that $\phi < q$. This implies that each signal- h expert applies with a lower probability than an expert with signal l . It is immediate to see that $G_h(\phi, b) = 0$ must hold as a consequence. However, this leads to a contradiction as $G_h(\phi, b) > G_l(\phi, b)$ and thus $G_l(\phi, b) < 0$, which means that experts with signal l would never apply.

Consequently $\phi \geq q$ has to be satisfied. This implies $G_l(\phi, b) > 0$ and thereby $G_h(\phi, b) > 0$. Hence we conclude that all experts find it profitable to apply and therefore $\phi = q$.

Finally, we note that like in the proof of Proposition 1, our refinement in the spirit of trembling-hand perfection allows us to rule out equilibria of the unperturbed game in which all experts refrain from applying with certainty. \square

C Proof of Proposition 3

Let $G_{\mathcal{T}}^D(\phi, b)$ be the expression implied by (11) for design D and $G_{\mathcal{T}}^{D'}(\phi, b)$ the corresponding expression for design D' . Because D' is *globally more informative* than D , we obtain $G_l^D(\phi, b) > G_l^{D'}(\phi, b) \forall b \geq \underline{b}, \phi \in (q_l, q_h]$. This has the following implications:

1. b^{*D} , the value of b implied by $G_l^D(q_h, b) = 0$, is smaller than the corresponding value $b^{*D'}$.
2. \bar{b}^D , the value of b implied by $G_l^D(q, b) = 0$, is smaller than the corresponding value $\bar{b}^{D'}$.

As a next step, we analyze all possible constellations for b separately:

1. Suppose $b \in [\underline{b}, b^{*D}]$. Then under both designs only experts with signal h apply, which entails $\phi = q_h$.
2. Suppose $b \in (b^{*D}, b^{*D'}]$. Then under design D experts with signal l apply with a strictly positive probability, while under design D' experts with signal l do not apply. Hence the probability that an individual agent working for the principal has high ability is strictly higher under design D' .

3. Suppose $b \in (b^{*D'}, \bar{b}^D)$. First, we observe that $\bar{b}^D \leq b^{*D'}$ might hold.³⁵ Then this constellation obviously cannot arise. Otherwise, ϕ is given by $G_l^{D'}(\phi, b) = 0$ or $G_l^D(\phi, b) = 0$ respectively. Because $G_{\mathcal{T}}^D(\phi, b) > G_{\mathcal{T}}^{D'}(\phi, b) \forall b \geq \underline{b}, \phi \in (q_l, q_h]$, we conclude that ϕ is smaller for D than for D' .
4. Suppose $b \in [\bar{b}^D, \bar{b}^{D'})$. Then under design D , $\phi = q$ holds, whereas $\phi > q$ under design D' .
5. Suppose $b \geq \bar{b}^{D'}$. Then all experts apply under both designs and $\phi = q$.

This establishes the claim of the proposition. □

D Proof of Proposition 4

In this appendix, we show that committees under *Opacity* and *Intermediate Transparency*, as defined in Section 3, are *globally, partially informative* and satisfy the *stable accuracy property*. This readily implies that a committee under *Full Transparency* also satisfies these properties because (i) the behavior of an individual expert under *Full Transparency* is independent of the number of experts and (ii) for one-member committees *Opacity* and *Full Transparency* are equivalent under the assumption that the overall decision is correct iff the individual's decision is correct. We consider *Opacity* first and then move on to *Intermediate Transparency*.

D.1 Opacity

Step 1: Globally, partially informative design In the following, we focus on the expected assessment of an expert's ability by the market in the *Opacity* scenario. We use i to denote the corresponding expert. In order to state the probability that the market assigns to the event of expert i being type H , it will be useful to introduce $P(C|\tau_i)$ as the probability of a correct committee decision, conditional on i 's true type $\tau_i \in \{H, L\}$. We note that $P(C|\tau_i)$

³⁵In this situation, the second and the fourth conditions analyzed here could hold simultaneously. However, this would not affect our results.

is also a function of ϕ , which is the market's assessment of individual experts' abilities prior to the outcome of the task becoming known. It is given by

$$P(C|H_i) = \sum_{n=0}^{N-1} \rho_n^{N-1} \pi_N(n+1), \quad (12)$$

$$P(C|L_i) = \sum_{n=0}^{N-1} \rho_n^{N-1} \pi_N(n), \quad (13)$$

where $\rho_n^{N'}$ is the probability of n experts out of N' experts being type H , provided that the probability of an individual expert being type H is ϕ . Probability $\rho_n^{N'}$ can be written as $\rho_n^{N'} = \binom{N'}{n} \phi^n (1-\phi)^{N'-n}$.

