Subjective Performance and the Value of Blind Evaluation*

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Abstract

The incentive and project selection effects of agent anonymity are investigated in a setting where an evaluator observes a subjective noisy signal of project quality. Although the evaluator cannot commit *ex ante* to an acceptance criterion, she decides up front between *informed review*, where the agent's ability is directly observable, or *blind review*, where it is not. An ideal acceptance criterion for the evaluator balances the goals of incentive provision and project selection. Relative to this, informed review results in an excessively steep equilibrium acceptance policy: the standard applied to low-ability agents is too stringent and the standard applied to high ability agents is too lenient. Blind review in which all types face the same standard often provides better incentives, but it ignores valuable information for selecting projects. In general, the evaluator prefers a policy of blind (resp. informed) review when the ability distribution is sufficiently skewed toward high (resp. low) types or the agent's payoff from acceptance is sufficiently high (resp. low).

Keywords: fairness, discrimination, peer effect, incentives.

JEL: C73, D02, D81.

> Before Paris, nobody drank our wine. Well, friends did. But their palates were ... less discriminating.
>
> –Bill Pullman as Jim Barrett in *Bottle Shock.*

1 Introduction

The settings in which an evaluator must rely only on her subjective impressions to assess output or performance are diverse and ubiquitous. In cultural environments individuals are asked to evaluate: wine, food, art, poetry, movies, and music. In retail settings experts and panel participants review a vast array of consumer products. In criminal trials and lawsuits

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juries are charged with weighing evidence. And in academia, faculty evaluate: exams, projects, and manuscripts. Given that subjective evaluation is endemic to so many significant situations, it is important to understand what elements add or detract from its efficacy. A crucial question in this regard is whether or not the reviewer should be permitted to use supplemental information such as the applicant's identity and prior record in the current evaluation, i.e., should the reviewer be "informed" or "blind"?

At first glance, the answer to this question may seem obvious: given that it is an individual's output or performance – and not his/her innate ability – that is being evaluated, the review process should be blind whenever feasible in order to minimize bias. Note, however, that not all "bias" is bad. Because evaluation is often inherently noisy, an effective use of information may well dictate that individuals with stronger track records face lower standards. Indeed, the mode of review, blind or informed, varies both across and within evaluation settings.

Wine tasting, for example, is virtually always performed blind. In 1976 a now famous blind tasting, known as the judgment of Paris, is credited with dispelling the widely held belief that fine French wines were superior to those produced in California.[1] Similarly, in classical music, Goldin and Rouse (2000) note that most major U.S. symphony orchestras adopted some form of blind auditioning for hiring new members in the 1970s and 80s. Likewise, consumer products ranging from hi-fi stereo equipment[2] to shampoo[3] are evaluated under conditions of blind review.

Settings in which a mixture of blind and informed review are performed include criminal trials, grading exams, and evaluating scholarly manuscripts for publication. In court proceedings, judges often, but not always, allow jurors to hear evidence on related crimes by the defendant, known as propensity or similar fact evidence. When grading exams, the student's identity is often known to the grader on minor exams but hidden on major ones, e.g., Ph.D. comprehensives. In manuscript evaluations, Blank (1991) reports that among 38 well-known journals in chemistry, biology, physics, mathematics, history, psychology, political science, sociology, and anthropology, 11 used blind review, as did 16 of 38 major economics journals.[4]

Settings in which informed review is the norm include grant proposals and student recruitment. And, there are, of course, numerous settings of subjective performance in which blind review is simply not feasible such as evaluating figure skaters, gymnasts, actors, and tenure cases.

Most extant studies on the effects of blind versus informed review (summarized below)

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[1] See Taber (2005) for a complete story. The Paris tasting is also the subject of the recent motion picture *Bottle Shock*.

[2] See `http://www.stereophile.com/features/141/index8.html`.

[3] See `http://www.consumersearch.com/www/family/shampoo-reviews`.

[4] In a more recent survey of 553 journals across 18 disciplines, Bachand and Sawallis (2003) find that 58% employ blind review.

have been experimental or empirical. While revealing important insights, many of these investigations have presented conflicting evidence, making it difficult – in the absence of a coherent theory – to draw general conclusions or make consistent policy recommendations. In this paper, a simple game-theoretic model is studied that focuses on three common features of many review processes: (1) the "applicant" can improve the quality of his "project" by expending effort; (2) evaluation is typically a noisy process in which the reviewer observes only an imperfect subjective signal of quality; and (3) knowing the identity of the applicant would provide the reviewer with additional information about his ability to produce a high quality project.[5] While the applicant cares only about getting his project accepted, the evaluator is a Bayesian decision maker who weighs her payoffs from implementing the right or the wrong decision.[6]

The equilibrium of this model is examined under three regimes: *commitment* which is an ideal benchmark setting where the quality signal is verifiable and the evaluator can credibly commit to an acceptance criterion, *informed review* in which the evaluator observes the applicant's ability and *blind review* in which the applicant's ability is hidden. In all three cases the reviewer follows a simple equilibrium strategy: accept the project if and only if the quality signal is above a certain threshold or *standard*.

Under informed review, the evaluator – not surprisingly – applies weak standards to high-ability applicants and tough standards to low-ability ones. In fact, these standards are *too* weak and *too* tough when compared with the ideal review process. In a sense, the benchmark process calls for a more "fair" standard across applicants, even though no direct preference for fairness is assumed.

The reason the ideal review policy is flatter than the one implemented under informed review is that it is designed not only to select good projects but also to provide incentives to produce them. Both weak and tough standards generate poor incentives, albeit for opposing reasons. The marginal return to effort is low to an agent who is either very likely to have his project accepted or very likely to have it rejected. The optimally designed acceptance policy thus creates better incentives for agents at both ends of the type distribution by raising the standards facing high-ability agents and lowering those facing low-ability ones. This policy, however, is not time-consistent. Once the applicant has invested effort in the project and submitted it for evaluation, the reviewer would prefer to renege and apply a steeper (informationally-efficient) acceptance policy. Hence, if the quality signal observed by

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[5] The model best fits the evaluation of cultural output such as wine, art, and music, or the grading of sophisticated exams or papers. While it captures some aspects of the academic research review process, the fit is imperfect because scholarly manuscripts are usually reviewed by referees who only advise an editor possessing the ultimate decision authority. Also, in disciplines such as economics where it is commonplace to post working papers on the Internet, blind review is practically infeasible.

[6] The model can be altered to allow the applicant to care about project quality so long as their is some residual incongruity between his payoffs and the evaluator's.

the evaluator is not verifiable (e.g., because it is subjective or impractical to quantify), then it will not be possible for her to credibly implement the relatively flat ideal acceptance criterion. It may, however, be possible for her to commit to remain ignorant about applicant types and apply a completely flat standard; that is, to perform blind review.

Under blind review, the evaluator sets a uniform standard as if she were assessing an applicant of average ability. This policy provides good incentives for applicants at both ends of the type distribution, but blind review is also clearly suboptimal when compared with the ideal policy. Specifically, blind review does not allow the evaluator to use any information about applicant ability to mitigate noise in the review process.

Hence, both informed and blind review procedures are suboptimal, but for different reasons. On one hand, *ex post* project selection is better under informed review, and on the other, *ex ante* incentives are often better under blind review. Thus, the evaluator's preference between review procedures will depend on the environment, especially the distribution of ability in the applicant pool. Specifically, when the distribution of applicants contains a large proportion of high-ability agents, then assessing project quality is relatively less important than providing incentives and the evaluator, therefore, prefers blind review. Conversely, when the applicant pool is skewed toward low ability, then project selection is paramount and the evaluator prefers informed review.

Although the theory predicts that blind review is likely to be chosen when the applicant pool is skewed toward high ability agents, informed review is practiced in a wide variety of institutional settings. One feature common in these settings but absent from the basic model is that reviewers often compete to attract high-quality applications. To investigate the impact of competition on the choice of review process, the model is extended to allow for two identical evaluators who decide strategically whether to adopt blind or informed review. The main finding in this context is that competition creates incentives for evaluators to adopt informed review. This is because high ability applicants strictly prefer the more lenient standards they face under informed review. Since these applicants are most likely to produce high-quality projects, evaluators adopt informed review in order to attract them.

The model is also extended to a setting where the quality of the project is a continuous (rather than a dichotomous) variable. The main findings are shown to be robust with respect to this specification and some additional insights regarding the role of measurement error are obtained.

The remainder of the paper is organized as follows. The relevant literature and its relation to this investigation are discussed in the next section. In Section 3, the basic model is presented. Sections 4, 5, and 6 contain the analysis of the commitment benchmark, informed review, and blind review settings respectively. The three settings are further investigated in the context of a parametric example in Section 7. Section 8 contains three generalizations and extensions of the basic model. Concluding remarks appear in Section 9. Several technical lemmas and the Proofs of all propositions are relegated to the appendix.

2 Related Literature

There is a large empirical and experimental literature on the impact of anonymity on the academic publication process, which is ably surveyed by Snodgrass (2006). In particular, papers by Blank (1991) in economics, Horrobin (1982) in modern languages, Link (1998) in medicine, Peters and Ceci (1982) in psychology, and Zuckerman and Merton (1971) in physics found compelling evidence that informed review is likely to introduce status, gender, or geographical bias in evaluation of scholarly manuscripts. In fact, several of these studies were initiated in response to concerns raised by young and/or female scholars, and subsequently led some journals such as the *American Economic Review* [Ashenfelter (1992)] and the journals of the modern language association, to change their evaluation policy to blind review.

In the 1970s and 80s, the concern about gender-biased hiring caused most major U.S. symphony orchestras to adopt some form of blind auditioning. Goldin and Rouse (2000) estimate that the switch to blind auditions can explain 25 percent of the increase in female orchestra musicians hired over the intervening years.

The theoretical literature on subjective performance evaluation is relatively small [e.g., Levin (2003) and MacLeod (2003)][7] and almost exclusively addresses contracting problems within an agency setting. The current investigation contributes to this literature by considering a complementary setting in which transfers between the parties are not allowed and the principal can remain ignorant of the agent's ability in order to motivate him. In this sense, the interplay between information and incentives at the heart of the analysis is reminiscent of the potential benefits of imperfect monitoring in an agency context. Most notably, Riordan (1990) and Sappington (1986) argue that while facilitating a more efficient quantity decision by the buyer, closer monitoring of costs may undermine a producer's incentives for cost-reduction, due to the fear of being held up by the buyer. In the same spirit, but within a dynamic model, Cremer (1995) shows that the principal may commit to an *ex ante* inefficient monitoring technology to induce the agent to work harder in case of a negative productivity shock.

This paper also relates to the labor literature on statistical discrimination, recognizing the (potential) tension between fairness and efficiency (or incentives). Papers by Norman (2003) and Persico (2002) highlight the fact that it is not a forgone conclusion that a more fair treatment of different groups of individuals interferes with a socially efficient allocation of re-

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[7] See Prendergast (1999) for an overview of the earlier literature.

sources. Depending on the elasticity of each group's production function, insisting on a more equal treatment of groups may also shift equilibrium production toward a more socially efficient level.

The paper most closely related to this one is Coate and Loury (1993), which builds on Arrow (1973). Coate and Loury study a model in which two identifiable groups that are *ex ante* identical invest in human capital. Employers receive noisy subjective signals regarding investment levels and decide who to hire. There are assumed to be multiple equilibria of the investment/evaluation game. Coate and Loury suppose that one group coordinates with employers on an equilibrium with a modest standard and higher investment, while the other group gets stuck in a Pareto inferior equilibrium with a high standard and low investment. In the setting investigated here, by contrast, agent ability is drawn from a continuum and represents real *ex ante* heterogeneity in productivity. Moreover, players are assumed to coordinate on the unique Pareto superior equilibrium. Coate and Loury demonstrate that forcing employers to use the same standard across groups can correct inefficient coordination failure. The focus here is on a very different but complementary question – when is it in the best interest of an evaluator to commit herself not to use fundamentally valuable information in the review process? Hence, the potential benefit of blind review in this context is not to break coordination failure but to raise productivity at both ends of the ability spectrum by pooling incentives.

3 The Basic Model

There are two risk-neutral parties: an applicant (the agent) and an evaluator (the principal) who play a three-stage game. In the first stage, the principal commits to a review policy, which is either *informed* (she directly observes the agent's type) or *blind* (she does not observe the agent's type).

In the second stage, the agent, who knows the review policy and knows his own type θ, exerts effort $p \in [0, 1]$ to prepare a *project* for review by the principal. The ultimate quality of the project is high ($q = h$) with probability p or low($q = l$) with probability $1 - p$.[8] The agent's effort cost is given by

$$C(p; \theta) = \frac{p^2}{2\theta},$$

where $\theta \in [\underline{\theta}, \overline{\theta}] \subset \Re_+$.[9] Hence, θ is a measure of the agent's productivity and may represent either his innate ability or his experience.

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[8] The focus of this investigation is the tradeoff between provision of incentives and the efficient use of information. Although there are a number of ways of capturing this tradeoff, the model presented here is probably the simplest. A version of the model with continuous quality is, however, analyzed in sub section 8.3

[9] The functional form assumed for effort cost is analytically helpful but not critical for the qualitative nature of the results presented below.

In the final stage of the game, the agent submits the project to the principal for evaluation. The principal does not observe p or q directly, but receives a subjective (i.e., non-verifiable) signal of quality, $\sigma \in [\underline{\sigma}, \overline{\sigma}]$. Based upon the outcome of this signal – and the agent's type if the review policy is informed – the principal decides whether to accept or reject the project.

The principal prefers to accept high-quality projects and to reject low-quality ones. In particular, her exogenous payoff from accepting a high-quality project is $v > 0$ and from accepting a low-quality one is $-\ell < 0$. Her payoff from rejecting a low-quality project is taken to be zero, which is sensible since she otherwise could get "something for nothing" in a degenerate equilibrium where she always rejects and the agent never exerts effort. The principal's cost from rejecting a high-quality project is also taken to be zero. This greatly simplifies the analysis and is reasonable in many settings. The more general case in which she also suffers a loss from a false rejection is, however, analyzed in subsection 8.1. It is notationally convenient to define the principal's loss/benefit ratio from accepting a project by $r \equiv \frac{\ell}{v}$.

The agent prefers the project to be accepted regardless of its underlying quality. Specifically, he receives an exogenous gross payoff of $u > 0$ if the principal accepts the project and zero if she rejects it. No monetary transfers between the parties are permitted.[10]

The agent's type, θ is distributed according to the distribution function $G(\cdot)$ possessing density $g(\cdot)$ and finite mean μ. The signal, σ, is drawn from one of two distributions: $F_h(\cdot)$ (with density $f_h(\cdot)$) if project quality is high or $F_l(\cdot)$ (with density $f_l(\cdot)$) if it is low. For analytical convenience, assume $f_q(\cdot)$ is bounded and twice differentiable. The likelihood ratio is defined by $R(\sigma) \equiv \frac{f_h(\sigma)}{f_l(\sigma)}$, and satisfies the following regularity conditions.

Assumption 1 (Signal Technology)**.** *The Likelihood ratio satisfies:*

(i) $R'(\sigma) > 0$*,*

(ii) $R(\underline{\sigma}) = 0$ *and* $R(\overline{\sigma}) = \infty$*,*

(iii) $\lim_{\sigma \to \overline{\sigma}} R(\sigma)(1 - F_q(\sigma)) = \lambda_q$ *exists for* $q \in \{l, h\}$ *and* $\lambda_h > 0$*.*

Part (i) is the familiar monotone likelihood ratio property (MLRP) indicating that higher signals are associated with high project quality. Part (ii) says that the most extreme signals (which occur with probability zero) are perfectly informative. This ensures equilibrium existence. Part (iii) is a boundary condition used below to identify the set of agent types that exert zero effort in equilibrium. Note that MLRP implies $F_l(\sigma) \geq F_h(\sigma)$ and thus $\lambda_h \geq \lambda_l \geq 0$. The requirement $\lambda_h > 0$ is necessary because all types of agent would otherwise exert zero effort under informed review.

