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Managerial career concerns and investments in information

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We extend the "implicit incentives" literature by analyzing how career concerns affect a risk-neutral manager's decision about how much to learn about a project before investing in it. The manager has unknown ability that determines the probability with which a good project is available, so the market updates ability assessments from project outcomes. While project choice is efficient in equilibrium, an unobservable investment in the precision of project evaluation allows the manager to control the probabilities of future reputational states. This distorts his investment in precision above first best when project payoffs can be observed only on accepted projects.

1. Introduction

■ Effort-aversion and project-choice moral hazard have been extensively studied in the literature, including the manner in which agents' career concerns affect effort choices (see Fama, 1980 and Holmström, 1982, 1999) and project selection (see Holmström and Ricart i Costa, 1986 and Hirshleifer and Thakor, 1992). In this article we focus on a fundamentally different incentive problem, namely one that arises from the manager's desire to distort corporate investments in information in order to influence the way the labor market learns about his ability. More specifically, the manager's investment in information precision allows him to alter the likelihoods with which the market forms inferences about managerial ability, thereby diminishing the probability of undesirable reputational outcomes.

Our focus is motivated by the observation that in real-world resource allocation decisions, the incentive problems that have to be resolved extend beyond effort and project choices to sophisticated games that managers play with corporate resources. One of these games has to

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do with how much of a firm's resources the manager devotes to acquiring information about investment opportunities, such as the amount of credit analysis a loan officer does before deciding on a loan application. More precise information requires more resources but reduces the likelihood of decision errors. Thus, the firm faces a tradeoff between the cost and the benefit of information precision. But a manager may face a different tradeoff due to career concerns if the precision of information influences the firm's perception of his ability. Our objective is to study these tradeoffs by addressing three questions: How do the career concerns of managers affect their incentives to invest in information? How are a manager's information-investment incentives affected by greater labor market uncertainty about his ability? What are the implications of the interaction between career concerns and information-investment incentives for regulatory policy and observed organizational practices?

As for the first question, we show that career concerns can cause the manager to overinvest in information. In doing so, he influences what the market can observe to draw inferences about his ability. To fix ideas and get to the heart of the intuition, consider a risk-neutral manager who generates new product ideas for the firm. Ideas may be good or bad, and a manager of higher ability is more likely to generate a good idea. Information is symmetric—*a priori* nobody knows either the manager's ability or whether the idea is good or bad.

The manager can invest in research and development, solicit consultants' opinions, engage in competitive intelligence, and so on to "test" his idea before proposing or abandoning it. These investments in information generate a (noisy) signal about the true quality of the idea, and the precision of the signal is increasing in the resources expended on such information. Everyone observes the signal the manager generates about the project; the critical asymmetry is that the manager's investment in signal precision is privately observed by him.[1]

The labor market learns about the manager's ability based on its prior assessment, the signal of project quality that is publicly observed, its equilibrium belief about the manager's choice of information precision, and the ultimate outcome of *accepted* projects. *Ex ante* the manager's choice of information precision does not influence the labor market's *ex post* beliefs about ability for any observed outcome. In fact, for any observable outcome, everybody agrees on the posterior assessment of the manager's ability. Moreover, the risk-neutral manager always follows the firm's desired (first-best) project-selection strategy. However, the manager's preference for investment in information (signal precision) does *not* agree with the firm's. More precise signals increase the probability with which bad projects are weeded out and good projects are accepted, implying that the manager's investment in signal precision influences the likelihood of a good reputation forming *ex post*. By manipulating his investment in information, the career-conscious manager can tilt the probabilities toward outcomes that are reputationally more favorable.

We consider a *de novo* project, where success or failure is observed only if the project is accepted. The manager gets the highest reputation if an accepted project turns out to be good, the next-highest reputation if a project is rejected, and the lowest reputation if an accepted project turns out to be bad. This tempts the manager to *overinvest* in information relative to the first best, because doing so increases the likelihood of the highest reputation forming and decreases the likelihood of the lowest reputation forming.

To develop the intuition further, we consider two alternative structures. First, suppose that project outcomes are observed on rejected projects in addition to accepted projects. In this case, the information-investment inefficiency disappears, since *all* the relevant outcomes are observed; there is no longer the "safe haven" of rejected projects that exists when only the payoffs on accepted projects are observed. With all possible outcomes observable, the manager cannot benefit from distorting investments in information to influence outcome probabilities. Second, suppose that project outcomes are observed only on rejected projects. Now projects that are accepted generate no additional information, while rejected projects reveal the project's type perfectly. In this case, the manager prefers the signal to be *wrong*, so that a rejected project ultimately turns out to

[1] Our results are identical if the manager *privately* observes the signal of project quality.

be good. The equilibrium for this information structure entails the manager *underinvesting* in information.