In line with Bayes' law, the probability of expert i being type H , conditional on the overall decision being (C)orrect or (W)rong can be stated as

$$P(H_i|C) = \frac{\phi P(C|H_i)}{\phi P(C|H_i) + (1-\phi) P(C|L_i)}, \quad (14)$$

$$P(H_i|W) = \frac{\phi(1 - P(C|H_i))}{\phi(1 - P(C|H_i)) + (1-\phi)(1 - P(C|L_i))}. \quad (15)$$

We note that the monotonicity of $\pi_N(n)$ with regard to n entails that $P(C|H_i) > P(C|L_i)$ holds for all $\phi \in [q_l, q_h]$. This has the implication that $P(H_i|C) > P(H_i|W)$ holds for all $\phi \in [q_l, q_h]$.

Using the notation introduced above, we obtain

$$k_{\mathcal{T}}^O(\phi) = [q_{\mathcal{T}} P(C|H_i) + (1 - q_{\mathcal{T}}) P(C|L_i)] P(H_i|C) \\ [1 - (q_{\mathcal{T}} P(C|H_i) + (1 - q_{\mathcal{T}}) P(C|L_i))] P(H_i|W), \quad (16)$$

where the superscript O stands for “*Opacity*.” With the help of (5) and (16), we can write the accuracy of the test under *Opacity* as

$$\alpha^O(\phi) = (P(C|H_i) - P(C|L_i))(P(H_i|C) - P(H_i|W)). \quad (17)$$

As $P(C|H_i) > P(C|L_i)$ and $P(H_i|C) > P(H_i|W)$ are satisfied for all $\phi \in [q_l, q_h]$, $\alpha^O(\phi) > 0$ holds for all $\phi \in [q_l, q_h]$. Hence an opaque committee is *globally, partially informative*.

Step 2: Stable accuracy property As a next step, we turn to the *stable accuracy property*. This property holds iff $\frac{\partial}{\partial \phi} k_i^O(\phi) > 0$ for all $\phi \in [q_l, q_h]$. According to (16), this can be written as

$$\begin{aligned} \frac{\partial}{\partial \phi} \left[(q_l P(C|H_i) + (1 - q_l) P(C|L_i)) P(H_i|C) \right. \\ \left. + (1 - (q_l P(C|H_i) + (1 - q_l) P(C|L_i))) P(H_i|W) \right] > 0 \end{aligned} \quad (18)$$

for all $\phi \in [q_l, q_h]$. Inequality (18) holds if, for all $\phi \in [q_l, q_h]$, four conditions are met: (i) $\frac{\partial P(C|\tau_i)}{\partial \phi} \geq 0 \forall \tau_i \in \{H, L\}$, (ii) $P(H_i|C) > P(H_i|W)$, (iii) $\frac{\partial P(H_i|C)}{\partial \phi} > 0$, and (iv) $\frac{\partial P(H_i|W)}{\partial \phi} > 0$. In the following, we show that each of these conditions holds.

(i) The property $\frac{\partial P(C|\tau_i)}{\partial \phi} \geq 0 \forall \tau_i \in \{H, L\}$ is intuitively clear: While keeping the competence of one expert fixed at τ_i , an increase in the probability of all other members being highly competent leads to an increase in the probability of a correct overall decision.³⁶ Formally, it is straightforward to show this by focusing on the distribution of the number of competent experts in the group of $N - 1$ remaining experts, i.e. those experts that are different from the expert under consideration. We note that an increase in ϕ leads to a new distribution that first-order stochastically dominates the original distribution. Because $\pi_N(n)$ weakly monotonically increases with n and strictly increases at least at one point, the property $\frac{\partial P(C|\tau_i)}{\partial \phi} \geq 0 \forall \tau_i \in \{H, L\}$ ensues.³⁷

(ii) Property $P(H_i|C) > P(H_i|W)$ has already been derived.