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[10] It seems natural in the evaluation environments alluded to in the Introduction to prohibit direct transfers. Nevertheless, a brief remark on the possibility of transfers appears in Section 7.

Example 1 (Signals)**.** *The following signal technology will be used repeatedly below in illustrative examples. The principal's subjective signal is drawn from one of the two triangular densities on [0,1]:* $f_h(\sigma) = 2\sigma$ *or* $f_l(\sigma) = 2(1-\sigma)$*. This implies* $R(\sigma) = \frac{\sigma}{1-\sigma}$, $\lambda_h = 2$, *and* $\lambda_l = 0$ *in agreement with Assumption 1.*

All aspects of the environment are common knowledge, and the solution concept is Pareto efficient Perfect Bayesian equilibrium (PBE). Hence, if multiple PBE exist and they are Pareto rankable, then the principal and agent are assumed to coordinate on the Pareto-superior one.

4 The Commitment Benchmark

The fundamental problem facing the principal is her inability to commit. Because her evaluation results in only a subjective non-verifiable assessment of quality, once she observes σ, the principal will accept the project if an only if doing so will yield her a positive expected payoff. While this is obviously optimal *ex post* (after the agent has sunk effort), it is not generally desirable from an *ex ante* perspective. To highlight this problem, the benchmark case of the principal's optimal review policy under commitment is characterized in this section. It should be understood that implementation of this policy requires both the signal σ to be verifiable and the principal to have the power to commit to abide by any review policy she announces.[11]

To begin the analysis, note that there is no scope for blind review in this context. With full power of commitment, the principal can choose to ignore information whenever doing so is advantageous to her. Hence, it may be assumed that the principal knows the agent's type, θ, when executing the review policy. In general, a review policy is a function, $\alpha(\sigma, \theta)$, specifying the probability that the principal accepts a type θ agent's project when the realized signal is σ. A review policy is called a *standard*, and denoted by $s(\theta)$, if it is a step function of the form

$$\alpha(\sigma, \theta) = \begin{cases} 0, & \text{if } \sigma < s(\theta) \\ 1, & \text{if } \sigma \geq s(\theta). \end{cases}$$

In other words, the project is accepted if and only if the signal σ achieves the standard $s(\theta)$. It can be shown, however, that MLRP implies that the principal always uses a standard when evaluating the project, and hence, there is no loss in generality from restricting attention to this class of review policies.

Given a standard s, a type θ agent will choose p so as to maximize his expected payoff

$$U(p, s; \theta) = u[p(1 - F_h(s)) + (1-p)(1 - F_l(s))] - \frac{p^2}{2\theta}, \tag{1}$$

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[11] Even if σ is verifiable, commitment may be problematic; especially when the review policy calls for the principal to reject a project she would rather accept. Nonetheless, in certain settings it is not completely unrealistic for the principal to commit to an *ex ante* standard. For instance, a PhD advisor may lay out in front of other committee members exactly what findings will constitute a viable thesis, or a supervisor may announce clear goals that must be achieved in order for subordinates to be promoted.

subject to the downward and upward feasibility restrictions, $p \geq 0$ and $p \leq 1$.

The first term in (1) is the agent's expected benefit. It is his exogenous payoff if the project is accepted, u, times the probability of acceptance (i.e., the probability that quality is high and the standard is met $p(1 - F_h(s))$ plus the probability that quality is low and the standard is met $(1 - p)(1 - F_l(s))$). The second term in (1) is just the effort cost $C(p; \theta)$.

The first-order condition characterizing an interior maximum along with the upward feasibility restriction can be combined to give the agent's reaction function:

$$P(s, \theta) = \min\{\theta u(F_l(s) - F_h(s)),\ 1\}. \tag{2}$$

If the feasibility restriction does not bind, then the agent's reaction function is "hump-shaped." To see this, note first that the most extreme standards would elicit no effort at all, $P(\underline{\sigma}, \theta) = P(\overline{\sigma}, \theta) = 0$. Next define $s^* \equiv R^{-1}(1)$. Then

$$P_s(s, \theta) = \theta u(1 - R(s)) f_l(s)$$

is positive for $s < s^*$ (effort is increasing in the standard) and negative for $s > s^*$ (effort is decreasing in the standard). This makes sense. Low standards elicit little effort because projects are rarely rejected and high standards elicit little effort because they are rarely accepted. The marginal return to effort is zero at the extremes and highest when the agent faces intermediate standards. Specifically, setting a standard of s^* would induce the agent to exert maximal effort regardless of his type. (See Figure 2 in Example 4 below.) If, however, θ is sufficiently high, then the upward feasibility restriction will bind for some intermediate range of standards; i.e., the "hump" of the reaction function will become a "plateau" truncated at a height of $P(s, \theta) = 1$.

Of course, inducing the agent to exert effort is only part of the principal's objective. In general, an optimal review policy must both provide incentives and select high-quality projects as often as possible. Specifically, the principal will commit herself to a standard that maximizes her expected payoff[12]

$$V(s, p) = vp(1 - F_h(s)) - \ell(1 - p)(1 - F_l(s)), \tag{3}$$

subject to the agent's reaction function (2).

The principal's objective is straightforward. It is her exogenous benefit from accepting a good project, v, times the probability the project is good and the standard is achieved, $p(1 - F_h(s))$, minus her exogenous loss from accepting a bad project, ℓ, times the probability the project is bad and the standard is achieved, $(1 - p)(1 - F_l(s))$.

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[12] In general there are two situations to consider. The principal might announce the review policy either *before* or *after* observing the agent's type. Because the expectation over θ of $V(s, P(s, \theta))$ is separable in θ, the optimal review policy in either case, however, is found by maximizing this function with respect to s for each value of $\theta \in [\underline{\theta}, \overline{\theta}]$.

Substituting the agent's reaction function directly into (3) results in the function

$$V(s,P(s,\theta)) = vP(s,\theta)(1-F_h(s)) - \ell(1-P(s,\theta))(1-F_l(s)). \tag{4}$$

This function is continuous, and hence achieves a maximum on the compact interval $[\underline{\sigma},\overline{\sigma}]$. The following assumption ensures sufficiency of the first-order condition.[13]

Assumption 2 (Single-Peaked Preferences)**.** *The function* $V(s,P(s,\theta))$ *is strictly quasi-concave in* s *whenever* $P(s,\theta) < 1$*.*

Ignoring the feasibility restrictions for the moment and differentiating (4) with respect to s yields the first-order condition

$$\underbrace{V_s(s,P(s,\theta))}_{\text{Selection Effect}} + \underbrace{V_p(s,P(s,\theta))P_s(s,\theta)}_{\text{Incentive Effect}} = 0. \tag{5}$$

Denote the solution to this equation by $s_0^C(\theta)$. This is the optimal standard the principal would announce for an agent whose type θ fell in the range $[\theta_-^C,\theta_+^C]$ where the feasibility restrictions do not bind.

Equation (5) identifies the tradeoff facing the principal, selection versus incentives. The first term in (5) represents the selection effect:

$$V_s(s,P(s,\theta)) = -[vP(s,\theta)R(s) - \ell(1-P(s,\theta))]f_l(s).$$

As is shown in the next section, setting this term alone equal to zero results in the standard that accepts projects if and only if they have positive expected value to the principal, i.e., if and only if they are *ex post* optimal. On the other hand, the second term in (5) represents the incentive effect:

$$V_p(s,P(s,\theta))P_s(s,\theta) = [v(1-F_h(s)) + \ell(1-F_l(s))]\theta u(1-R(s))f_l(s).$$

As discussed above, setting this term alone equal to zero results in the standard, $s^* = R^{-1}(1)$, that maximizes the agent's effort. In general, it is not possible to set both of these terms to zero simultaneously. In other words, there is tension between the efficient use of information and motivating the agent.

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[13] It is easy to verify that if $R(s) \leq 1$, Assumption 2 is automatically satisfied; and if $R(s) > 1$, it is satisfied whenever

$$-\frac{(R(s)+\frac{r-1}{2})(1-F_l(s))R'(s)}{(R(s)-1)(R(s)+r)} + f_l(s) < 0.$$

This inequality turns out not to be too stringent owing to the assumptions that $f_l(s)$ is bounded, and $\lim_{s\to\overline{\sigma}}[R(s)(1-F_l(s))]$ exists.

Define the endpoints of the interval $[\theta_-^C, \theta_+^C]$ by

$$\theta_-^C \equiv \frac{r}{u(2\lambda_h + (r-1)\lambda_l)}, \tag{6}$$

and

$$\theta_+^C \equiv \min\{\theta \mid P(s_0^C(\theta), \theta) = 1\}. \tag{7}$$

The following result completely characterizes the benchmark solution.

Proposition 1 (Equilibrium under Commitment)**.**

Principal: *Under commitment, the principal sets the standard*

$$s^C(\theta) \equiv \begin{cases} \overline{\sigma}, & \text{if } \theta < \theta_-^C \\ s_0^C(\theta), & \text{if } \theta \in [\theta_-^C, \theta_+^C] \\ \min\{s \mid P(s,\theta) = 1\}, & \text{if } \theta > \theta_+^C \end{cases}$$

Moreover, $s^C(\theta)$ is continuous, strictly decreasing for $\theta > \theta_-^C$, and $\lim_{\theta\to\infty} s^C(\theta) = \underline{\sigma}$.

Agent: *Under commitment, the agent chooses effort level*

$$p^C(\theta) \equiv \begin{cases} 0, & \text{if } \theta < \theta_-^C \\ P(s_0^C(\theta), \theta), & \text{if } \theta \in [\theta_-^C, \theta_+^C] \\ 1, & \text{if } \theta > \theta_+^C. \end{cases}$$

Moreover, $p^C(\theta)$ is continuous, and strictly increasing for $\theta \in (\theta_-^C, \theta_+^C)$.

Several key insights emerge from Proposition 1. First, there is a negative relationship between an agent's ability and the standard set for him. This is a consequence of the selection effect. Higher ability agents are more likely to produce good projects. Recognizing this, the principal accordingly lowers the standard confronting them. It is shown in the next section, however, that this response is attenuated by the commitment setting by the incentive effect. In order to elicit more effort from the agent, the principal commits herself to a standard, $s^C(\theta)$, that is "too flat" to be ex post optimal. In other words, under $s^C(\theta)$, there is a chance that the principal will be forced to reject the project of a high ability agent or accept the project of a low ability one when she would prefer to do otherwise. This possibility is most starkly illustrated for ability levels $\theta \geq \theta_+^C$. For these high-ability types, the upward feasibility restriction binds; i.e., these types exert full effort ($p = 1$). Nevertheless, the standard facing such an agent, $s^C(\theta)$, is greater than the minimum standard, $\underline{\sigma}$. Hence, even though the principal knows for sure that the project is good, she commits herself to reject it with positive probability. Only by doing so can she induce the agent to exert effort in the first place.

At the other end of the spectrum are the low ability agents with $\theta \leq \theta_-^C$. These types of agents are effectively *pre-screened* in the sense that the principal commits never to accept their projects; i.e., $s^C(\theta) = \overline{\sigma}$. Consequently, these types exert no effort, so the downward feasibility restriction binds ($p = 0$). It is true that by lowering the standard facing these types of agents the principal could induce positive effort, but the expected gain arising from the improved incentives would be outweighed by the possibility of having to accept a project that is likely to be low-quality.

Finally, it is straightforward to verify that $s^* \in (s^C(\theta_+^C), \overline{\sigma})$.[14] Hence, there exists a unique critical type θ^* such that $s^C(\theta^*) = s^*$. For this one type of agent, there is no conflict between selection and incentives. In particular, the standard, s^*, set for type θ^* both induces maximal effort and leads to an *ex post* optimal acceptance criterion. For all other types, $\theta \neq \theta^*$, however, the benchmark solution $s^C(\theta)$, strikes a balance between selecting good projects *ex post* and providing incentives *ex ante*.

Example 2 (Commitment). *Suppose the signal technology from Example 1 and that* $v = \ell = u = 1$. *(An example with general parameter values is solved below in Section 7.) From (2), the agent's reaction function is*

$$P(s,\theta) = \min\{2\theta s(1-s),\ 1\}.$$

For $\theta < 2$, *this is hump-shaped and attains a maximum at* $s^* = \frac{1}{2}$. *From (3), the principal's payoff is*

$$V(s,p) = p(1-s^2) - (1-p)(1-s)^2.$$

Substituting $P(s,\theta)$ *into this and maximizing gives the commitment solution*

$$s^C(\theta) = \begin{cases} 1, & \text{if } \theta < \theta_-^C \\ \frac{1}{3} + \frac{1}{6\theta}, & \text{if } \theta \in [\theta_-^C, \theta_+^C] \\ \left(\frac{1}{2}\right)\left(1 - \sqrt{1 - \frac{2}{\theta}}\right), & \text{if } \theta > \theta_+^C, \end{cases}$$

where $\theta_-^C = \frac{1}{4}$ *and* $\theta_+^C = 1 + \frac{3\sqrt{2}}{4}$. *As Proposition 1 indicates,* $s^C(\theta)$ *is decreasing for* $\theta > \theta_-^C$. *Low types with* $\theta \le \theta_-^C$, *are prescreened and induced to exert no effort (*$P(1,\theta) = 0$*), while high types with* $\theta \ge \theta_+^C$ *are induced to exert full effort (*$P(s^C(\theta),\theta) = 1$*). Note that for* $\theta = \theta_+^C$, *the principal knows that the project is high-quality, but she sets a standard of* $s^C(\theta_+^C) \approx 0.4142$. *This means that she rejects the project with probability* $F_h(s^C(\theta_+^C)) \approx 0.1716$. *Finally, setting* $s^C(\theta) = s^*$ *and solving reveals that the critical type that exerts maximum effort is* $\theta^* = 1$.

5 Informed Review

If the principal is unable to credibly commit to a standard, then she cannot act as a Stackleberg leader, maximizing her expected payoff subject to the agent's reaction function. Instead, after

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[14] See the proof of Proposition 3.

the agent has sunk effort, p, in the project, the principal will decide what standard, s, to apply. Because the principal cannot observe p when she selects s, the temporal ordering of moves is actually immaterial. In other words, the effort and standard are determined in a Nash equilibrium of a simultaneous-move game.

If the principal has opted for informed review, then she observes the agent's type when choosing the standard. Hence, she maximizes her expected payoff, $V(s,p)$, given in (3) with respect to s holding fixed p. The first-order condition is

$$V_s(s, P(s,\theta)) = -[vpR(s) - \ell(1-p)]f_l(s) = 0. \tag{8}$$

Rearranging this yields the principal's reaction function

$$S(p) = R^{-1}\left(r\frac{1-p}{p}\right). \tag{9}$$

Note that Assumption 1 implies: $S(0) = \overline{\sigma}$, $S(1) = \underline{\sigma}$, and $S'(p) = -\frac{r}{p^2 R'(s)} < 0$. This makes sense: if the principal believes the project is certainly bad ($p = 0$), then no signal realization will convince her to accept it; i.e., she sets the maximum standard, $\overline{\sigma}$. Similarly, if she believes the project is certainly good ($p = 1$), then no signal realization will deter her from accepting it; i.e., she sets the minimum standard, $\underline{\sigma}$. In general, the higher the principal believes p to be, the lower she sets the standard for acceptance.