As for the second question, we find that when the manager's information investment is unobservable and the payoff can be observed only on an accepted project, the manager's private returns to investment in information are increasing in the market's uncertainty about his ability. This suggests that younger or less-seasoned managers will overinvest in information to a greater extent. Moreover, since increased information expenditures lead to fewer errors in project selection, we predict that the *ex ante* variance of firm value is decreasing in the market's *ex ante* (presignal) uncertainty about managerial ability, as long as the prior beliefs about managerial ability aren't too low. By contrast, the more weight the manager's utility function attaches to firm value, the smaller the distortion away from first best and the higher the variance of firm value, again as long as prior beliefs about managerial ability aren't very low.

As for the third question, our analysis has a host of implications for regulatory policy and organizational practice. Our analysis (i) implies that the self-interested behavior of career-conscious bank managers may actually reduce the risk exposure of federal deposit insurance, (ii) explains why younger mutual fund managers may choose portfolios with less unsystematic risk, (iii) indicates that firms with more career-conscious managers will have longer product-development cycle times, and (iv) shows that, in the context of divesting unproductive assets, the manager's overinvestment in information could actually *ameliorate* another distortion arising from his career concerns, namely his propensity to delay asset divestiture relative to the shareholders' optimum.

Our model extends the seminal work of Holmström (1982, 1999), which demonstrates that career concerns create a divergence between the project-choice preferences of a firm and a manager who invests for the firm. In the Holmström model, a manager observes projects and recommends promising ones for investment. No one (including the manager) knows the manager's ability, but project outcomes are related to ability. Holmström's main result is that if the manager is risk neutral and his payoffs are linear in the posterior belief about his ability, then there is no divergence between the manager's choice of project and the first best, as long as the manager can communicate project risk to the market. When the manager's signal about project quality is also observed by the market,[2] career concerns distort the manager's decision away from first best only when he is risk averse or the output technology is nonlinear in managerial ability so that the process of learning about ability is nonlinear.

The intuition in the Holmström result is straightforward: if the manager's payoffs are linear functions of the market's posterior beliefs about his ability, then the expected value of the manager's payoff from proposing a project is equal to the payoff based on the prior assessment of his ability. Hence, a risk-neutral manager is willing to follow the firm's preferred investment strategy as long as he and the market both see the risk of the project. For career concerns to matter, something must break the symmetry between the risk faced by the manager and the risk faced by the firm. Holmström shows that managerial risk aversion or a managerial payoff that is nonlinear in posterior beliefs about his ability can achieve this.

Our result about investment distortions in this environment is based on an important distinction between our model and Holmström's, namely that we allow the manager to invest unobservably in the precision of a signal that noisily reveals project quality. It is this investment, which Holmström does not consider, that is inefficient.

Apart from Holmström, there are numerous articles that have examined investment inefficiencies arising from career concerns.[3] In Holmström and Ricart i Costa (1986), the inefficiency is overinvestment in projects, to which the firm responds by rationing capital. Hermalin (1993)

[2] Holmström also considers a variant of his base setting in which a risk-neutral manager whose payoff is linear in posterior beliefs about his ability *privately* observes a signal (whose probability distribution he cannot manipulate) about project risk that the market does not see. A "lemons" argument shows that in this case, the only equilibrium is degenerate—the manager never invests in the project unless it is riskless.

[3] Lambert (1986) shows that in a static agency setting with no career concerns, lazy managers will invest too little in information to learn about projects.

examines how career concerns affect the riskiness of the projects managers choose. Hirshleifer and Thakor (1992) show that managers invest in excessively safe projects to protect their human capital against conspicuous and early project failure. Narayanan (1985) shows that a career-conscious manager is myopic, preferring lower-valued, short-term projects to higher-valued, long-term projects. Scharfstein and Stein (1990) examine how career concerns can lead managers to ignore their potentially valuable information and instead exhibit herd behavior in their investment choices. In Prendergast and Stole (1996), investment distortions arise from managers attempting to influence perceptions of their ability to learn about project profitability. A novice manager's desire to appear as a quick learner makes him exaggerate his initial information, while later-career managers respond too conservatively to new information in order to hide previous investment errors.