(iii) Condition $\frac{\partial P(H_i|C)}{\partial \phi} > 0$ is somewhat tedious to ascertain. To prove it, it will be useful to introduce $P(H_i|n) = n/N$ as the probability that an individual expert i is highly competent, conditional on n experts out of N experts being highly competent. Importantly, like $\pi_N(n)$,

³⁶Only in the case where the expert is the only member serving on the committee does $\frac{\partial P(C|\tau_i)}{\partial \phi} \geq 0$ hold with equality.

³⁷This is intimately related to the result that a decision-maker with non-decreasing utility function prefers a lottery over any other lottery that is first-order stochastically dominated by it (see Mas-Colell et al. (1995, p. 195)).

$P(H_i|n)$ is independent of ϕ . Now an alternative way of stating the probability of an expert being type H , conditional on the overall decision being correct (C), is

$$P(H_i|C) = \frac{\sum_{n=0}^N P(H_i|n)\pi_N(n)\rho_n^N}{\sum_{n=0}^N \pi_N(n)\rho_n^N}. \quad (19)$$

Note that $\xi_n := \frac{\pi_N(n)\rho_n^N}{\sum_{n'=0}^N \pi_N(n')\rho_{n'}^N}$ is a probability mass function for a distribution of n on $0, \dots, N$. Let the corresponding cumulative distribution function be $C(n) := \sum_{l=0}^n \xi_l$. We will show that an increase in ϕ leads to a new distribution that first-order stochastically dominates the original distribution in a strict sense, i.e. for the new cumulative distribution function $\tilde{C}(n)$, we have $\tilde{C}(n) < C(n) \forall n = 0, \dots, N - 1$. Taken with the observation that $P(H_i|n)$ strictly increases with n , this proves the claim.

It remains to show that an increase in ϕ actually renders a new distribution that first-order stochastically dominates the original distribution in the strict sense specified above. For this purpose, it suffices to show that the derivative of $C(n)$ with respect to ϕ is strictly negative for all $n = 0, \dots, N - 1$:

$$\frac{\partial C(n)}{\partial \phi} = \frac{\left(\sum_{k=0}^n \pi_N(k) \frac{\partial \rho_k^N}{\partial \phi}\right) \left(\sum_{l=0}^N \pi_N(l) \rho_l^N\right) - \left(\sum_{k=0}^n \pi_N(k) \rho_k^N\right) \left(\sum_{l=0}^N \pi_N(l) \frac{\partial \rho_l^N}{\partial \phi}\right)}{\left(\sum_{k=0}^N \pi_N(k) \rho_k^N\right)^2}$$

This expression is strictly negative for $n = 0, \dots, N - 1$ if the numerator is smaller than zero, which is equivalent to

$$\left(\sum_{k=0}^n \pi_N(k) \frac{\partial \rho_k^N}{\partial \phi}\right) \left(\sum_{l=n+1}^N \pi_N(l) \rho_l^N\right) - \left(\sum_{k=0}^n \pi_N(k) \rho_k^N\right) \left(\sum_{l=n+1}^N \pi_N(l) \frac{\partial \rho_l^N}{\partial \phi}\right) < 0. \quad (20)$$

At this point, it is useful to observe

$$\frac{\partial \rho_k^N}{\partial \phi} = \frac{k - N\phi}{\phi(1 - \phi)} \rho_k^N, \quad (21)$$

which directly follows from $\rho_k^N = \binom{N}{k} \phi^k (1 - \phi)^{N-k}$. With equation (21), inequality (20) can be restated as

$$\begin{aligned} & \left(\sum_{k=0}^n \frac{k - N\phi}{\phi(1 - \phi)} \pi_N(k) \rho_k^N\right) \left(\sum_{l=n+1}^N \pi_N(l) \rho_l^N\right) \\ & - \left(\sum_{k=0}^n \pi_N(k) \rho_k^N\right) \left(\sum_{l=n+1}^N \frac{l - N\phi}{\phi(1 - \phi)} \pi_N(l) \rho_l^N\right) < 0. \end{aligned}$$

Re-arranging yields

$$\sum_{k=0}^n \sum_{l=n+1}^N \frac{k-l}{\phi(1-\phi)} \pi_N(k) \pi_N(l) \rho_k^N \rho_l^N < 0.$$

Because $k-l < 0$ for all summands, we obtain the claim.