(See Figure 2 in Example 4 below.) Observe also that (9) implies that the principal always makes an *ex post* optimal acceptance decision. Specifically, the principal's expected payoff from accepting the project when she observes signal σ is

$$v\frac{pf_h(\sigma)}{pf_h(\sigma) + (1-p)f_l(\sigma)} - \ell\frac{(1-p)f_l(\sigma)}{pf_h(\sigma) + (1-p)f_l(\sigma)}.$$

MLRP implies that this expression is monotone increasing in σ. Moreover, it is easy to verify that it is negative if $\sigma < S(p)$, zero if $\sigma = S(p)$, and positive if $\sigma > S(p)$. Hence, the standard, $S(p)$, induces the principal to accept the project if and only if doing so has a positive expected payoff conditional on the observed signal.

Solving the agent and principal's reaction functions (2) and (9) results in the equilibrium standard and effort under informed review, $(s^I(\theta), p^I(\theta))$. Observe that a degenerate Nash equilibrium in which the principal never accepts the project ($s^I(\theta) = \overline{\sigma}$) and the agent never exerts effort ($p^I(\theta) = 0$) always exists. Indeed, for values of θ less than a cutoff θ^I_- (defined below), this is the unique equilibrium, in which case the agent is said to be *prescreened*. For higher values of θ, however, non-degenerate Nash equilibria typically exist. In this case, the following observation, which obtains directly from the Envelope Theorem, implies that the set of equilibria are Pareto rankable.

Lemma 1. **(i)** *The principal's indirect payoff, $V(S(p), p)$ is increasing in p.*

(ii) *The agent's indirect payoff,* $U(P(s,\theta),s;\theta)$*, is decreasing in* s*.*

Because the principal's reaction function is downward-sloping, equilibria with lower standards (which the agent prefers) involve higher effort (which the principal prefers). Hence, when multiple equilibria exist, the one with the lowest standard and highest effort is Pareto superior, and the players are presumed to coordinate on it.[15]

Momentarily ignoring the feasibility restrictions and substituting for p in (8) from (2) gives

$$V_s(s,P(s,\theta)) = -[vP(s,\theta)R(s) - \ell(1-P(s,\theta))]f_l(s) = 0 \tag{10}$$

Define $s_0^I(\theta)$ to be the smallest root to this equation. Then $s_0^I(\theta)$ is the equilibrium standard when the feasibility restrictions on p do not bind. Note that (10) says that the *selection effect* identified in (5) is set to zero under informed review; i.e., the equilibrium standard is *ex post* optimal.

Define the cutoff type by

$$\theta^I_- \equiv \frac{r}{u(\lambda_h - \lambda_l)}. \tag{11}$$

The following result fully characterizes the equilibrium under informed review.

Proposition 2 (Equilibrium under Informed Review)**.**

Principal: *Under informed review, the principal sets the standard*

$$s^I(\theta) \equiv \begin{cases} \overline{\sigma}, & \text{if } \theta < \theta^I_- \\ s_0^I(\theta), & \text{if } \theta \geq \theta^I_-. \end{cases}$$

Moreover, $s^I(\theta)$ *is strictly decreasing for* $\theta > \theta^I_-$ *, and* $\lim_{\theta\to\infty} s^I(\theta) = \underline{\sigma}$*.*

Agent: *Under informed review, the agent chooses effort level*

$$p^I(\theta) \equiv \begin{cases} 0, & \text{if } \theta < \theta^I - \\ P(s_0^I(\theta),\theta), & \text{if } \theta \geq \theta^I_-. \end{cases}$$

Moreover, $p^I(\theta)$ *is strictly increasing for* $\theta > \theta^I_-$*, and* $\lim_{\theta\to\infty} p^I(\theta) = 1$*.*

Proposition 2 is intuitive. As in the benchmark setting, higher ability agents exert more effort in equilibrium and therefore face lower standards. Two differences from the commitment case are, however, readily apparent. First, at the low end of the type space, the range over which prescreening occurs is larger under informed review than under commitment ($\theta^I_- > \theta^C_-$). In other words, more types are induced to exert positive effort under commitment. Second, at the high end of the type space, the agent never exerts full effort under informed review while

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[15] The Pareto efficient equilibrium does not, however, maximize social surplus (i.e., the sum of the player's expected payoffs). In general, the principal sets too high of a standard and the agent exerts too little effort in equilibrium because they do not account for the externalities their choices impose on the other player.

all types greater than θ_+^C do under commitment.[16] Hence, at both extremes of the type space, the agent exerts less effort under informed review than under commitment. In fact, this holds generally as is stated in the following key result. (See Figure 1 below.)

Proposition 3 (Commitment vs. Informed Review)**.** *The equilibrium profile of standards is 'flatter' under commitment than under informed review and effort is higher. Specifically, suppose* $\theta > \theta_-^C$ *(else* $s^C(\theta) = s^I(\theta) = \overline{\sigma}$*), then*

$$s^C(\theta) \begin{cases} < s^I(\theta), & \text{if } \theta < \theta^* \\ = s^I(\theta), & \text{if } \theta = \theta^* \\ > s^I(\theta), & \text{if } \theta > \theta^*, \end{cases}$$

and $p^C(\theta) \geq p^I(\theta)$ *with strict inequality if* $\theta \neq \theta^*$*.*

Proposition 3 is easily understood. The commitment standard, $s^C(\theta)$, strikes a balance between the goals of project selection and incentive provision, while the informed-review standard, $s^I(\theta)$, puts weight only on project selection. For low types, $\theta < \theta^*$, the incentive effect is negative; i.e., *lowering* the standard induces more effort. Hence, commitment involves more *lenient* standards than informed review for low-ability agents. On the other hand, for high types, $\theta > \theta^*$, the incentive effect is positive; i.e., *raising* the standard induces more effort. Hence, commitment involves more *stringent* standards than informed review for high-ability agents. For the one critical type, $\theta = \theta^*$, there is no conflict between selection and incentives, and the standards are, therefore, identical under either regime, $s^C(\theta^*) = s^I(\theta^*) = s^*$.[17] In other words, under commitment, the principal implements a flatter (and hence more equitable) profile of standards in order to generate better incentives for all types of agents. In this light, it is not surprising that equilibrium effort is uniformly higher under commitment than under informed review.

Example 3 (Informed Review)**.** *Suppose the signal technology of Example 1 and that* $v = \ell = u = 1$*. From (9), the principal's reaction function is*

$$S(p) = 1 - p.$$

This gives the ex post optimal acceptance criterion. Solving it and the agent's reaction function,

$$P(s, \theta) = \min\{2\theta s(1 - s),\ 1\}$$

yields the equilibrium standard under informed review,

$$s^I(\theta) = \begin{cases} 1, & \text{if } \theta < \theta_-^I \\ \frac{1}{2\theta}, & \text{if } \theta \geq \theta_-^I, \end{cases}$$

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[16] Indeed, inducing full effort by the agent requires commitment to a standard that is not *ex post* optimal because the principal's best response to $p = 1$ is $s = \underline{\sigma}$ and the agent's best response to $s = \underline{\sigma}$ is $p = 0$.

[17] Recall that $s^* = R^{-1}(1)$ at which effort is maximized.

where $\theta^I_- = \frac{1}{2}$. *Comparison with Example 2 reveals that the region of prescreening is larger under informed review than under commitment* $\frac{1}{2} > \frac{1}{4}$. *Notice also that no finite type ever exerts full effort under informed review. For* $\theta > \theta^I_-$, *the equilibrium profile under informed review,* $s^I(\theta)$, *is steeper than the one under commitment,* $s^C(\theta)$, *and imposes higher standards for* $\theta < 1$ *and lower standards for* $\theta > 1$. *It is straightforward to check that effort is uniformly lower under informed review.*

6 Blind Review

If, as is often the case, the principal observes only a subjective signal of project quality, then she will not be able to commit to the relatively flat profile of standards $s^C(\theta)$. In this case, it may, nevertheless, be possible for her to commit to remain ignorant of the agent's type when performing an evaluation. That is, she may be able to implement a policy of blind review and impose the same completely flat standard s^B on all agent types. While blind review forces the principal to disregard information that is valuable for project selection, it can be an effective method for providing incentives. For instance, Proposition 2 indicates that a blind review procedure with $s^B = s^*$ would raise the effort of all types relative to a policy of informed review. Of course, even under blind review the principal can only implement a standard, s^B, that is *ex post* optimal given the information she possesses. The question is whether it is ever advantageous for her to commit to possessing less information.

In order to explore the relative merits of blind review, it is analytically convenient to rule out cases in which the upward feasibility restriction on effort binds. Hence, the following additional assumption is imposed below.[18]

Assumption 3 (Bounded Effort)**.** *The highest ability agent never exerts full effort,*

$$\overline{\theta}u(F_l(s^*) - F_h(s^*)) < 1.$$

Because the principal does not observe θ, the equilibrium standard is a best response to the agent's expected effort:

$$s^B = R^{-1}\left(r\frac{1 - E[p^B(\theta)]}{E[p^B(\theta)]}\right). \tag{12}$$

Similarly, in equilibrium the agent's effort is a best response to the standard,

$$p^B(\theta) = \theta u(F_l(s^B) - F_h(s^B)). \tag{13}$$

Invoking Assumption 3 when taking the expectation of (13) over θ gives

$$E[p^B(\theta)] = \mu u(F_l(s^B) - F_h(s^B)). \tag{14}$$

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[18] A stronger assumption, which is easier to check, is simply $\overline{\theta}u \leq 1$.

These three equations define the equilibrium standard and effort under blind review. In particular, comparing the solution to (12), (13) and (14) to the solution to (2) and (9) yields the following characterization.

Proposition 4 (Equilibrium under Blind Review)**.**

Principal: *Under blind review, the principal sets the standard equal to the one she would have set for the mean type of agent under informed review,* $s^B = s^I(\mu)$.

Agent: *Under blind review, the agent chooses effort level* $p^B(\theta) = P(s^I(\mu), \theta)$.

While this result follows from the fact that the agent's reaction function $P(s, \theta)$ is linear in θ, it has intuitive appeal. In particular, it seems reasonable that, when ignorant of the agent's type, the principal sets the standard as if she faced the average type, μ in the population under informed review (see Figure 1.). An implication of Proposition 4 is that the standard adopted under blind review and the effort it induces is sensitive to the distribution of types. For instance, if the mean type of agent is less than the prescreening cutoff, $\mu \leq \theta^I_-$, then Proposition 4 indicates that blind review results in the degenerate equilibrium in which no project is ever accepted, $s^B = \overline{\sigma}$, and no type of agent exerts effort, $p^B(\theta) = 0$. If $G(\theta^I_-) < 1$, then informed review clearly dominates blind review in this case because it induces positive effort by some high types. The following result provides a comparison between the standards and induced effort under informed and blind review.

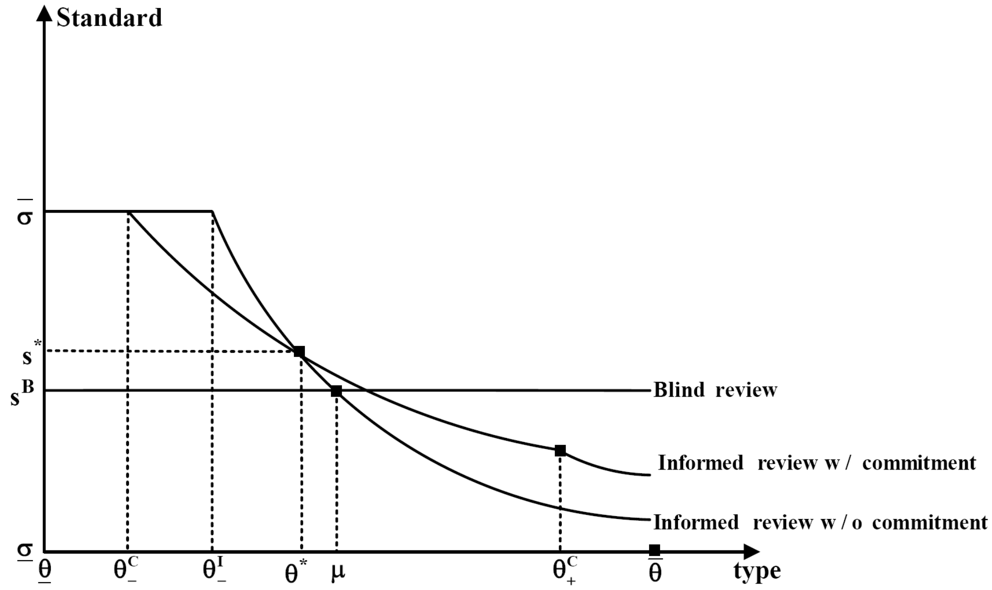

Figure 1: Equilibrium Standards

Proposition 5 (Comparing Outcomes)**.**

(i) *Agents with less than average ability face a lower standard under blind review than under informed review and agents with greater than average ability face a higher standard:*

$$s^B \begin{cases} < s^I(\theta), & \textit{if } \theta < \mu \textit{ and } \mu > \theta^I_- \\ > s^I(\theta), & \textit{if } \theta > \mu. \end{cases}$$

(ii) *Expected effort is higher under blind review than under informed review if the mean type is sufficiently close to the critical type; i.e., there exists* $\epsilon > 0$ *such that*

$$|\mu - \theta^*| < \epsilon \;\Rightarrow\; E[p^B(\theta)] > E[p^I(\theta)].$$

Part (i) of Proposition 5 is a direct consequence of Propositions 2 and 4. Because the profile of standards under informed review is decreasing and because blind review is equivalent to an informed review over the mean type, the principal applies a tougher standard under blind review to types above the mean and a weaker standard to types below the mean. Combining this with the fact that agents always like lower standards (part (ii) of Lemma 1) reveals that an agent whose ability is above the mean prefers informed review while one whose ability is below the mean prefers blind review. In other words, a high-ability agent would like to reveal his identity to the evaluator and a low-ability one would like to remain anonymous. This observation raises an interesting policy question: why not simply let agents self-select the mode of review when they apply? The answer is that such a policy would lead *all* agents including the low-ability types to opt for informed review; because once the highest types select informed review, the highest remaining types in the applicant pool will do likewise, until unravelling causes the pool of agents preferring blind review to vanish.[19][20]

Part (ii) of Proposition 5 is also easily grasped. In the event $\mu = \theta^*$, the standard under blind review is the one that maximizes the effort of all types, $s^B = s^*$. Clearly, no other review policy will elicit higher average effort than blind review in this case. Suppose, however, that μ is slightly greater than θ^* (the discussion is analogous for $\mu < s^*$). Then $s^B = s^I(\mu)$ will be less than s^*. For types $\theta > \mu$, blind review still imposes a higher standard than informed review, so these types would continue to exert more effort under blind review. Types in the interval $[\theta^*, \mu)$, however, would exert more effort under informed review because it calls for a higher standard, $s^I(\theta) \in (s^B, s^*]$. Of course, s^B is also too low for a neighborhood of types less than θ^*. However, there is a type $\theta' < \theta^*$ for whom the excessively low standard $s^B < s^*$ would elicit the same effort as the excessively high one $s^I(\theta') > s^*$. For all types $\theta < \theta'$, blind

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[19] Such equilibrium unravelling is similar in spirit to the one that generates the full disclosure of product quality by a monopolist. See, e.g., Milgrom (1981).

[20] It is interesting in this context to note that the proponents of blind review in the cases of journals and symphony orchestras did not advocate a system of self-selection (see, Blank (1991), and Goldin and Rouse (2000)). Only a small number of psychology journals appear to offer this choice to authors.

review would induce strictly higher effort. In other words, if $\mu \neq \theta^*$, then there is a band of types around θ^* who would exert more effort under informed review while the extreme types outside this band would exert more effort under blind review. When μ is distant from θ^* (e.g., $\mu \leq \theta^I_-$), then the band of types who would work harder under informed review is large, and it is the superior evaluation procedure.