The feature that most significantly distinguishes our article from this literature is that we provide a model in which the manager can *alter* the probabilities of occurrence of the various states in which the market forms differing assessments of the manager's ability. That is, the manager can influence the relative probability weights on reputational states that are observed and not observed.[4] Thus, it is not a model of whether a manager works too much or too little or distorts his project choice. Rather, it is a model that shows the prevalence of investment distortions of a different sort that arise due to the manager's attempt to manipulate the market's inference of ability by introducing a statistical bias in this inference by becoming better informed on the margin.

The rest of the article is organized as follows. Section 2 develops the model. Section 3 contains an analysis of the first-best and reputational equilibria. Section 4 examines the implications of changing the key assumptions in the model. Section 5 discusses applications of the analysis. Many of these implications and applications are quite specific to our model and do not result from the "standard" career concerns model (e.g., Holmström, 1982, 1999). Section 6 concludes.

2. The model

■ **Agents and investment opportunities.** We consider a two-period (three-date) world in which a manager is employed by the owners of a firm to generate and evaluate investment opportunities. The manager generates a project idea at $t = 0$, and the project may be either good (G) or bad (B). The quality of a project (G or B) depends on the manager's skill, which is unknown to the labor market, the firm, and the manager. The probability that a project is type G depends on the manager's ability, $p \in [0, 1]$, via the assumption that Pr[project idea is $G \mid p] = p$, $\forall\, p \in [0, 1]$. The uncertainty about p is described by a continuous probability density function $f(p)$, and we denote

$$E[p] = \int_0^1 pf(p)dp \equiv \overline{p} \tag{1}$$

$$\text{Var}[p] = \int_0^1 p^2 f(p)dp - \overline{p}^2 \equiv \sigma^2. \tag{2}$$

Consequently, the universal $t = 0$ (unconditional) belief about the manager's project is

$$\Pr[G] = E[p] = \overline{p}. \tag{3}$$

The project, if accepted, requires an investment of I at $t = 1$, and the true value of the accepted project is perfectly revealed at $t = 2$. We denote the payoffs on good and bad projects, respectively, as G and B, with $B < I < G$. Ignoring discounting, the project's unconditional expected NPV is

$$E[NPV] = \overline{p}G + [1 - \overline{p}]B - I. \tag{4}$$

[4] In a setting different from ours, Hirshleifer and Chordia (2000) build a model in which a career-conscious manager affects the formation of his reputation by choosing when to resolve uncertainty about a project. Since project payoffs help resolve managerial type-uncertainty, the manager has an incentive to manipulate when they are observed.

We assume that the firm is *a priori indifferent* to this project, that is, $E[NPV] = 0$.[5]

□ **Project signals.** At $t = 0$, the manager decides how much to spend on evaluating the project before making an investment decision at $t = 1$.[6] The evaluation generates an observable signal $s \in \{s_G, s_B\}$. Signal observability ensures that the manager's project choice is efficient.[7] We capture the investment in information by allowing the manager to choose θ, the precision of the signal s, given by

$$\Pr[s = s_G \mid G] = \Pr[s = s_B \mid B] = \theta,$$

where $\theta \in [1/2, 1]$.[8] Larger values of θ increase the informativeness of the signal; the cost of this precision is given by $C(\theta)$, an increasing and convex function of θ that satisfies the Iñada conditions $C'(1/2) = 0$ and $C'(1) = \infty$. Initially we assume that the cost of precision is borne entirely by the owners of the firm, but we will relax this later. Lastly, while the signal is publicly observed at $t = 1$, we assume that the precision (θ) and the resources invested in this precision ($C(\theta)$) are known only by the manager. One might think that it should not be difficult to observe something as tangible as the resources dedicated to investigation of a project's quality. However, it may be difficult to discern when exactly a product idea first came to the manager and how long the manager worked on it before making it known to others in the organization. Equally difficult to determine might be the organizational resources tied up in investigating the project, since these would include the costs of developing and testing prototypes and conducting market research, as well as the time of various people helping to generate information about the project.