(iv) To show $\frac{\partial P(H_i|W)}{\partial \phi} > 0$, we can rely on several of our previous findings. The probability of an expert being type H , conditional on the overall decision being wrong (W), can be formulated as

$$P(H_i|W) = \frac{\sum_{n=0}^N P(H_i|n)(1-\pi_N(n))\rho_n^N}{\sum_{n=0}^N (1-\pi_N(n))\rho_n^N}. \quad (22)$$

Because the remaining steps are essentially identical to those we have presented to show (iii) (one simply has to substitute $1-\pi_N(n)$ for each $\pi_N(n)$), the details are omitted. This completes the proof for committees under *Opacity*.

D.2 Intermediate Transparency

Under *Intermediate Transparency*, the number of correct decisions is publicized. We use c to denote this number. Given c , the probability that an individual has made a correct decision is c/N . The respective probability of a wrong decision is $(N-c)/N$. Because the probability of an expert who has made a correct decision having high ability is $(\phi p_H)/\bar{p}$, where

$$\bar{p} := \phi p_H + (1-\phi)p_L, \quad (23)$$

and the corresponding probability for an expert with a wrong decision is $(\phi(1-p_H))/(1-\bar{p})$, we can write the probability that the market attaches to an individual's high ability, given that c decisions were correct, as

$$\begin{aligned} P(H_i|c) &= \frac{c}{N} \frac{\phi p_H}{\bar{p}} + \frac{N-c}{N} \frac{\phi(1-p_H)}{1-\bar{p}} \\ &= \left(\frac{1-p_H}{1-\bar{p}} + \frac{c}{N} \frac{p_H - \bar{p}}{\bar{p}(1-\bar{p})} \right) \phi. \end{aligned} \quad (24)$$

Moreover, given his private signal $\mathcal{T} \in \{h, l\}$, an expert expects the market to assign the following probability to his having high ability

$$k_{\mathcal{T}}^{IT} = \sum_{c=0}^{N-1} \left\{ \left[P(H_i|c+1)(q_{\mathcal{T}}p_H + (1-q_{\mathcal{T}})p_L) + P(H_i|c)(q_{\mathcal{T}}(1-p_H) + (1-q_{\mathcal{T}})(1-p_L)) \right] \times \binom{N-1}{c} \bar{p}^c (1-\bar{p})^{N-1-c} \right\}, \quad (25)$$

where the superscript *IT* stands for *Intermediate Transparency*. We have used that the probability of the expert under consideration acting correctly is $q_{\mathcal{T}}p_H + (1-q_{\mathcal{T}})p_L$, conditional on his signal \mathcal{T} . In addition, the above equation relies on the fact that the probability of c of $N-1$ other experts making a correct choice is $\binom{N-1}{c} \bar{p}^c (1-\bar{p})^{N-1-c}$.

With the help of (24), $\sum_{c=0}^{N-1} \binom{N-1}{c} \bar{p}^c (1-\bar{p})^{N-1-c} = 1$, as well as $\sum_{c=0}^{N-1} c \binom{N-1}{c} \bar{p}^c (1-\bar{p})^{N-1-c} = (N-1)\bar{p}$, we can rearrange (25) as

$$k_{\mathcal{T}}^{IT}(\phi) = \left(1 + \frac{(q_{\mathcal{T}} - \phi)(p_H - p_L)(p_H - \bar{p})}{\bar{p}(1-\bar{p})} \frac{1}{N} \right) \phi. \quad (26)$$

Utilizing (5) and (26), we can state the accuracy under *Intermediate Transparency* in the following way:

$$\alpha^{IT}(\phi) = \frac{(p_H - p_L)(p_H - \bar{p})}{\bar{p}(1-\bar{p})} \frac{\phi}{N}. \quad (27)$$

It is clear that (27) is strictly positive for all $\phi \in [q_l, q_h]$. Hence the test is *globally, partially informative*.