It is worth remarking on the reason blind review provides better incentives than informed review when μ is close to θ^*. Agents work harder under blind review in this case because of a peer effect deriving from an *evaluation externality*. Under informed review, high-ability agents rest on their lorals, knowing that the principal will give them the benefit of the doubt. Low-ability agents also exert little effort under informed review, but for the opposite reason – they are aware that the principal will discriminate against them. Blind review pools high and low ability agents together and improves incentives at both ends of the spectrum. It is credible for the principal to apply a tougher standard to high ability agents if she cannot distinguish them from the low-ability ones. By the same token, it is credible for her to apply a relatively soft standard to low-ability agents when she cannot differentiate them from high-ability ones. This points to the value of having a diverse applicant pool. When blind review is conducted on a group containing both low ($\theta < \theta^*$) and high ($\theta > \theta^*$) ability agents, the resulting peer effect raises the productivity at both ends of the distribution. In this sense, blind review may not only be more fair than informed review, but more efficient as well.

When choosing the review policy at the beginning of the game, the principal's objective is not only to raise effort but also to make a correct acceptance decision. Define the principal's equilibrium payoff under informed review by $V^I(\theta) \equiv V(s^I(\theta), p^I(\theta))$. By proposition 4 the principal's expected equilibrium payoff under blind review is

$$\begin{aligned} E[V^B(\theta)] &= vE[p^B(\theta)](1 - F_h(s^B)) - \ell(1 - E[p^B(\theta)])(1 - F_l(s^B)) \\ &= vp^I(\mu)(1 - F_h(s^I(\mu)) - \ell(1 - p^I(\mu))(1 - F_l(s^I(\mu))) = V^I(\mu). \end{aligned}$$

Hence, when choosing between review policies, the principal compares her expected payoff under informed review, $E[V^I(\theta)]$, with her expected payoff under blind review, $V^I(\mu)$. Evidently, if $V^I(\cdot)$ is convex or concave everywhere, then Jensen's inequality will suffice to rank the two payoffs irrespective of the type distribution. In general, however, $V^I(\cdot)$ is S-shaped, possessing both a convex and a concave region, as the following lemma records.

Lemma 2. *If θ^I_- is sufficiently low, then there exist two points, $\theta_L \leq \theta_H$, such that $V^I(\theta)$ is strictly convex for $\theta < \theta_L$ and strictly concave for $\theta > \theta_H$.*

The intuition behind Lemma 2 is that for very high types, effort is close to its maximum, and so is the principal's payoff. Thus, there are diminishing marginal returns to ability. For very low types, on the other hand, a rise in ability not only raises effort but significantly improves the probability of making a correct acceptance decision.

In light of Lemma 2, it is clear that the principal's choice between the two review procedures depends crucially on the distribution of types. If, for instance, all types receiving positive probability density under $g(\cdot)$ are above θ_H (where $V^I(\cdot)$ is concave), then Jensen's inequality implies that blind review dominates informed review. On the other hand, if $g(\cdot)$ puts weight only on types less than θ_L (where $V^I(\cdot)$ is convex), then the principal prefers Informed Review. In general, which review procedure is optimal depends on whether high types or low types are more prevalent in the population, as is noted in the following key result.

Proposition 6 (Blind vs. Informed Review). *Suppose that the support of the ability distribution includes a (low) region where $V^I(\cdot)$ is convex and a (high) region where it is concave; i.e., $\underline{\theta} < \theta_L \leq \theta_H < \overline{\theta}$. Then, the principal prefers blind [resp. informed] review if*

(i) *the ability distribution is sufficiently skewed toward high [resp. low] types, and/or*

(ii) *the payoff from acceptance for the agent, u, is sufficiently large [resp. small].*

Part (i) of Proposition 6 indicates that incentives are more important than project selection when evaluating high-ability agents. It is relatively cheap for these agents to exert effort, and blind review motivates them to do so. Project selection, however, becomes the dominant concern when evaluating low-ability agents, and informed review is, therefore, preferable in this case.

The second part of Proposition 6 states that, fixing the type distribution, the principal is also more likely to prefer blind review, as the agent's payoff from acceptance, u, increases. Note from (2) that an increase in u is equivalent to an increase in θ. Hence, agents with high rewards from acceptance will behave like those with high ability, in which case blind review is the principal's preferred mode of evaluation. This finding is consistent with the example mentioned in the Introduction that a student's identity is often revealed to the grader in minor exams, but not on major ones such as PhD qualifying exams.

Example 4 (Blind Review). *Suppose the signal technology of Example 1 and that $v = \ell = u = 1$. Suppose also that there are only two possible types, $\theta \in \{\frac{1}{2}, \frac{3}{2}\}$, that are equally likely. Hence, the expected value of θ is $\mu = 1$, which (as noted in Example 2) is also the critical type θ^*. The table below displays the equilibrium standards, efforts and error probabilities under informed and blind review, and the solution is depicted in Figure 2*

Because $\mu = \theta^*$, the flat standard under blind review induces higher effort from both types of agent. Indeed, as noted in Example 3, $\theta^I_- = \frac{1}{2}$, so the low-ability agent is prescreened under informed review and therefore exerts no effort at all. Although blind review provides better

	INFORMED	BLIND
STANDARD: $\theta = \frac{1}{2}$	1	$\frac{1}{2}$
STANDARD: $\theta = \frac{3}{2}$	$\frac{1}{3}$	$\frac{1}{2}$
EFFORT: $\theta = \frac{1}{2}$	0	$\frac{1}{4}$
EFFORT: $\theta = \frac{3}{2}$	$\frac{2}{3}$	$\frac{3}{4}$
$\Pr\{\text{ACCEPT} \mid q = 0\}$	$\frac{1}{9}$	$\frac{1}{4}$
$\Pr\{\text{REJECT} \mid q = 1\}$	$\frac{1}{9}$	$\frac{1}{4}$

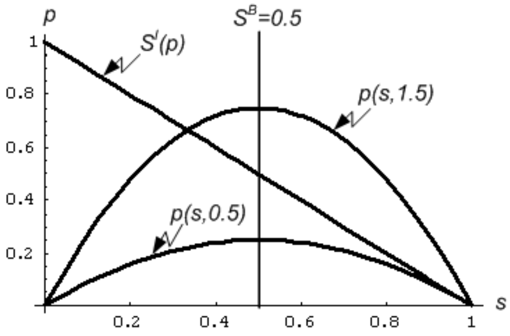

Figure 2: Solutions for Informed and Blind Review

incentives, this comes at a cost. The probability of making a mistake (either accepting a bad project or rejecting a good one) is substantially higher under blind review. From Example 3 *it is straightforward to compute*

$$V^I(\theta) = \left(1 - \frac{1}{2\theta}\right)^2 .$$

This is S-shaped with an inflection point at $\theta_H = \theta_L = \frac{3}{4}$*. The principal's expected equilibrium payoffs under informed and blind review are respectively:* $E[V^I(\theta)] = \frac{2}{9}$ *and* $V^I(\mu) = \frac{1}{4}$*. Hence, blind review is the preferred mode of evaluation in this case.*

7 A Fully Parametric Example

In this section an example is solved for general values of $r = \frac{\ell}{v}$ and u, and comparative statics with respect to these parameters are investigated. Hence, suppose the signal technology from Example 1. Also, suppose the agent's ability is distributed *uniformly* on $[\underline{\theta}, \overline{\theta}]$.

7.1 Commitment

The commitment solution is

$$s^C(\theta) = \begin{cases} 1 & \text{if } \theta < \theta_-^C \\ \frac{\sqrt{17+10r+9r^2+16r(1-r)/(\theta u)}-5r-1}{8(1-r)} & \text{if } \theta \in [\theta_-^C, \theta_+^C] \\ \frac{1-\sqrt{1-\frac{2}{\theta u}}}{2} & \text{if } \theta > \theta_+^C, \end{cases}$$

where $\theta_-^C = \frac{r}{4u}$ and

$$\theta_+^C = \frac{13 + 20r - r^2 + (5+r)\sqrt{17 + 14r + r^2}}{16u(1+r)}.$$

Notice that the evaluator optimally prescreens agents with sufficiently low types, i.e., $\theta \leq \frac{r}{4u}$. Prescreening naturally becomes more prevalent as her loss-to-benefit ratio, r, from accepting projects rises. Prescreening, however, becomes less endemic as the agent's payoff from acceptance increases, because all types work harder when u rises. Note also that for agents whose projects are evaluated, the optimal standard, $s^C(\theta)$ increases in r, and decreases in θ and u, which is intuitive. It is somewhat more surprising that as r increases, more agents are induced to exert full effort; i.e., θ_+^C decreases. In fact, if $r > 8.05$, then $\theta_+^C < \theta_-^C$. In this case, the agent is either induced to exert *no* effort (if $\theta < \theta_+^C$) or *full* effort (if $\theta \geq \theta_+^C$).

7.2 Informed and Blind Review

The equilibrium standard under informed review is,

$$s^I(\theta) = \begin{cases} 1, & \text{if } \theta < \frac{r}{2u} \\ \frac{\sqrt{r^2+2r(1-r)/(\theta u)}-r}{2(1-r)}, & \text{if } \theta \geq \frac{r}{2u} \end{cases}$$

The comparative statics and prescreening properties of the informed-review standard are qualitatively similar to the commitment case. However, informed review leads to more prescreening by also excluding the types between $\frac{r}{4u}$ and $\frac{r}{2u}$. Moreover, the informed-review standard is higher than the commitment standard for $\theta < \theta^* = \frac{2r}{(1+r)u}$, and lower otherwise.

In this setting, Assumption 3 is $\overline{\theta} < \frac{2}{u}$. This ensures that the highest type does not exert full effort under blind review. With this in hand, the standard under blind review is $s^B = s^I(\mu)$.

The principal's expected equilibrium payoff under informed review is $V^I(\theta) = V(s^I(\theta), P(s^I(\theta), \theta))$. Clearly, $V^I(\theta) = 0$ for $\theta < \frac{r}{2u}$, because these low types are prescreened. Moreover, it is easy to verify that $V^I(\theta)$ is strictly convex for $\theta \in (\frac{r}{2u}, \theta_L)$ and strictly concave for $\theta \in (\theta_H, \frac{2}{u})$, where $\theta_L = \theta_H = \frac{3r}{2(1+r)u}$.

7.3 The Principal's Review Preference

For ease of exposition, set $\underline{\theta} = \frac{r}{2u}$ to eliminate prescreening, because the same effect from including prescreened types can be captured by a lower $\overline{\theta}$. It follows that the principal strictly prefers blind review, i.e., $V^I(\mu) > E[V^I(\theta)]$ if and only if $\overline{\theta} > \hat{\theta}(r,u)$, where $\hat{\theta}(r,u) > \theta_H$, and $\hat{\theta}(r,u)$ is strictly increasing in r and strictly decreasing in u. In other words, blind review becomes more attractive as the principals loss/benefit ratio decreases and the agents payoff from acceptance increases. Moreover, the condition, $\hat{\theta}(r,b) > \theta_H$ for blind review to dominate highlights the need for a sufficient mass of high types above the inflection point. For instance, if $r = u = 1$, then $\hat{\theta} \approx 1.09435$ and $\theta_H = 0.75$.

REMARK 1. If, in this example, one posed the more general question of what the best hybrid information structure is, then the answer would be for the principal to optimally adopt informed review for $\theta \in [\frac{r}{2u}, \theta_1]$ and blind review for $\theta \in [\theta_1, \overline{\theta}]$, where θ_1 maximizes the principal's expected payoff. For a general treatment of optimal hybrid review policies, see Taylor and Yildirim (2006).

REMARK 2. In some evaluation settings, applicants may receive direct compensation conditional on the acceptance of their projects. Although a full analysis of a setting involving transferable utility is beyond the scope of this paper, some insight can be gleaned by extending Example 1. Consider the informed review setting, but now suppose the principal solicits a type θ agent to submit his project and commits to paying him, $w \geq 0$ if accepted. For a given w, this implies the following change of payoffs at the evaluation stage: $u' := u + w$, $\ell' := \ell + w$ and $v' := v - w$, which in turn implies $r' := \frac{\ell + w}{v - w}$. Hence, a direct payment increases the loss/benefit ratio, and raises the standard for all θ. Note that if payoffs were purely transfers, i.e., $\ell = u = 0$, then clearly the optimal w, denoted $w^*(\theta)$ would be strictly positive for all θ to induce any effort. The same would still be true, if the agent enjoyed an intrinsic benefit, but the principal incurred no loss from accepting a bad project, i.e, $\ell = 0$ and $u > 0$. If, on the contrary, $\ell > 0$, and $u = 0$, then it is easy to verify that $w^*(\theta) > 0$ for a sufficiently small ℓ and $w^*(\theta) = 0$ for a sufficiently large ℓ. Finally, if $\ell > 0$ and $u > 0$, specifically if $\ell = u = v = 1$, one finds that $w^*(\theta) > 0$ if $\theta \in (1, 1.5)$ and $w^*(\theta) = 0$ if $\theta \notin (1, 1.5)$. Overall, it seems that direct compensation to the agent is less likely to occur when the principal's loss/benefit ratio becomes larger, but not when the agent has an intrinsic benefit.

8 Generalizations and Extensions

In this section, the basic model is extended in three dimensions to highlight the robustness of the results obtained above and glean some important additional insights.

8.1 Two Types of Error

Up to now, it has been assumed that the evaluator suffers a loss only from a false acceptance. In some settings, however, she may also suffer a loss from a false rejection. For instance, misjudging a potentially good musician is probably as costly for the performance of a symphony orchestra as hiring a potentially bad one. In Taylor and Yildirim (2006), it is shown that accounting for both types of error does not qualitatively change the main results derived from the basic model, especially those pertaining to the comparison of informed and blind review. Thus, in this subsection only the new insights regarding the evaluator's equilibrium payoff and the optimal level of prescreening are highlighted.

Suppose, in addition to the loss, $-\ell < 0$ from a false acceptance, the principal also incurs a loss, $-\overline{\ell} < 0$ from a false rejection. While this generalization does not alter the agent's payoff in (1), the expected loss from rejecting a good project needs to be subtracted from the principal's payoff in (3):

$$\overline{V}(s,p) = vp(1-F_h(s)) - \ell(1-p)(1-F_l(s)) - \overline{\ell}pF_h(s). \tag{15}$$

Maximizing (15) with respect to s, the principal's reaction function is

$$\overline{S}(p) = R^{-1}(\overline{r}\frac{1-p}{p}), \tag{16}$$

where $\overline{r} \equiv \frac{\ell}{v+\overline{\ell}}$, is the modified loss/benefit ratio from accepting a project.[21] Since $R' > 0$, (16) implies that the principal is more likely to accept a project as her loss from a false rejection increases. Applying the Envelope Theorem, the principal's indirect payoff satisfies

$$\frac{d}{dp}\overline{V}(\overline{S}(p),p) = v(1-F_h(\overline{S}(p))) + \ell(1-F_l(\overline{S}((p))) - \overline{\ell}F_h(\overline{S}(p)),$$

which is clearly positive if $\overline{S}(p)$ is close to $\underline{\sigma}$ and negative if $\overline{S}(p)$ is close to $\overline{\sigma}$. Hence, in contrast to part (i) of Lemma 1, the principal's indirect payoff does not monotonically increase in p. In fact, since $\overline{S}(0) = \overline{\sigma}$ and $\overline{s}'(p) < 0$, her indirect payoff strictly decreases in p whenever p is small, because such a project is very likely to be rejected and thus very likely to expose the principal to a false rejection. More interestingly, a sufficiently small p may result in a negative payoff for the evaluator, $\overline{V}(\overline{S}(p),p) < 0$, which never occurs in the basic model with $\overline{\ell} = 0$. The evaluator would, of course, avoid a negative payoff if she could commit to prescreening those agents who are unlikely to exert a high enough effort. Intuitively, in the absence of commitment, knowing the evaluator's fear of a false rejection, some low ability agents who are unlikely to produce a good project will submit their projects, and the evaluator will review them to minimize the chances of a false rejection.