□ **Preferences.** All agents are assumed to be risk neutral, and the labor market for managers of varying ability is perfectly competitive. While the firm's owners seek to maximize the expected value of the firm, the manager cares about both firm value and the labor market's $t = 2$ perception of his ability. The manager's utility function is assumed to be

$$U = \alpha \times E_0\left[E_2\left[p \mid \{\Omega_2\}\right]\right] + \pi, \tag{5}$$

where $\{\Omega_2\}$ represents the labor market's information set at $t = 2$, π is the profit of the firm, and $\alpha > 0$ captures the relative weight the manager places on expected reputation. The information set $\{\Omega_2\}$ includes the prior assessment of managerial ability $\overline{p}$, the observed $t = 1$ signal $s \in \{s_G, s_B\}$, the firm's $t = 1$ investment decision, and the $t = 2$ outcome if the project is accepted. The exterior expectation, E_0, represents the manager's lottery over $t = 2$ outcomes as of date $t = 0$, and the interior expectation, E_2, represents the labor market's revised beliefs at $t = 2$, conditional on $\{\Omega_2\}$.

3. Equilibrium analysis

■ **First-best equilibrium.** Because the unconditional NPV of the project is zero, for any $\theta > 1/2$, the firm always prefers to invest if the signal $s = s_G$ and never prefers to invest if the signal $s = s_B$.[9] Following this investment policy, when the project's type is G and s_G is observed (which occurs with probability $p\theta$), the project's NPV is $G - I > 0$; when the project's type is B and s_G is observed (occurring with probability $[1 - p][1 - \theta]$), the project's NPV is $B - I < 0$.

[5] This assumption simplifies the analysis but does not affect the results. Later we shall show that our result of overinvestment in information precision holds for any project that is evaluated by the manager.

[6] Since the manager decides how much to invest in information, he has *real* authority as defined by Aghion and Tirole (1997).

[7] Actually, the observability assumption is not restrictive because the manager in our model has no incentive to distort project choice.

[8] Assuming $\theta \geq 1/2$ is reasonable because it ensures that the signal is informative in the sense that $\Pr[G \mid s = s_G] \geq \Pr[G] = \overline{p}$, with strict inequality for $\theta > 1/2$. Since the unconditional project NPV is zero, the NPV conditional upon observing s_G is positive, and upon observing s_B is negative.

[9] Note that if $\theta = 1/2$, the signal is uninformative and the project remains a zero-*NPV* investment. However, the choice of $\theta = 1/2$ in equilibrium is ruled out by the Iñada conditions.

Hence, the objective function of the firm, upon taking expectations over p using (1), is

$$\pi(\theta) = \overline{p}\theta \times [G - I] + [1 - \overline{p}][1 - \theta][B - I] - C(\theta). \tag{6}$$

Given that $\pi(\theta)$ is concave and satisfies the Iñada conditions (via $C(\theta)$), the unique first-best precision θ^{fb} is the solution to the first-order condition

$$C'(\theta^{fb}) = \overline{p} \times [G - I] + [1 - \overline{p}][I - B] = 2\overline{p}[1 - \overline{p}][G - B], \tag{7}$$

where the second equality follows from the fact that the unconditional NPV is zero.

The intuition behind this result is straightforward. The first-best investment in project information trades off the cost of this information, $C(\theta^{fb})$, against its benefit, which is a decreased likelihood of accepting bad projects and rejecting good ones. The benefit of not accepting a bad project is $I - B$ and the benefit of not rejecting a good one is $G - I$. Further, the benefit of information is proportional to the difference in the payoffs, $G - B$, a measure of project payoff volatility. Thus, the first-best investment in information is increasing in project payoff volatility and decreasing in the cost of signal precision.

□ **Second-best reputational equilibrium.** When a manager's ability is unknown, the manager may be tempted to manipulate the precision of the signal in order to influence the labor market's *ex post* inference about his ability. Of course, in equilibrium the market will not be systematically deceived about the expected ability of the manager. Hence, an equilibrium in this model is a manager's strategy (his choice of signal precision θ^*) and the market's beliefs about θ^* (a set of conditional expectations detailed in Lemma 1) such that

(i) the manager's equilibrium choice of precision is utility maximizing given the beliefs of the market, and

(ii) the market updates beliefs according to Bayes' rule, and the market's beliefs coincide with the manager's choice of precision.[10]

We begin with the labor market's potential assessments of the manager's ability at $t = 2$. The manager's lottery consists of three potential outcomes: observing the good signal s_G joint with a good project outcome (occurring with probability $p\theta$); observing the good signal s_G joint with a bad outcome (occurring with probability $[1 - p][1 - \theta]$); and observing the bad signal s_B and no outcome since the project is rejected (occurring with probability $p[1 - \theta] + [1 - p]\theta$). Hence, there are three possible reputations that the manager may have at $t = 2$, and these reputations are captured by the market's posterior expectations of p, given the three outcomes. These are $E[p \mid s_G, G]$, $E[p \mid s_G, B]$, and $E[p \mid s_B]$. Observe that the market's conditional expectations are built upon equilibrium beliefs over the manager's privately optimal choice of θ^*. These posteriors are characterized in the following lemma.