It remains to prove that *Intermediate Transparency* satisfies the *stable accuracy property*. For this purpose, observe that $k_l^{IT}(\phi)$, defined in (26), is a strictly monotonically increasing function of ϕ for arbitrary N if it is a strictly monotonically increasing function for $N=1$. However, for $N=1$, *Intermediate Transparency* is equivalent to *Full Transparency* and we have already shown in our analysis of *Opacity* that *Full Transparency* satisfies the *stable accuracy property* and hence involves an increasing function $k_l(\phi)$. This completes the proof.

□

E Proof of Proposition 5

The accuracy under *Intermediate Transparency* has been derived in (27). This expression is a monotonically decreasing function of N . In addition, it is equal to the accuracy under *Full Transparency* for $N = 1$. Hence the accuracy under *Full Transparency* is strictly higher than under *Intermediate Transparency* for $N \geq 2$.

F Proof of Proposition 6

Using (14) and (15), we can rewrite Equation (17) in the following way

$$\alpha^O(\phi) = \phi(1 - \phi) \frac{(P(C|H_i) - P(C|L_i))^2}{(\phi P(C|H_i) + (1 - \phi)P(C|L_i))(1 - (\phi P(C|H_i) + (1 - \phi)P(C|L_i)))}. \quad (28)$$

We write z_H^N and z_L^N for $P(C|H_i)$ and $P(C|L_i)$ to save space. We also introduce $\bar{z}^N := \phi z_H^N + (1 - \phi)z_L^N$, which is the unconditional probability of a correct decision. With this notation (28), can be expressed as

$$\alpha^O(\phi) = \frac{\phi}{1 - \phi} \frac{(z_H^N - \bar{z}^N)^2}{\bar{z}^N (1 - \bar{z}^N)}. \quad (29)$$

Note that $z_\tau^N = \sum_{n=\frac{N+1}{2}}^{N-1} \binom{N-1}{n} \bar{p}^n (1 - \bar{p})^{N-1-n} + p_\tau \binom{N-1}{\frac{N-1}{2}} \bar{p}^{\frac{N-1}{2}} (1 - \bar{p})^{\frac{N-1}{2}}$, where $\bar{p} = \phi p_H + (1 - \phi)p_L$, entails $z_H^N - \bar{z}^N = \binom{N-1}{\frac{N-1}{2}} \bar{p}^{\frac{N-1}{2}} (1 - \bar{p})^{\frac{N-1}{2}} (p_H - \bar{p})$, which implies

$$\alpha^O(\phi) = \frac{\phi}{1 - \phi} \frac{\left(\binom{N-1}{\frac{N-1}{2}} \bar{p}^{\frac{N-1}{2}} (1 - \bar{p})^{\frac{N-1}{2}} (p_H - \bar{p}) \right)^2}{\bar{z}^N (1 - \bar{z}^N)}. \quad (30)$$

For convenience, we repeat the accuracy under *Intermediate Transparency*, Equation (27), as

$$\alpha^{IT}(\phi) = \frac{(p_H - p_L)(p_H - \bar{p})}{\bar{p}(1 - \bar{p})} \frac{\phi}{N}. \quad (31)$$

Note that $\alpha^{IT}(\phi) > \alpha^O(\phi)$ holds for all ϕ iff

$$\bar{z}^N (1 - \bar{z}^N) > N \bar{p}^N (1 - \bar{p})^N \left(\frac{N-1}{2} \right)^2, \quad (32)$$

where we have used $p_H - \bar{p} = (1 - \phi)(p_H - p_L)$. As $\bar{z}^N = \sum_{n=\frac{N+1}{2}}^N \binom{N}{n} \bar{p}^n (1 - \bar{p})^{N-n}$ and $1 - \bar{z}^N = \sum_{n=\frac{N+1}{2}}^N \binom{N}{n} (1 - \bar{p})^n \bar{p}^{N-n}$, (32) is equivalent to