The discussion thus far reveals two potential observations caused purely by a costly false rejection: First, the evaluator may receive a negative equilibrium payoff from some intermediate type agents, and second equilibrium prescreening may be too little compared to the commitment benchmark. Before formally confirming these observations, notice that the non-monotonicity of the evaluator's indirect payoff implies that unlike in the basic model, equilibria under informed review are not always Pareto rankable. For consistency, however, continue to assume that players coordinate on the equilibrium with the highest effort and lowest standard.

Proposition 7 (Two Types of Error). *Suppose both types of error are costly to the evaluator, i.e.,* $\ell, \overline{\ell} > 0$. *Then, in equilibrium*

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[21] By accepting a project, the principal may not only receive v but also avoid $-\overline{\ell}$, explaining $v + \overline{\ell}$ in $\overline{r}$.

(i) *under informed review there exist two types, $\overline{\theta}^I_- < \overline{\theta}^I_r$ such that*

$$\overline{V}(\theta)\begin{cases} = 0 & \textit{if } \theta \leq \overline{\theta}^I_- \textit{ or } \theta = \overline{\theta}^I_r \\ < 0 & \textit{if } \overline{\theta}^I_- < \theta < \overline{\theta}^I_r \\ > 0 & \textit{if } \theta > \overline{\theta}^I_r, \end{cases}$$

(ii) *if $\overline{\ell}$ is sufficiently large, then compared with commitment, there is less prescreening under informed review, namely, $\overline{\theta}^I_- < \overline{\theta}^C_-$.*

Hence, when the evaluator is sufficiently concerned about a false rejection, there may be too little prescreening under informed review as opposed to too much prescreening as seen in the basic model. The reason is as suggested above: when the evaluator fears rejecting a good project, she cannot credibly discourage some intermediate type agents from submitting projects in equilibrium, even though they are unlikely to produce a high-quality project.[22]

Example 5 (Two Types of Error)**.** Suppose the signal technology of Example 1 and that $v = \ell = \overline{\ell} = u = 1$. From (16), the principal's reaction function is $\overline{S}(p) = \frac{1-p}{1+p}$ whereas the agent's reaction function remains as in Examples 2, 3 and 4, $\overline{P}(s,\theta) = P(s,\theta) = \min\{2\theta s(1-s),\ 1\}$. The equilibrium standard under informed review is then given by

$$\overline{s}^I(\theta) = \begin{cases} 1, & \text{if } \theta < \overline{\theta}^I_- \\ \sqrt{\frac{1}{4} + \frac{1}{2\theta}} - \frac{1}{2}, & \text{if } \theta \geq \overline{\theta}^I_- \end{cases}$$

where $\overline{\theta}^I_- = \frac{1}{4}$. Compared with Example 3 where $\overline{\ell} = 0$, the evaluator prescreens fewer types when she is also concerned about a false rejection. Simple algebra shows the evaluator's informed payoff is $\overline{V}^I(\theta) = (6\theta + 1)(\sqrt{1 + \frac{2}{\theta}} - 1) - 5$ for $\theta \geq \frac{1}{4}$ so that $\overline{V}^I(\theta) < 0$ if and only if $\theta \in (\frac{1}{4}, \frac{2}{3})$. For instance, in equilibrium the agent of type $\theta = \frac{1}{2}$ exerts effort, $p^I(\theta) \simeq 0.236$ in anticipation of the standard, $\overline{s}^I(\theta) \simeq 0.618$, yielding $\overline{V}^I(\theta) \simeq -0.056$. If the evaluator did not review this project, then her payoff would be $-\overline{\ell}p^I(\theta) = -0.236$. Under commitment, it is straightforward to compute that the evaluator prescreens types $\theta < \overline{\theta}^C_- \simeq 0.667$. Hence, in contrast to Example 3, the region of prescreening is larger under commitment than under informed review. For the cutoff type, $\theta = \overline{\theta}^C_-$, it is interesting to note that $\overline{s}^C(\overline{\theta}^C_-) \simeq 0.499$ and $\overline{p}^C(\overline{\theta}^C_-) > 0.332$. That is, unlike Example 2, the commitment standard is discontinuous at the cutoff type, $\overline{\theta}^C_-$ because, to avoid a false rejection, the principal deals with only those types who are able to exert high enough effort. Finally, $\overline{V}^I(\theta)$ is still S-shaped with an inflection point at $\overline{\theta}_L = \overline{\theta}_H = \frac{3}{4}$.

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[22] Of course, if the evaluator could set a submission fee, she would improve her commitment power to exclude the types that yield her a negative expected payoff. See Taylor and Yildirim (2006) for details.

8.2 Competing Evaluators and Informed Review Bias

In practice there are often multiple evaluators, e.g., schools, companies, and academic journals, that compete for (high-quality) applications. In this subsection, the basic model is extended to show how competition among evaluators impacts the equilibrium mode of review.

Suppose there are two *ex ante* symmetric evaluators, $i = 1, 2$, who simultaneously and publicly announce their review policies, $\tau_i \in \{I, B\}$. Upon observing τ_1 and τ_2, each agent then exerts effort and applies to one evaluator. To parameterize the degree of competition, one of three possible situations is assumed to obtain. With probability $1 - \phi$ an agent is *unattached* (i.e., he is free to apply to either evaluator); with probability $\frac{\phi}{2}$ he is attached to evaluator 1; and with probability $\frac{\phi}{2}$ he is attached to evaluator 2. Attachments are independent across agents and over types. For simplicity, also assume that re-applications are not feasible and in case of indifference, an unattached agent selects between the evaluators with equal probability.

Let $\pi_i^{\tau_1,\tau_2}$ be evaluator i's expected payoff in the subgame with review policies, τ_1 and τ_2. Note that if $\tau_1 = \tau_2 = I$, then *ex ante* each agent is equally likely to apply to either evaluator, resulting in equal payoffs, $\pi_i^{I,I} = \frac{1}{2}E[V^I(\theta)]$. If, on the other hand, $\tau_1 = \tau_2 = B$, then a straightforward argument shows that in equilibrium, both evaluators adopt the same standard tailored to the population mean, μ, yielding equal payoffs, $\pi_i^{B,B} = \frac{1}{2}V^I(\mu)$. The equilibrium characterization with different review policies is the least obvious.

Suppose, without loss of generality, $\tau_1 = B$ and $\tau_2 = I$. Moreover, suppose, in equilibrium, the mean type that applies to evaluator 1 is m_1. This implies that an unattached type θ prefers evaluator 1 whenever $\theta < m_1$. Hence, the conditional mean ability for evaluator 1 is

$$M_1(m_1; \phi) \equiv \frac{(1 - \frac{\phi}{2}) \int_{\underline{\theta}}^{m_1} \theta dG(\theta) + \frac{\phi}{2} \int_{m_1}^{\overline{\theta}} \theta dG(\theta)}{(1 - \frac{\phi}{2})G(m_1) + \frac{\phi}{2}(1 - G(m_1))}.$$

In equilibrium, the conditional mean, $m_1 = \mu_1(\phi)$ has to solve

$$M_1(m_1; \phi) - m_1 = 0. \tag{17}$$

Lemma 3. *There exists a unique solution, $\mu_1(\phi)$ to (17). The function $\mu_1(\phi)$ is strictly increasing and has boundary values, $\mu_1(0) = \underline{\theta}$ and $\mu_1(1) = \mu$.*

Lemma 3 is rather intuitive. It says that as each agent becomes less likely to be attached, fewer high types choose blind review, which raises its standard and further discourages applications by high unattached types in the remaining pool. In particular, in the absence of attached types, namely when $\phi = 0$, a complete unravelling of unattached types occurs in that they all apply to evaluator 2 who performs an informed review.

In light of Lemma 3, equilibrium payoffs for evaluators 1 and 2 in the subgame with $\tau_1 = B$ and $\tau_2 = I$ are given respectively by

$$\pi_1^{B,I}(\phi) = [(1 - \frac{\phi}{2})G(\mu_1(\phi)) + \frac{\phi}{2}(1 - G(\mu_1(\phi)))]V^I(\mu_1(\phi))$$

and

$$\pi_2^{B,I}(\phi) = \frac{\phi}{2}\int_{\underline{\theta}}^{\mu_1(\phi)} V^I(\theta)dG(\theta) + (1 - \frac{\phi}{2})\int_{\mu_1(\phi)}^{\overline{\theta}} V^I(\theta)dG(\theta).$$

The following lemma characterizes these payoffs.

Lemma 4. *In the unique equilibrium with $\tau_1 = B$ and $\tau_2 = I$, the evaluators' payoffs have these properties:*

- $\pi_1^{B,I}(\phi)$ *is strictly increasing, and* $\pi_1^{B,I}(0) = 0$ *and* $\pi_1^{B,I}(1) = \frac{1}{2}V^I(\mu)$.
- $\pi_2^{B,I}(\phi)$ *is strictly decreasing, and* $\pi_2^{B,I}(0) = E[V^I(\theta)]$ *and* $\pi_2^{B,I}(1) = \frac{1}{2}E[V^I(\theta)]$.

In other words, the evaluator using blind review is better off when there are more attached types, because they have a direct positive effect on her payoff as well as a positive indirect effect through attracting high unattached types who, by Lemma 3, anticipate a lower standard. By the same token, the evaluator using informed review is worse off when there are more attached types.

Having characterized the evaluators' payoffs in each subgame, the equilibrium review policies can now be determined.

Proposition 8 (Equilibrium with Competing Evaluators). *Suppose $\frac{1}{2}V^I(\mu) < E[V^I(\theta)] < V^I(\mu)$. Then, there exist two cutpoints, $0 < \phi^* \leq \phi^{**} < 1$, such that for $\phi < \phi^*$, the unique equilibrium has $\tau_1 = \tau_2 = I$ whereas for $\phi > \phi^{**}$, the unique equilibrium has $\tau_1 = \tau_2 = B$. For $\phi \in [\phi^*, \phi^{**}]$, both symmetric and asymmetric review policies may occur in equilibrium.*

The message of Proposition 8 is that competition between evaluators to attract high quality applications is likely to lead evaluators to adopt informed review, even when each would individually prefer blind review, i.e., $E[V^I(\theta)] < V^I(\mu)$, and such competition is more pronounced as potential applicants lack strong preferences for evaluators, i.e., when ϕ is small. Said differently, blind review is likely to be prevalent in settings with little or no reviewer competition. This finding is consistent with the anecdotal evidence that, unlike field journals targeting a specific audience, general-interest journals across various disciplines disproportionately utilize informed review.

Example 6 (Competing Evaluators). *Suppose the signal technology of Example 1 and that $v = \ell = u = 1$ and $\overline{\ell} = 0$. Suppose also that the agent's ability is uniformly distributed on*

$[0.5, 2]$*, so* $\mu = 1.25$*. From Example 4,* $V^I(\theta) = \left(1 - \frac{1}{2\theta}\right)^2$*, which implies* $V^I(\mu) = 0.36$ *and* $E[V^I(\theta)] \simeq 0.326$*. Hence, if there were a single evaluator, she would opt for blind review. With two evaluators, one calculates* $\mu_1(\phi) = \frac{2-5\phi+3\sqrt{1-(1-\phi)^2}}{4(1-\phi)}$*, and the cutpoints* $\phi^* \simeq 0.810$ *and* $\phi^{**} \simeq 0.812$*. Applying Proposition 8,* $\tau_1 = \tau_2 = I$ *is the unique equilibrium for* $\phi < 0.810$ *and* $\tau_1 = \tau_2 = B$ *is the unique equilibrium for* $\phi > 0.812$*. For* $\phi \in (0.810, 0.812)$*, there are exactly two equilibria:* $\tau_1 = \tau_2 = I$ *and* $\tau_1 = \tau_2 = B$*. Finally, for the knife-edge values* $\phi = 0.810$ *or* $\phi = 0.812$*, asymmetric review policies are also sustained as equilibria.*

8.3 Continuous Quality

In the basic model, the agent submits a project that is one of two possible qualities, high or low. In many settings, however, quality is continuous rather than dichotomous. To verify robustness and generality of the results, a continuous-quality version of the model is explored in this subsection. While the analysis reveals several new insights, the fundamental conclusions from the dichotomous-quality setting are shown to translate naturally. Suppose that the agent can select any effort level $x \geq 0$ at cost $C(x;\theta) = \frac{x^2}{2\theta}$. As before, he receives an exogenous benefit of u if the project is accepted and zero if it is rejected. If the principal accepts the project, then she receives a payoff of $q = x + y$, where y is the outcome of a random productivity shock that is Normally distributed with zero mean and variance v_y^2. If the principal rejects the project, then she receives a payoff of $v_0 > 0$ from an outside option.[23] Hence, the principal prefers to accept the project if $q \geq v_0$ and to reject it if $q < v_0$.

When presented with the project, the principal observes $\sigma = q + z$, where z is Normally distributed measurement error with zero mean and variance v_z^2.[24] Define $\epsilon = y + z$ and note that ϵ is Normally distributed with zero mean and variance $v_\epsilon^2 = v_y^2 + v_z^2$. Denote the Normal CDF and PDF for random variable j respectively by $F_j(\cdot)$ and $f_j(\cdot)$, for $j \in \{y, z, \epsilon\}$.

If the principal employs a standard s, then she rejects the project if $\sigma < s$ (i.e., if $x + y + z < s$), which occurs with probability $F_\epsilon(s - x)$. In particular, the principal's expected payoff from employing a standard s when the agent exerts effort x is

$$V(s,x) = F_\epsilon(s-x)v_0 + (1 - F_\epsilon(s-x))\,x + \int_{\infty}^{+\infty} y\,(1 - F_z(s-x-y))\,f_y(y)\,dy. \tag{18}$$

Similarly, a type θ agent's expected payoff from exerting effort x when the principal imposes a standard s is

$$U(x,s;\theta) = u\,(1 - F_\epsilon(s-x)) - \frac{x^2}{2\theta}. \tag{19}$$

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[23] It is necessary to assume $v_0 > 0$ in order to avoid (uninteresting) corner solutions in which low-ability agents exert zero effort.

[24] Note that if there were no measurement error (i.e., $v_z^2 = 0$), then the principal would observe quality directly, and observing the agents type would be of no value to her.

The agent's reaction function is found by differentiating (19) with respect to x and is defined implicitly by

$$X(s,\theta) = \theta u f_\epsilon(s - X(s,\theta)) \tag{20}$$

As in the dichotomous-quality setting, the agent's reaction function is hump-shaped. Low standards elicit little effort because projects are rarely rejected and high standards elicit little effort because they are rarely accepted. Unlike the two-quality version of the model, however, the standard that maximizes effort does depend on the agents type. It occurs along the 45-degree line in $s - x$-space where $s = \theta u f_\epsilon(0)$. Hence, in order to induce maximal effort, higher ability agents should face higher standards.

The following result characterizes the equilibrium standards and effort levels for the commitment, informed-review, and blind-review regimes.

Proposition 9 (Equilibrium with Continuous Quality)**.**

(i) *The equilibrium standard and effort under commitment, $(s^C(\theta), x^C(\theta))$, are found by solving (20) and:*

$$S^C(x) = v_0\left(\frac{v_Y^2 + v_z^2}{v_y^2}\right) - x\left(\frac{v_z^2}{v_y^2}\right) + \frac{\left(x - S^C(x)\right)\left(1 - F_\epsilon(S^C(x) - x)\right)}{v_y^2}. \tag{21}$$

(ii) *The equilibrium standard and effort under informed review, $(s^I(\theta), x^I(\theta))$, are found by solving (20) and:*

$$S^I(x) = v_0\left(\frac{v_Y^2 + v_z^2}{v_y^2}\right) - x\left(\frac{v_z^2}{v_y^2}\right). \tag{22}$$

(iii) *The equilibrium standard and effort under blind review, $(s^B, x^B(\theta))$, are found by solving (20) and:*

$$S^B(x) = v_0\left(\frac{v_Y^2 + v_z^2}{v_y^2}\right) - \hat{x}\left(\frac{v_z^2}{v_y^2}\right) \tag{23}$$

and

$$\hat{x} = \frac{\int_{\underline{\theta}}^{\overline{\theta}} x^B(\theta) f_\epsilon(s^B - x^B(\theta)) g(\theta)\, d\theta}{\int_{\underline{\theta}}^{\overline{\theta}} f_\epsilon(s^B - x^B(\theta)) g(\theta)\, d\theta}. \tag{24}$$

To obtain intuition for Proposition 9, first consider the principals reaction function under informed review (22). This is linear and decreasing in x. In other words – just as in the dichotomous-quality version of the model – the principal employs a lower standard when she anticipates higher effort by the agent. Because the agent's reaction function $X(s,\theta)$ is increasing in ability, it is easy to see that under informed review the equilibrium effort, $x^I(\theta)$, is increasing and the equilibrium standard, $s^I(\theta)$, is decreasing in θ. Hence, high ability agents face lower standards in equilibrium, but nevertheless, do exert more effort than low ability ones.

Consider the type $\theta^* = \frac{v_0}{uf_\epsilon(0)}$. Under informed review, (20) and (22) indicate that this critical type of agent faces the standard $s^I(\theta^*) = v_0$ and exerts effort $x^I(\theta^*) = v_0$. Moreover, no other standard would elicit higher effort from this type of agent; i.e., the principals reaction function intersects the critical type of agent's reaction function at its peak. For types $\theta > \theta^*$, the intersection occurs to the left of the peak and for types $\theta < \theta^*$, it occurs to the right. (See Figure 3.) In other words, the standards facing high ability agents are too low and the standards facing low ability agents are too high to induce maximal effort.

Next consider the equilibrium effort, $x^B(\theta)$, and standard, s^B, implemented under blind review as defined by (20), (23) and (24). Comparing (22) with (23), it is easy to see that the standard adopted under blind review equals the one that would be employed against some intermediate type of agent

$$\hat{\theta} = \frac{\hat{x}}{uf_\epsilon((v_y^2 + v_z^2)(v_0 - \hat{x})/v_y^2)}.$$

Unlike in the dichotomous-quality setting, this intermediate type, $\hat{\theta}$ need not be the mean type, μ.

Suppose – for the sake of discussion – that the distribution of types is such that $\hat{\theta} = \theta^*$. Then $s^B = v_0$ and all types (other than θ^*) exert strictly higher effort under blind review than under informed review. (more generally, if $\hat{\theta} \neq \theta^*$, then there is a band of types around θ^* that exert lower effort under blind review while the types below and above this band exert higher effort, just as in the dichotomous-quality setting.) This is easily understood. First consider types $\theta > \theta^*$. As discussed above, effort maximization requires using standards greater than v_0 against these high-ability agents. Such standards are not, however, credible when the signal, σ, observed by the principal is subjective. In fact, under informed review the principal employs standards less than v_0 against these agents in equilibrium. Thus, adopting blind review and implementing a standard of $s^B = v_0$ would raise the effort of high-ability agents. For types $\theta < \theta^*$, effort maximization requires using standards less than v_0. Informed review, however, implements standards higher than v_0 against these low-ability agents. Hence, adopting blind review and a standard of $s^B = v_0$ would also raise the effort of low-ability agents.

Of course, neither informed review nor blind review is optimal. As in the dichotomous quality setting, informed review uses information efficiently *ex post* but provides poor incentives *ex ante*, while blind review often provides better incentives but sacrifices valuable information. To see this, consider the effort, $x^C(\theta)$, and the standard, $s^C(\theta)$, implemented under the commitment benchmark as defined in (20) and (21). In particular, observe that (21) differs from (22) only by inclusion of the *incentive term* $(x - s)(1 - F_\epsilon(s - x))/v_y^2$. In other words, the commitment standard differs from the informed-review standard in order to provide better incentives.

If $\theta = \theta^*$, then the incentive term in (21) vanishes and commitment and informed review yield the same effort and standard, namely $x = s = v_0$. This makes sense, θ^* is the type whose effort is maximized under informed review, so that there is no conflict between provision of incentives and efficient use of information for this type. For $\theta < \theta^*$, it is easy to check that the incentive term is negative ($x^C(\theta) < v_0 < s^C(\theta)$). This implies directly that the standards facing low-ability agents are lower (more lenient) under commitment than under informed review. Similarly, for $\theta > \theta^*$, the incentive term is positive ($x^C(\theta) > v_0 > s^C(\theta)$, so that the standards facing high-ability agents are higher (more stringent) under commitment than under informed review. The reasoning is similar to that of the dichotomous-quality setting; the equilibrium standard profile under commitment $s^C(\theta)$, balances provision of incentives *ex ante* with efficient use of information *ex post* and is, therefor, flatter than the equilibrium profile, $s^I(\theta)$, adopted under informed review. On the other hand, the equilibrium standard implemented under blind review, s^B, does not – by definition – depend on θ and is, therefore, completely flat.

While neither informed or blind review is optimal in general, it is important to understand when one of these two review policies is likely to out-perform the other from the principal's perspective. The complexity of the continuous-quality model makes it difficult to answer this question precisely, but Proposition 9 does provide some guidance. Specifically, there are two conditions that make blind review relatively more attractive. First, If v_y^2 is small, then quality is less random and the incentive term in (21) is large. Second, if $\hat{\theta}$ is close to θ^*, then nearly every type of agent will exert more effort under blind review than under informed review.

Example 7 (Continuous Quality). *Suppose there are two possible types of agent, $\theta \in \{0.5, 1.5\}$ occurring with equal probability. Also suppose $v_0 = v_y^2 = v_z^2 = 1$ and $u = \frac{1}{f_\epsilon(0.5)}$. It is straightforward to verify that $\hat{x} = v_0 = 1$, ensuring that both types of agent exert strictly higher effort under blind review than under informed review. The actual solutions and equilibrium payoffs are presented in Table 7 and depicted in Figure 3. The flat standard under blind review elicits significantly more effort by both types of agent than the steeply declining standard arising under informed review. Indeed, the improvement in incentives more than offsets the loss*

	INFORMED	BLIND
STANDARD: $\theta = 0.5$	1.652	1.000
STANDARD: $\theta = 1.5$	0.619	1.000
EFFORT: $\theta = 0.5$	0.348	0.500
EFFORT: $\theta = 1.5$	1.381	1.500
P'S PAYOFF	1.290	1.334

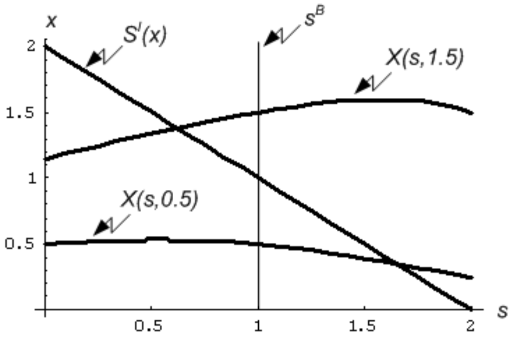

Figure 3: Solutions for Informed and Blind Review

of information in this example making blind review the preferred mode of evaluation for the principal.

9 Conclusion

The issue at the heart of this paper concerns the tradeoff between the effective use of information and the provision of incentives in a setting where commitment to a review standard is infeasible. It was shown in this context that when the evaluator observes the innate ability of the applicant, the equilibrium review policy is unduly biased – the standards facing high ability applicants are too weak and those facing low-ability applicants are too tough. While this policy uses information optimally *ex post*, it provides poor incentives *ex ante*. In particular, if the evaluator could commit to a review procedure, then she would implement a flatter (less biased) one. Commitment to such a policy is, however, often impractical or impossible because of the subjective nature of many performance measures: the taste of a fine wine, the skill of a classical musician, the quality of an essay. Although it is not possible to commit to a highly tailored acceptance procedure in such environments, it is often possible to commit to remain ignorant of the identity (and hence the ability) of the applicant; that is, to perform blind review.

The uniform standard implemented under blind review often provides good incentives for agents at both ends of the ability distribution, but it sacrifices information at the project selection stage. Hence, whether the evaluator prefers blind or informed review depends critically on whether incentives or project selection is more important to her. Blind review was shown to be the preferred mode of evaluation if: the applicant pool contains a high proportion of high ability agents, the applicant's stakes from acceptance are relatively high, wrong decisions are relatively less costly, or there is limited competition among evaluators.

There are a number of intriguing issues not addressed here. For instance, it would be interesting to investigate the effects of more general non-monetary incentive devices. In academia, for example, there is a whole gradation of rewards associated with acceptance (lead article, long or short paper, best paper prize, and so on) that can be used to induce higher types to exert more effort. Similarly, it would also be interesting to study the role of peer effects in a setting where an applicant's benefit from acceptance, u is determined endogenously. Specifically, the status or prestige enjoyed by an agent whose project is accepted might well depend on the average quality of other projects accepted by the evaluator. It would likewise be instructive to study a dynamic version of the model in which the "ability" of an agent corresponds to his history of prior acceptances and rejections. In particular, it would be useful to explore the interaction between the review policies of evaluators and the career concerns of agents in such a setting. While these and other avenues for further research in this area appear fruitful, it seems quite likely that the basic message of this paper will remain in tact. Fairness is not the only reason to level the playing field – often it is also the best thing the evaluator can do.

Appendix

This appendix contains the proofs of all lemmas and propositions presented in the text as well as the statement and proofs of two technical lemmas.

PROOF OF PROPOSITION 1. Note first that if a type θ agent is subject to s sufficiently close to $\overline{\sigma}$, then $P(s,\theta) < 1$; hence $V(s,P(s,\theta))$ is strictly quasi-concave in s by Assumption 2. This means $s^C(\theta) = \overline{\sigma}$ if and only if $\lim_{s\to\overline{\sigma}} \frac{d}{ds}V(s,P(s,\theta)) > 0$. Simply differentiating (4) and noting $\lim_{s\to\overline{\sigma}} P(s,\theta) = 0$ and $\lim_{s\to\overline{\sigma}} R(s)P(s,\theta) = u\theta(\lambda_h - \lambda_l)$ by Assumption 1, we find $s^C(\theta) = \overline{\sigma}$ and thus $p^C(\theta) = 0$ if and only if $\theta < \frac{r}{u[2\lambda_h+(r-1)\lambda_l]} = \theta^C_-$. Second, suppose $P(s,\theta) > 0$. If we ignore the constraint $P(s,\theta) \leq 1$, then by Assumption 2, $s^C(\theta) = s^C_0(\theta)$ is the unique solution to $\frac{d}{ds}V(s^C_0(\theta),P(s^C_0(\theta),\theta)) = 0$, or equivalently to (5). If $P(s^C_0(\theta),\theta) > 1$, then $s^C(\theta) \neq s^C_0(\theta)$; rather $s^C(\theta) = \min\{s|P(s,\theta) = 1\}$, because for $P(s,\theta) = 1$, (4) reduces to $V(s,P(s,\theta)) = v(1 - F_h(s))$, which is strictly decreasing in s. By construction, $s^C(\theta)$ is continuous for $\theta \neq \theta^C_-$. Since $\lim_{s\to\overline{\sigma}} V(s,p) = 0$ for any $p \in [0,1]$, $s^C(\theta)$ is also continuous at $\theta = \theta^C_-$. This implies that $p^C(\theta) = P(s^C(\theta),\theta)$, $p^C(\theta)$ is also continuous for all θ.

To prove that $s^C(\theta)$ is strictly decreasing for $\theta > \theta^C_-$, note that for $\theta \in (\theta^C_-,\theta^C_+)$, $\frac{d}{d\theta}s^C(\theta) =^{sign} V_p(\cdot)P_{s\theta}(\cdot) + V_{sp}(\cdot)P_\theta(\cdot)$ by Assumption 2. Since $P_\theta(\cdot) = \frac{P(\cdot)}{\theta}$, and $V_p(\cdot)P_{s\theta}(\cdot) = \frac{V_p(\cdot)P_s(\cdot)}{\theta} = -\frac{V_s(\cdot)}{\theta}$ (where the last equality is due to the FOC), the r.h.s. simplifies to $V_p(\cdot)P_{s\theta}(\cdot)+V_{sp}(\cdot)P_\theta(\cdot) = \frac{1}{\theta}[V_{sp}(\cdot)P(\cdot)-V_s(\cdot)]$. From (3), $V_s(s,p) = -pf_h(s)v+(1-p)f_l(s)\ell$ and $V_{sp}(s,p) = -[f_h(s)v+\ell f_l(s)]$, which imply $V_{sp}(\cdot)P(\cdot) - V_s(\cdot) = -f_l(s)\ell < 0$. Hence, $\frac{d}{d\theta}s^C(\theta) < 0$ for $\theta > \theta^C_-$. For $\theta > \theta^C_+$, we have $P(s^C(\theta),\theta) = 1$, and thus $\frac{d}{d\theta}s^C(\theta) = -\frac{P_\theta(\cdot)}{P_s(\cdot)} < 0$, where $P_s(\cdot) > 0$ because $s^C(\theta) < s^* = R^{-1}(1)$. As a result, $s^C(\theta)$ is strictly decreasing for all $\theta > \theta^C_-$. From here, it easily follows that $p^C(\theta)$ is strictly increasing for $\theta \in (\theta^C_-,\theta^C_+)$.