$$\left(\sum_{n=\frac{N+1}{2}}^N \binom{N}{n} x^n \right) \left(\sum_{n=\frac{N+1}{2}}^N \binom{N}{n} x^{-n} \right) > N \binom{N-1}{\frac{N-1}{2}}, \quad (33)$$

where $x := \frac{\bar{p}}{1-\bar{p}}$. The left-hand side of (33) can be written as $\sum_{n=-\frac{N-1}{2}}^{\frac{N-1}{2}} g_n x^n$, where the coefficients g_n satisfy $g_n > 0$ and $g_n = g_{-n}$ for all n with $-(N-1)/2 \leq n \leq (N-1)/2$. As a consequence, the left-hand side of (33) is equivalent to $g_0 + \sum_{n=1}^{\frac{N-1}{2}} g_n (x^n + x^{-n})$. Because $x^n + x^{-n}$ increases with x for $x > 1$ and $n \geq 1$, the left-hand side of (33) increases with x . Hence (33) holds for all $x > 1$ if it holds for $x = 1$:

$$\left(\sum_{n=\frac{N+1}{2}}^N \binom{N}{n} \right) \left(\sum_{n=\frac{N+1}{2}}^N \binom{N}{n} \right) > N \binom{N-1}{\frac{N-1}{2}}. \quad (34)$$

This condition is equivalent to

$$2^{N-1} > \sqrt{N} \binom{N-1}{\frac{N-1}{2}}. \quad (35)$$

With the help of $\sqrt{2\pi} n^{n+1/2} e^{-n+\frac{1}{12n+1}} < n! < \sqrt{2\pi} n^{n+1/2} e^{-n+\frac{1}{12n}}$ (see Robbins (1955)), it is straightforward but somewhat tedious to derive

$$\sqrt{N} \binom{N-1}{\frac{N-1}{2}} < 2^{N-1} \sqrt{\frac{2}{\pi}} \frac{1}{\sqrt{N-1}} e^{\frac{1}{12} \frac{-3N+5}{N^2-1}}. \quad (36)$$

Hence a sufficient condition for (35) is

$$1 > \sqrt{\frac{2}{\pi}} \frac{\sqrt{N}}{\sqrt{N-1}} e^{\frac{1}{12} \frac{-3N+5}{N^2-1}}. \quad (37)$$

As $-1 < \frac{1}{12} \frac{-3N+5}{N^2-1} < 0 \forall N \geq 3$ and $e^y < 1 + y/2 \forall y \in (-1, 0)$, a sufficient condition for (37) is

$$1 > \frac{2}{\pi} \left(1 + \frac{1}{12} \frac{-3N+5}{N^2-1} \right) + \frac{1}{N}. \quad (38)$$

It is immediate to verify that (38) holds for all N with $N \geq 3$ because $\pi > 3$, $\frac{1}{12} \frac{-3N+5}{N^2-1} < 0$ and $\frac{1}{N} \leq \frac{1}{3}$. Hence *Intermediate Transparency* is *globally more informative than Opacity*. \square

G Proof of Proposition 8

In order to stress that the accuracy under *Opacity* depends on N , we introduce additional superscripts N for $\alpha^O(\phi)$. We have to show that $\alpha^{O,N}(\phi)$ (see (29)), is a strictly monotonically decreasing function of N for odd values N and arbitrary given values of $\phi \in [q_l, q_h]$. The change in $\alpha^{O,N}(\phi)$ induced by an increase of N by 2 equals (up to a strictly positive factor)

$$\frac{(z_H^{N+2} - \bar{z}^{N+2})^2}{\bar{z}^{N+2} (1 - \bar{z}^{N+2})} - \frac{(z_H^N - \bar{z}^N)^2}{\bar{z}^N (1 - \bar{z}^N)}. \quad (39)$$