Finally, suppose $\lim_{\theta\to\infty} s^C(\theta) = \underline{s}^C > \underline{\sigma}$. Then, there is a sufficiently large $\hat{\theta} < \infty$ such that $p^C(\hat{\theta}) = 1$ and $s^C(\hat{\theta}) > \underline{\sigma}$. But in this case, the principal could strictly improve her payoff, $v(1 - F_h(s))$, by setting a standard, $(s^C(\hat{\theta}) + \underline{\sigma})/2$. Hence, $\lim_{\theta\to\infty} s^C(\theta) = \underline{\sigma}$. ■

Proof of Lemma 1. Since, by definition, $V_s(S(p),p) = U_p(P(s,\theta),s;\theta) = 0$, (1) and (3) imply that $\frac{d}{ds}U(P(s,\theta),s;\theta) = \frac{\partial}{\partial s}U(P(s,\theta),s;\theta) < 0$ and $\frac{d}{ds}V(S(p),p) = \frac{\partial}{\partial p}V(S(p),p) > 0$. ■

Proof of Proposition 2. First observe that $V(s,p)$ is strictly quasi-concave in s because $R'(s) > 0$. This means $s^I(\theta) = \overline{\sigma}$ if and only if $\lim_{s\to\overline{\sigma}} V_s(s,P(s,\theta)) > 0$. Since $\lim_{s\to\overline{\sigma}} P(s,\theta) = 0$ and $\lim_{s\to\overline{\sigma}} R(s)P(s,\theta) = u\theta(\lambda_h - \lambda_l)$ by Assumption 1, we have $s^I(\theta) = \overline{\sigma}$ and thus $p^I(\theta) = 0$ if and only if $\theta < \frac{r}{u(\lambda_h-\lambda_l)} = \theta^I_-$. Suppose $\theta > \theta^I_-$. Then, as argued in the text, $s^I(\theta) = s^I_0(\theta)$, which is the smallest root to $\hat{S}^{-1}(s,r) - P(s,\theta) = 0$, where $\hat{S}^{-1}(s,r) \equiv S^{-1}(R^{-1}(r\frac{1-p}{p}))$. Differentiating with respect to θ, we find

$$\frac{\partial}{\partial\theta}s^I_0(\theta) = \frac{P_\theta(s^I_0(\theta),\theta)}{\hat{S}^{-1}_s(s^I_0(\theta),r) - P_s(s^I_0(\theta),\theta)}.$$

Since $\hat{S}^{-1}_s(s^I_0(\theta),r) < 0$ by our equilibrium selection, $\hat{S}^{-1}_s(s^I_0(\theta),r) - P_s(s^I_0(\theta),\theta) < 0$ whenever $P_s(s^I_0(\theta),\theta) \geq 0$. Now, consider $P_s(s^I_0(\theta),\theta) < 0$, and suppose, on the contrary, that $\hat{S}^{-1}_s(s^I_0(\theta),r) - P_s(s^I_0(\theta),\theta) \geq 0$. If $\hat{S}^{-1}_s(s^I_0(\theta),r) - P_s(s^I_0(\theta),\theta) = 0$ for some θ, then by continuity, there is a sufficiently small $\epsilon > 0$ such that $s^I_0(\theta) = s^I_0(\theta+\epsilon)$. But, from (2), this would imply $p^I(\theta) < p^I(\theta+\epsilon)$, and thus $s^I_0(\theta) \neq s^I_0(\theta+\epsilon)$, yielding a contradiction. Hence, $\hat{S}^{-1}_s(s^I_0(\theta),r) - P_s(s^I_0(\theta),\theta) > 0$. However, if this were the case, then by continuity, we must have $\hat{S}^{-1}_s(s^I_0(\theta)-\epsilon,r) - P_s(s^I_0(\theta)-\epsilon,\theta) < 0$ for some $\epsilon > 0$. Given $\hat{S}^{-1}(\underline{\sigma},r) - P(\underline{\sigma},\theta) > 0$, this would generate another equilibrium with a greater effort, contradicting our equilibrium selection. Thus, for $s^I_0(\theta) \neq \overline{\sigma}$, it must be that $\hat{S}^{-1}_s(s^I_0(\theta),r) - P_s(s^I_0(\theta),\theta) < 0$. Hence, $\frac{\partial}{\partial\theta}s^I_0(\theta) < 0$.

Next, we show $p^I(\theta) < 1$ for all θ. Clearly, if $p^I(\hat{\theta}) = 1$ for some $\hat{\theta} < \infty$, then $s^I(\hat{\theta}) = S(1) = \underline{\sigma}$, to which the agent would reply by $p^I(\hat{\theta}) = 0$, contradicting $p^I(\hat{\theta}) = 1$. Hence, $p^I(\theta) < 1$ for all θ. Now, observe from (9) that $p^I(\theta) = \frac{r}{r+R(s^I_0(\theta))}$, which reveals

$$\frac{\partial}{\partial\theta}p^I(\theta) = -\frac{rR'(\cdot)}{[r+R(\cdot)]^2}\frac{\partial}{\partial\theta}s^I_0(\theta) > 0.$$

Finally, suppose $\lim_{\theta\to\infty} p^I(\theta) \to \overline{p}^I < 1$. From (9), this implies $\lim_{\theta\to\infty} s^I_0(\theta) = \underline{\sigma}^I > \underline{\sigma}$. But then, since $F_l(\underline{\sigma}^I) - F_h(\underline{\sigma}^I) > 0$, it must be that $\overline{p}^I = 1$ by (2), yielding a contradiction. Hence, $\overline{p}^I = 1$ and $\underline{\sigma}^I = \underline{\sigma}$.■

Proof of Proposition 3. Suppose $\theta > \theta^C_-$. Since $\theta^C_- < \theta^I_-$, clearly $s^C(\theta) < s^I(\theta) = \overline{\sigma}$ for $\theta \in (\theta^C_-, \theta^I_-)$. Next, note that $\theta^C_+ > \theta^*$: otherwise, if $\theta^C_+ \leq \theta^*$, then there would be some finite $\theta \geq \theta^C_+$ for which $p^I(\theta) = 1$, contradicting Proposition 2.

Suppose $\theta < \theta^*$, but, on the contrary, $s^C(\theta) = s^C_0(\theta) \geq s^I(\theta)$. Since $s^I(\theta) > s^I(\theta^*)$, it follows that $V_s(s^I(\theta), p^I(\theta)) = 0$ and $P_s(s^I(\theta),\theta) < 0$, which imply $\frac{d}{ds}V(s,P(s,\theta))\Big|_{s=s^I(\theta)} < 0$, and by Assumption 2 reveal $s^C(\theta) < s^I(\theta)$ – a contradiction. Thus, $s^C(\theta) < s^I(\theta)$ for $\theta < \theta^*$. Given $\theta^C_+ > \theta^*$, a similar line of argument shows that $s^C(\theta^*) = s^I(\theta^*)$, and $s^C(\theta) > s^I(\theta)$ for $\theta^* < \theta \leq \theta^C_+$. Finally, suppose $\theta > \theta^C_+$. Then, $s^C(\theta) = \min\{s | P(s,\theta) = 1\}$ by Proposition 1. If , on the contrary, $s^C(\theta) \leq s^I(\theta)$, then since $\theta > \theta^C_+$, we would have $1 = P(s^C(\theta),\theta) \leq P(s^I(\theta),\theta)$ because $P_s(s,\theta) > 0$ for $\theta > \theta^C_+$. But this would imply $p^I(\theta) = 1$, contradicting Proposition 1. Hence, $s^C(\theta) > s^I(\theta)$ for $\theta > \theta^C_+$. Finally, to prove $p^C(\theta) \geq p^I(\theta)$ with strict inequality if $\theta \neq \theta^*$, simply recall $P_s(s,\theta) =^{sign} s^* - s$ whenever $P(s,\theta) < 1$. ■

Proof of Proposition 4. Directly follows from (12), (13), and (14). ■

Proof of Proposition 5. Since $s^I(\theta)$ is strictly decreasing for $\theta > \theta^I_-$, and $s^B = s^I(\mu)$, part (i) immediately follows. To prove part (ii), note that $F_l(s) - F_h(s)$ is strictly quasi-concave in s, achieving its unique maximum at $s = s^*$. If $\mu = \theta^*$ so that $s^B = s^*$, then $p^B(\theta) > p^I(\theta)$ for all $\theta \neq \theta^*$. Hence, $E[p^B(\theta)] > E[p^I(\theta)]$. If $\mu < \theta^*$ so that $s^B > s^*$, then the strict quasiconcavity of $F_l(s) - F_h(s)$ implies that there is a unique $s^l < s^*$ such that $F_l(s) - F_h(s) > F_l(s^B) - F_h(s^B)$ if and only if $s \in (s^l, s^B)$. Equivalently, since $s^I(\theta)$ is strictly decreasing, there is a unique $\theta^h(\mu) > \theta^*$ such that $\theta^h(\mu)$ is continuous and strictly decreasing in μ, and $\theta^h(\theta^*) = \theta^*$. Moreover, $p^I(\theta) > p^B(\theta)$ for $\theta \in (\mu, \theta^h(\mu))$ and $p^I(\theta) < p^B(\theta)$ for $\theta \notin (\mu, \theta^h(\mu))$. This means $E[p^B(\theta)] > E[p^I(\theta)]$ if μ is sufficiently close to θ^*. The same line of argument holds if μ is strictly greater than but sufficiently close to θ^*. Together it follows that there exists $\epsilon > 0$ such that $|\mu - \theta^*| < \epsilon \Longrightarrow E[p^B(\theta)] > E[p^I(\theta)]$. ■

Proof of Lemma 2. To save on notation, let $p = p^I(\theta)$ and $s = s^I(\theta)$ in this proof, and consider $\theta > \theta^I_-$ so that $p > 0$. We first prove the following claim.

Claim. *$\frac{p''}{p's'} \to \infty$, as $\theta \to \infty$.*

Proof. Since $p < 1$ by Proposition 2, $p = \theta u(F_l(s) - F_h(s))$. Differentiating with respect to θ, we obtain

$$p' = u[(F_l(s) - F_h(s)) + \theta(f_l(s) - f_h(s))s']$$

and

$$p'' = u[(f_l(s) - f_h(s))(2s' + \theta s'') + (f'_l(s) - f'_h(s))\theta(s')^2].$$

Again, by Proposition 2, we know $p \to 1$ and $s \to \underline{\sigma}$ as $\theta \to \infty$. Suppose $\theta s' \to a < 0$. Then, $p' \to u[f_l(\underline{\sigma}) - f_h(\underline{\sigma})]a < 0$, which contradicts $p' > 0$, because $f_l(\underline{\sigma}) - f_h(\underline{\sigma}) > 0$. Hence, $\theta s' \to 0$, which implies $s' \to 0$.

Note that $\frac{p'}{\theta s'} = u[\frac{F_l(s)-F_h(s)}{\theta s'} + f_l(s) - f_h(s)]$. Moreover, by L'Hospital rule, $\lim_{\theta\to\infty} \frac{F_l(s)-F_h(s)}{\theta s'} = \lim_{\theta\to\infty} \frac{(f_l(s)-f_h(s))s'}{s'+\theta s''}$. This means for a sufficiently large θ, $\frac{p'}{\theta s'} \approx u[f_l(\underline{s}) - f_h(\underline{\sigma})]\frac{2s'+\theta s''}{s'+\theta s''}$. Since $\frac{p'}{\theta s'} < 0$, $f_l(\underline{\sigma}) - f_h(\underline{\sigma}) > 0$ and $s' < 0$, we must have $s' + \theta s'' > 0$ and $2s' + \theta s'' < 0$. Now, observe that since $s' \to 0$ and $s'' > 0$, it follows $s'' \to 0$. Using L'Hospital rule, $\frac{s'}{s''} \approx \frac{s''}{s'''}$ for a sufficiently large θ, implying that $s''' < 0$. A similar limit argument shows that $\frac{F_l(s)-F_h(s)}{s'} \approx$

$\frac{[f_l(\underline{\sigma})-f_h(\underline{\sigma})]s'}{s''} \approx \frac{[f_l'(\underline{\sigma})-f_h'(\underline{\sigma})](s')^2+[f_l(\underline{\sigma})-f_h(\underline{\sigma})]s''}{s'''}$. Given $s''' < 0$, the numerator of the last ratio must be positive, or, equivalently $\frac{f_l'(\underline{\sigma})-f_h'(\underline{\sigma})}{f_l(\underline{\sigma})-f_h(\underline{\sigma})} > -\frac{s''}{(s')^2}$. Next, consider the following ratio:

$$\frac{p''}{p's'} = \frac{u[(f_l(s) - f_h(s))(2s' + \theta s'') + (f_l'(s) - f_h'(s))\theta(s')^2]}{p's'}.$$

Dividing the r.h.s. by $\theta(s')^2$, we obtain

$$\frac{p''}{p's'} = \frac{(f_l(s) - f_h(s))\frac{2s'+\theta s''}{\theta(s')^2} + f_l'(s) - f_h'(s)}{\frac{p'}{\theta s'}}u.$$

Thus, for a large θ

$$\begin{aligned}
\frac{p''}{p's'} &\approx \frac{[f_l(\underline{\sigma}) - f_h(\underline{\sigma})]\frac{2s'+\theta s''}{\theta(s')^2} + f_l'(\underline{\sigma}) - f_h'(\underline{\sigma})}{[f_l(\underline{\sigma}) - f_h(\underline{\sigma})]\frac{2s'+\theta s''}{s'+\theta s''}}u \\
&= \frac{s' + \theta s''}{\theta(s')^2}u + \frac{[f_l'(\underline{\sigma}) - f_h'(\underline{\sigma})]}{[f_l(\underline{\sigma}) - f_h(\underline{\sigma})]}\frac{s' + \theta s''}{2s' + \theta s''}u \\
&> \frac{s' + \theta s''}{\theta(s')^2}u - \frac{s''}{(s')^2}\frac{s' + \theta s''}{2s' + \theta s''}u \\
&= \frac{s' + \theta s''}{2s' + \theta s''}[\frac{2}{\theta s'}]u = +\infty,
\end{aligned}$$

where the last line follows because $p' = -\frac{p^2R'}{r}s'$ and $R'(\underline{\sigma}) < \infty$, revealing $\frac{p'}{\theta s'} = -\frac{p^2R'}{\theta r} \to 0^-$ as $\theta \to \infty$. Furthermore, given $\frac{p'}{\theta s'} \approx u[f_l(\underline{\sigma}) - f_h(\underline{\sigma})]\frac{2s'+\theta s''}{s'+\theta s''}$, we have $\frac{2s'+\theta s''}{s'+\theta s''} \to -\infty$, which, together with $\frac{2}{\theta s'} \to -\infty$, proves the claim.■

Now, note that

$$V^{I''}(\theta) = V_{ps}(\cdot)s'p' + V_p(\cdot)p'', \tag{A1}$$

where $V_s(s,p) = -pf_h(s)v + (1-p)f_l(s)\ell$ and $V_{ps}(s,p) = -f_h(s)v - \ell f_l(s)$.

As $\theta \to \theta^{I}_{-}$, since $s \to \overline{\sigma}$, we have $V_{ps}(\cdot) \to -f_h(\overline{\sigma})v - \ell f_l(\overline{\sigma}) < 0$ and $V_p(\cdot) \to 0$. Hence, $V^{I''}(\theta) > 0$. Finally, for $\theta \to \infty$, we have $s \to \underline{\sigma}$, $V_{ps}(\cdot) \to -f_h(\underline{\sigma})v - \ell f_l(\underline{\sigma}) < 0$ and $V_p(\cdot) \to v + \ell > 0$. Moreover, since, by the Claim, $\frac{p''}{p's'} \to +\infty$, the second term in (A1) dominates, and given $p'' < 0$, implies $V^{I''}(\theta) < 0$.

Overall, there exist two cutpoints $\theta^{I}_{-} < \theta_L \leq \theta_H < \infty$ such that $V^I(\theta)$ is strictly convex for $\theta < \theta_L$ and strictly concave for $\theta > \theta_H$. ■

PROOF OF PROPOSITION 6. Suppose $\underline{\theta} < \theta_L \leq \theta_H < \overline{\theta}$, where θ_L and θ_H are the two cutpoints defined in Lemma 2, and by definition, they are independent of type distribution. Let $G(\theta_H) = G_H < \mu/\theta_H$. Since $V^I(\theta)$ is strictly concave for $\theta > \theta_H$, Jensen's inequality implies

$\int_{\theta_H}^{\overline{\theta}} V^I(\theta)\frac{dG(\theta)}{1-G_H} < V^I(\int_{\theta_H}^{\overline{\theta}} \theta\frac{dG(\theta)}{1-G_H})$, or equivalently $\int_{\theta_H}^{\overline{\theta}} V^I(\theta)dG(\theta) < (1-G_H)V^I(\int_{\theta_H}^{\overline{\theta}} \theta\frac{dG(\theta)}{1-G_H})$. Then,

$$\begin{aligned} E[V(\theta)] &< (1-G_H)V^I(\frac{\mu - \int_{\underline{\theta}}^{\theta_H} \theta dG(\theta)}{1-G_H}) + \int_{\underline{\theta}}^{\theta_H} V^I(\theta)dG(\theta) \\ &\leq (1-G_H)V^I(\frac{\mu-\theta_H G_H}{1-G_H}) + V^I(\theta_H)G_H \equiv \Phi(G_H) \end{aligned}$$

Note that $\Phi'(0) = V^I(\theta_H) - V^I(\mu) + (\mu-\theta_H)V^{I\prime}(\mu) < 0$ because $V^I(\theta)$ is strictly concave for $\theta > \theta_H$ by hypothesis, and $G_H = 0$ implies $\mu > \theta_H$. Note also that $\Phi(0) = V^I(\mu)$. Thus, there is some $\epsilon^B > 0$ such that $E[V(\theta)] < V^I(\mu)$ whenever $G_H < \epsilon^B$. A similar line of argument shows that there is some $\epsilon^I > 0$ such that $E[V(\theta)] > V^I(\mu)$ whenever $G(\theta_L) = G_L > 1-\epsilon^I$, completing the proof of part (i).

To prove the second part, fix a type distribution $G(\theta)$, and let $\hat{\theta} \equiv u\theta \in [u\underline{\theta}, u\overline{\theta}]$ so that $\hat{G}_u(\hat{\theta}) = G(\frac{\theta}{u})$. Clearly, $\hat{G}_u(\theta_H) = G(\frac{\theta_H}{u}) \to 0$ as $u \to \infty$, which implies that there is some $u_H > 0$ such that $\hat{G}_u(\theta_H) < \epsilon^B$ for all $u > u_H$. Applying the result from part (i), we then have $E[V(\theta)] < V^I(\mu)$ for all $u > u_H$. A parallel line of argument reveals that there is some $u_L > 0$ such that $\hat{G}_u(\theta_L) > 1-\epsilon^I$ for all $u < u_L$, and thus $E[V(\theta)] > V^I(\mu)$. ■

PROOF OF PROPOSITION 7. Suppose $\ell > 0$ and $\overline{\ell} > 0$. Note first that $\overline{V}_{ps}(s,p) < 0$, $\overline{V}_p(\underline{\sigma}, p) = v + \ell > 0$, and $\overline{V}_p(\overline{\sigma}, p) = -\overline{\ell} < 0$. Thus, there is a unique $s_d \in (\underline{\sigma}, \overline{\sigma})$ such that $\overline{V}_p(s,p) =^{sign} s_d - s$. In equilibrium under informed review, the exact argument in the proof of Proposition 2 reveals that $\overline{s}^I(\theta) = \overline{\sigma}$ (and $\overline{p}^I(\theta) = 0$) if and only if $\theta < \frac{\overline{r}}{u(\lambda_h-\lambda_l)} = \overline{\theta}^I_-$. Thus, $\overline{V}^I(\theta) = 0$ for $\theta < \overline{\theta}^I_-$. The arguments in Proposition 2 also show $\frac{d}{d\theta}\overline{s}^I(\theta) < 0$ and $\frac{d}{d\theta}\overline{p}^I(\theta) > 0$ for $\theta \geq \overline{\theta}^I_-$. Let $\theta \geq \overline{\theta}^I_-$. Then, $\frac{d}{d\theta}\overline{V}^I(\theta) = \frac{d}{d\theta}\overline{V}(\overline{s}^I(\theta), \overline{p}^I(\theta)) = \overline{V}_p(\overline{s}^I(\theta), \overline{p}^I(\theta))\frac{d}{d\theta}\overline{p}^I(\theta)$. Since $\frac{d}{d\theta}\overline{p}^I(\theta) > 0$, this implies $\frac{d}{d\theta}\overline{V}^I(\theta) =^{sign} s_d - \overline{s}^I(\theta)$, and since $\frac{d}{d\theta}\overline{s}^I(\theta) < 0$, it also implies that there is a unique $\overline{\theta}_d > \overline{\theta}^I_-$ such that $\frac{d}{d\theta}\overline{V}^I(\theta) < 0$ for $\theta < \overline{\theta}_d$ and $\frac{d}{d\theta}\overline{V}^I(\theta) > 0$ for $\theta > \overline{\theta}_d$. Clearly, $\overline{V}^I(\theta) < 0$ for $\theta \leq \overline{\theta}_d$. Given that $\frac{d}{d\theta}\overline{V}^I(\theta) > 0$ for $\theta > \overline{\theta}_d$ and $\overline{V}^I(\theta) > 0$ for a sufficiently large θ, there is a unique $\overline{\theta}^I_r > \overline{\theta}_d$ such that $\overline{V}^I(\overline{\theta}^I_r) = 0$ and thus $\overline{V}^I(\theta) < 0$ for $\theta \in (\overline{\theta}_d, \overline{\theta}^I_r)$. Overall, there exist two types $\overline{\theta}^I_-$ and $\overline{\theta}^I_r$ such that $\overline{V}^I(\theta) = 0$ if $\theta \leq \overline{\theta}^I_-$ or $\theta = \overline{\theta}^I_r$; $\overline{V}^I(\theta) < 0$ if $\theta \in (\overline{\theta}^I_-, \overline{\theta}^I_r)$; and $\overline{V}^I(\theta) > 0$ if $\theta > \overline{\theta}^I_r$, proving part (i).

To prove part (ii), note that since, under commitment, setting $\overline{s}^C(\theta) = \overline{\sigma}$ is always feasible for the principal, $\overline{V}^C(\theta) \geq 0$ for all θ. Note also that type $\theta = \overline{\theta}^I_- \equiv \frac{\overline{r}}{u(\lambda_h-\lambda_l)}$ is not prescreened under commitment if and only if $\overline{V}^C(\overline{\theta}^I_-) > 0$. Let $\theta(\epsilon) = \overline{\theta}^I_- + \epsilon$ for $\epsilon > 0$. By definition, $\overline{s}^I(\theta(\epsilon)) < \overline{\sigma}$, and $\theta(\epsilon) \to \epsilon$ as $\overline{\ell} \to \infty$. Suppose $\overline{s}^C(\theta(\epsilon)) < \overline{\sigma}$. Then, $V^C(\overline{s}^C(\theta(\epsilon)), p^C(\theta(\epsilon))) \approx -[1 - F^h(\overline{s}^C(\theta(\epsilon)))]\ell < 0$ for a small ϵ and large $\overline{\ell}$, which means the principal is better off setting $\overline{s}^C(\theta(\epsilon)) = \overline{\sigma}$. ■

Proof of Lemma 3. Integrating by parts and arranging terms, (17) simplifies to:

$$H(m_1;\phi) \equiv 2(1-\phi)\int_{\underline{\theta}}^{m_1} G(\theta)d\theta + \phi m_1 - \phi\mu = 0. \tag{A2}$$

Note that $H(m_1;\phi)$ is strictly increasing in m_1 and that $H(\underline{\theta};\phi) \le 0$ and $H(\mu;\phi) > 0$. Thus, there is a unique solution $m_1 = \mu_1(\phi)$ to (A2), and its boundary values are $\mu_1(0) = \underline{\theta}$ and $\mu_1(1) = \mu$. Furthermore, $\mu_1(\phi)$ is strictly increasing, because $H_\phi(m_1;\phi) = -2\int_{\underline{\theta}}^{m_1} G(\theta)d\theta + m_1 - \mu < 0$ for $m_1 \le \mu$. ■

Proof of Lemma 4. Recall that

$$\pi_1^{B,I}(\phi) = [(1-\frac{\phi}{2})G(\mu_1(\phi)) + \frac{\phi}{2}(1-G(\mu_1(\phi)))]V^I(\mu_1(\phi))$$

and

$$\pi_2^{B,I}(\phi) = \frac{\phi}{2}\int_{\underline{\theta}}^{\mu_1(\phi)} V^I(\theta)dG(\theta) + (1-\frac{\phi}{2})\int_{\mu_1(\phi)}^{\overline{\theta}} V^I(\theta)dG(\theta).$$

From Lemma 3, we have $\pi_1^{B,I}(0) = 0$ and $\pi_1^{B,I}(1) = \frac{1}{2}V^I(\mu)$. Next, we differentiate $\pi_1^{B,I}(\phi)$ to obtain

$$\frac{d}{d\phi}\pi_1^{B,I}(\phi) = [(1-\phi)G(\mu_1) + \frac{\phi}{2}][\frac{d}{d\theta}V^I(\mu_1)]\mu_1' + [-G(\mu_1) + (1-\phi)g(\mu_1)\mu_1' + \frac{1}{2}]V^I(\mu_1) > 0,$$

where $-G(\mu_1) + (1-\phi)g(\mu_1)\mu_1' + \frac{1}{2} \ge 0$ follows from (17).

Again, from Lemma 3, we have $\pi_2^{B,I}(0) = E[V^I(\theta)]$ and $\pi_2^{B,I}(1) = \frac{1}{2}E[V^I(\theta)]$. Differentiating $\pi_2^{B,I}(\phi)$ yields

$$\frac{d}{d\phi}\pi_2^{B,I}(\phi) = \frac{1}{2}[\int_{\underline{\theta}}^{\mu_1(\phi)} V^I(\theta)dG(\theta) - \int_{\mu_1(\phi)}^{\overline{\theta}} V^I(\theta)dG(\theta)] - (1-\phi)V^I(\mu_1)g(\mu_1)\mu_1' < 0.■$$

Proof of Proposition 8. Suppose $\frac{1}{2}V^I(\mu) < E[V^I(\theta)] < V^I(\mu)$. Since $0 < \frac{1}{2}E[V^I(\theta)] < \frac{1}{2}V^I(\mu)$, by Lemma 4 there is $\phi_1 \in (0,1)$ such that $\pi_1^{B,I}(\phi) < \frac{1}{2}E[V^I(\theta)]$ if and only if $\phi < \phi_1$. Moreover, since $\frac{1}{2}E[V^I(\theta)] < \frac{1}{2}V^I(\mu) < E[V^I(\theta)]$, by Lemma 4 there is also $\phi_2 \in (0,1)$ such that $\pi_2^{B,I}(\phi) > \frac{1}{2}V^I(\mu)$ if and only if $\phi < \phi_2$. Define $\phi^* = \min\{\phi_1,\phi_2\}$ and $\phi^{**} = \max\{\phi_1,\phi_2\}$. Clearly, $0 < \phi^* \le \phi^{**} < 1$. If $\phi < \phi^*$, then $\pi_1^{B,I}(\phi) < \frac{1}{2}E[V^I(\theta)]$ and $\pi_2^{B,I}(\phi) > \frac{1}{2}V^I(\mu)$, which imply that choosing informed review is a strictly dominant strategy for each evaluator, and thus the unique equilibrium has $\tau_1 = \tau_2 = I$. A similar argument shows that if $\phi > \phi^{**}$, then choosing blind review is a strictly dominant strategy for each evaluator, and thus the unique equilibrium has $\tau_1 = \tau_2 = B$. Suppose $\phi^* \ne \phi^{**}$ and $\phi \in (\phi^*,\phi^{**})$. If $\phi^* = \phi_2$ and $\phi^{**} = \phi_1$, then there are exactly two equilibria: $\tau_1 = \tau_2 = I$ and $\tau_1 = \tau_2 = B$. If, on the other hand, $\phi^* = \phi_1$ and $\phi^{**} = \phi_2$, then there are also two equilibria: $\tau_i = B$ and $\tau_j = I$ for $i,j = 1,2$ and $i \ne j$. ■

Proof of Proposition 9. First we state and prove a useful technical lemma.

Lemma A1.

$$\int_{-\infty}^{+\infty} y f_z(s-x-y) f_y(y)\,dy = \frac{f_\epsilon(s-x)(s-x)v_y^2}{v_y^2+v_z^2}$$

Proof. Observe that

$$F_z(s-x-y)f_y(y) = \left(2\pi\sqrt{v_z^2 v_y^2}\right)^{-1} \exp\left(-(s-x-y)^2/2v_z^2) - (y^2/2v_y^2)\right).$$

Combining terms in the exponential yields

$$\frac{s-x-y)^2}{2v_z^2} + \frac{y^2}{2v_y^2} = \frac{\left(v_y^2+v_z^2\right)\left[y^2 - 2y\left(v_y^2/\left(v_y^2+v_z^2\right)\right)(s-x)\right] + v_y^2(s-x)^2}{2v_y^2 v_z^2}.$$

Completing the square for the term in brackets gives

$$\frac{\left(v_y^2+v_z^2\right)\left(y-(v_y^2/(v_y^2+v_z^2))(s-x)\right)^2}{2(v_y^2 v_z^2} + \frac{(s-x)^2}{2\left(v_y^2+v_z^2\right)}.$$

Note that

$$f_\epsilon(s-x) = \left(\sqrt{2\pi\left(v_y^2+v_z^2\right)}\right)^{-1} \exp\left(-\frac{(s-x)^2}{2\left(v_y^2+v_z^2\right)}\right).$$

Combining this with the previous expression gives

$$f_z(s-x-y)f_y(y) = f_\epsilon(s-x)\left(\sqrt{2\pi w^2}\right)^{-1} \exp\left(-\frac{\left(y-v_y^2(s-x)/(v_y^2+v_z^2)\right)^2}{2w^2}\right),$$

where

$$w^2 = \frac{v_y^2 v_z^2}{v_y^2+v_z^2}.$$

Using this fact yields

$$\int_{-\infty}^{+\infty} y f_z(s-x-y) f_y(y)\,dy = f_\epsilon(s-x)\int_{-\infty}^{+\infty} y\left(\sqrt{2\pi w^2}\right)^{-1} \exp\left(-\frac{\left(y-v_y^2(s-x)/(v_y^2+v_z^2)\right)^2}{2w^2}\right).$$

Noting that the integral on the right is the expected value of a Normally distributed random variable with mean $v_y^2(s-x)/\left(v_y^2+v_z^2\right)$ completes the proof. □

Each case of Proposition 9 is now proven in turn.

(i) For the commitment case, maximize the evaluator's payoff (18) with respect to s and x, subject to the agent's reaction function (20). Letting γ denote the Lagrange multiplier, the first-order conditions are

$$f_\epsilon(s-x)(v_0-x) - \int_{-\infty}^{+\infty} y f_z(s-x-y) f_y(y)\,dy + \gamma\theta u f_\epsilon'(s-x) = 0 \qquad \text{(A3)}$$

and

$$-\left[f_\epsilon(s-x)(v_0-x)-\int_{-\infty}^{+\infty} y f_z(s-x-y)f_y(y)\,dy+\gamma\theta u f'_\epsilon(s-x)\right]+1-F_\epsilon(s-x)-\lambda=0. \tag{A4}$$

Noting from (A3) that the bracketed expression in (A4) is zero yields $\gamma = 1 - F_\epsilon(s-x)$. Substituting this into (A3) and invoking Lemma A1 gives

$$f_\epsilon(s-x)\left(v_0-x-\frac{(s-x)v_y^2}{v_y^2+v_z^2}\right)+(1-F_\epsilon(s-x))f'_\epsilon(s-x)=0,$$

or

$$s=\left(\frac{v_y^2+v_z^2}{v_y^2}\right)\left(v_0+\frac{(1-F_\epsilon(s-x)f'_\epsilon(s-x)}{f_\epsilon(s-x)}\right)-x\frac{v_z^2}{v_y^2}.$$

Noting that

$$\frac{f'(\epsilon(s-x)}{f_\epsilon(s-x)}=\frac{x-s}{v_y^2+v_z^2}$$

completes the proof for this case.

(ii) for the informed-review case, maximize the evaluator's payoff (**??**) with respect to s. The first-order condition is

$$f_\epsilon(s-x)(v_0-x)-\int_{-\infty}^{+\infty} y f_z(s-x-y)f_y(y)\,dy=0.$$

Invoking Lemma A1 and solving for s completes the proof for this case.

(iii) For the blind-review case, compute the expected value of the evaluator's payoff (18) with respect to θ. Then maximize this with respect to s to get the first-order condition

$$\int_{\underline{\theta}}^{\overline{\theta}}\left(f_\epsilon(s-x^B(\theta))(v_0-x^B(\theta))+\int_{-\infty}^{+\infty} y f_z(s-x^B(\theta)-y)f_y(y)\,dy\right)g(\theta)\,d\theta=0.$$

Invoking Lemma A1 and solving for s completes the proof for this case. ■

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