Recall that $z_\tau^N = \sum_{n=\frac{N+1}{2}}^{N-1} \binom{N-1}{n} \bar{p}^n (1 - \bar{p})^{N-1-n} + p_\tau \binom{N-1}{\frac{N-1}{2}} \bar{p}^{\frac{N-1}{2}} (1 - \bar{p})^{\frac{N-1}{2}}$ entails $z_H^N - \bar{z}^N = \binom{N-1}{\frac{N-1}{2}} \bar{p}^{\frac{N-1}{2}} (1 - \bar{p})^{\frac{N-1}{2}} (p_H - \bar{p})$. Using this expression for $z_H^N - \bar{z}^N$, we obtain that (39) is proportional to

$$\begin{aligned} & \frac{\left(\binom{N+1}{\frac{N+1}{2}} \bar{p}^{\frac{N+1}{2}} (1 - \bar{p})^{\frac{N+1}{2}} \right)^2}{\bar{z}^{N+2} (1 - \bar{z}^{N+2})} - \frac{\left(\binom{N-1}{\frac{N-1}{2}} \bar{p}^{\frac{N-1}{2}} (1 - \bar{p})^{\frac{N-1}{2}} \right)^2}{\bar{z}^N (1 - \bar{z}^N)} \\ &= \left[\frac{\left(4 \frac{N}{N+1} \bar{p} (1 - \bar{p}) \right)^2}{\bar{z}^{N+2} (1 - \bar{z}^{N+2})} - \frac{1}{\bar{z}^N (1 - \bar{z}^N)} \right] \left(\frac{N-1}{2} \right)^2 \bar{p}^{N-1} (1 - \bar{p})^{N-1}, \end{aligned} \quad (40)$$

where we have used that $\binom{N+1}{\frac{N+1}{2}} = 4 \frac{N}{N+1} \binom{N-1}{\frac{N-1}{2}}$. The right-hand side of (40) is negative iff

$$\frac{\bar{z}^{N+2} (1 - \bar{z}^{N+2})}{(\bar{p}(1 - \bar{p}))^2 \bar{z}^N (1 - \bar{z}^N)} > \left(4 \frac{N}{N+1} \right)^2.$$

Using $\bar{z}^N = \sum_{i=(N+1)/2}^N \binom{N}{i} \bar{p}^i (1 - \bar{p})^{N-i}$, this condition can be rewritten as

$$\frac{(N+1)^2 \left(\sum_{i=\frac{N+3}{2}}^{N+2} \binom{N+2}{i} \left(\frac{\bar{p}}{1-\bar{p}} \right)^i \right) \left(\sum_{i=\frac{N+3}{2}}^{N+2} \binom{N+2}{i} \left(\frac{1-\bar{p}}{\bar{p}} \right)^i \right)}{N^2 \left(\sum_{i=\frac{N+1}{2}}^N \binom{N}{i} \left(\frac{\bar{p}}{1-\bar{p}} \right)^i \right) \left(\sum_{i=\frac{N+1}{2}}^N \binom{N}{i} \left(\frac{1-\bar{p}}{\bar{p}} \right)^i \right)} > 16,$$

or, equivalently,

$$\begin{aligned} & \left(\sum_{i=\frac{N+3}{2}}^{N+2} (N+1) \binom{N+2}{i} x^i \right) \left(\sum_{i=\frac{N+3}{2}}^{N+2} (N+1) \binom{N+2}{i} x^{-i} \right) \\ & > \left(\sum_{i=\frac{N+1}{2}}^N 4N \binom{N}{i} x^i \right) \left(\sum_{i=\frac{N+1}{2}}^N 4N \binom{N}{i} x^{-i} \right), \end{aligned} \quad (41)$$

where $x := \frac{\bar{p}}{1-\bar{p}}$. The left-hand side of (41) can be rewritten in the following way:

$$\begin{aligned}
& \left(\sum_{i=\frac{N+3}{2}}^{N+2} (N+1) \binom{N+2}{i} x^i \right) \left(\sum_{i=\frac{N+3}{2}}^{N+2} (N+1) \binom{N+2}{i} x^{-i} \right) \\
&= \left(\sum_{i=\frac{N+1}{2}}^{N+1} (N+1) \binom{N+2}{i+1} x^{i+1} \right) \left(\sum_{i=\frac{N+1}{2}}^{N+1} (N+1) \binom{N+2}{i+1} x^{-(i+1)} \right) \\
&= \left(\sum_{i=\frac{N+1}{2}}^{N+1} (N+1) \binom{N+2}{i+1} x^i \right) \left(\sum_{i=\frac{N+1}{2}}^{N+1} (N+1) \binom{N+2}{i+1} x^{-i} \right).
\end{aligned}$$

This expression is larger than the right-hand side of (41) if

$$(N+1) \binom{N+2}{i+1} > 4N \binom{N}{i}, \quad i = \frac{N+1}{2}, \dots, N+1. \quad (42)$$

With the help of $\binom{n}{k} = \frac{n!}{k!(n-k)!}$, it is easy to show that (42) is equivalent to

$$(N+1)^2(N+2) > 4N(i+1)(N+1-i), \quad i = \frac{N+1}{2}, \dots, N+1. \quad (43)$$

It is straightforward to verify that, if i could be freely chosen from the set of real numbers, the right-hand side of (43) would be maximized by $i = N/2$. Accordingly, (43) holds for all $i = \frac{N+1}{2}, \dots, N+1$, if it is satisfied for $i = N/2$, which yields

$$(N+1)^2(N+2) > 4N(N/2+1)(N+1-N/2) = N(N+2)^2.$$

As $(N+1)^2 > N(N+2)$, this inequality is fulfilled for all N , which proves (41) and hence $\alpha^{O,N}(\phi)$ strictly monotonically decreases with N for all odd values of N . \square

H Analysis of the Model with a Finite Pool of Experts

We note that the expressions for $P(H_i|C)$ and $P(H_i|W)$ given in (14) and (15) also hold in this version of our model. If an expert of type L works for the principal, his expected utility will be

$$U_{in} = w + b + \delta (w + (p_L P(H_i|C) + (1 - p_L) P(H_i|W)) \Delta). \quad (44)$$

If he does not work for the principal, the expert's expected utility will be

$$U_{out} = w + (1 - \phi) \Delta + \delta \{w + [p_H(1 - P(H_i|C)) + (1 - p_H)(1 - P(H_i|W))] \Delta\}. \quad (45)$$

This expression is easy to interpret. We assume that the outside expert's market wage in the first period is determined before the performance of the expert working for the principal becomes known. As a consequence, the expert who is not working for the principal earns $w + (1 - \phi)\Delta$ in the first period because the probability of his being type H is $1 - \phi$. Moreover, expression (45) takes into account the fact that the other expert will make a correct decision with probability p_H . In this case, the other expert's perceived ability will be $P(H_i|C)$ and the low-type expert under consideration will be estimated to be type H with probability $1 - P(H_i|C)$. Conversely, the high-ability expert will make a wrong decision with probability $1 - p_H$. Then the market assigns probability $1 - P(H_i|W)$ to the event of the outside expert being of high competence.

It can be directly verified with the help of $\frac{\partial P(H_i|C)}{\partial \phi} > 0$ and $\frac{\partial P(H_i|W)}{\partial \phi} > 0$, which were established in Step 2 of Appendix D.1 that $G_L^{FP}(\phi, b) := U_{in} - U_{out}$ monotonically increases with ϕ . Obviously, $G_L^{FP}(\phi, b)$ also increases with b . As a consequence of these observations, applying to the committee is more attractive for experts of low ability when ϕ is large. For intermediate values of b , i.e. values between the ones implicitly defined by $G_L^{FP}(1, b) = 0$ and $G_L^{FP}(0, b) = 0$, the equilibrium value of ϕ is determined by $G_L^{FP}(\phi, b) = 0$.³⁸ Because $G_L^{FP}(\phi, b)$ increases with b , the equilibrium value of ϕ is a decreasing function of b .

For completeness, we compute the optimal wage chosen by the principal at which only experts of high ability apply. Setting $U_{in} = U_{out}$ for $\phi = 1$ yields $b = -\delta\Delta$. Hence the principal chooses a wage discount over w that is exactly equal to the discounted future wage surplus $\delta\Delta$ that the expert will receive in the second period because he can reveal his high ability by working on the committee. \square

³⁸Interestingly, the difference $U_{in} - U_{out}$ for experts of type H is identical to $G_L^{FP}(\phi, b)$. Consequently, both types of experts are indifferent between applying and not applying in any equilibrium.

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