Lemma 1. The three reputational assessments that the manager can achieve are

$$E[p \mid s_G, G] = \overline{p} + \frac{\sigma^2}{\overline{p}}$$
$$E[p \mid s_G, B] = \overline{p} - \frac{\sigma^2}{1 - \overline{p}}$$
$$E[p \mid s_B] = \overline{p} - \frac{\sigma^2[2\theta^* - 1]}{\overline{p} - [2\overline{p} - 1]\theta^*},$$

where θ^* is the equilibrium belief about the manager's privately optimal choice of signal precision in a second-best equilibrium. These assessments satisfy $E[p \mid s_G, B] < E[p \mid s_B] < E[p] = \overline{p} < E[p \mid s_G, G]$.

Proof. See the Appendix.

[10] Note that our definition of equilibrium does not specify any beliefs in response to out-of-equilibrium moves. This is because there are no out-of-equilibrium moves.

The manager will choose θ to maximize his expected utility from (4), given the market's equilibrium conditional expectations. Since the θ used in determining the conditional expectations in Lemma 1 is the equilibrium belief about the manager's choice of θ, denoted θ^*, the manager cannot influence these expectations. However, the manager's choice of θ does influence the relative likelihoods of the three reputations forming. The manager will then choose θ to maximize

$$\max_{\theta} E[U] = \alpha\overline{p}\theta E[p \mid s_G, G] + \alpha [1 - \overline{p}] [1 - \theta] E[p \mid s_G, B] + \alpha [\overline{p} [1 - \theta] + [1 - \overline{p}] \theta] E[p \mid s_B] + \pi(\theta).$$

The manager's first-order condition is then

$$\frac{\partial E[U]}{\partial \theta} = \alpha\overline{p} \{E[p \mid s_G, G] - E[p \mid s_B]\} + \alpha [1 - \overline{p}] \{E[p \mid s_B] - E[p \mid s_G, B]\} + \pi'(\theta) = 0. \tag{8}$$

A necessary and sufficient condition for an equilibrium to exist is that there exists at least one θ^* that satisfies

$$\pi'(\theta^*) + \alpha\sigma^2 \frac{1}{[\overline{p} - [2\overline{p} - 1]\theta^*]} = 0. \tag{9}$$

This leads to our main result.

Theorem 1. There exists at least one second-best equilibrium choice of precision, θ^*, that represents the manager's privately optimal choice satisfying (9). Moreover, in any equilibrium, this precision is strictly greater than the first-best precision. That is, $\theta^* > \theta^{fb}$.

Proof. See the Appendix.

This theorem establishes that a reputation-conscious ($\alpha > 0$) manager with a project idea always overinvests in information relative to the first best. The intuition is the following. The expected value of the manager's reputation must be $\overline{p}$ in equilibrium. So if the market could observe θ^*, the manager's expected utility is simply $E[U] = \pi(\theta) + \alpha\overline{p}$. This result follows from the fact that the manager's objective function is a martingale with respect to beliefs because the payoffs are linear functions of the posterior beliefs (see Holmström, 1982, 1999). In this case, the first-order condition would be $\pi'(\theta) = 0$, yielding the first best. The reason why $\pi'(\theta) = 0$ does not give the manager's choice of θ is that this choice affects only the relative probabilities of the market's relevant conditional expectations about managerial ability, without affecting the equilibrium belief of θ^*. From Lemma 1 we know that the manager's reputation increases—relative to the market's prior beliefs about managerial ability—in only one of three possible outcomes, ($E[p \mid s_G, G]$), and the probability of this outcome is increasing in signal precision θ. Hence, the second term in (9)—which relates to the marginal impact of θ on the probabilities of more favorable reputational states—is strictly positive, which leads to $\pi'(\theta^*) < 0$, implying our result that $\theta^* > \theta^{fb}$.[11] The extent to which θ^* exceeds θ^{fb} will depend on α and σ^2, as shown next.

Theorem 2. For all equilibrium θ^* satisfying (9), we have

(i) θ^* is strictly increasing in α, the weight the manager attaches to his reputation, and

(ii) θ^* is strictly increasing in σ^2, the cross-sectional variance of perceived ability.

Proof. The proof is immediate, since $\alpha\sigma^2\{1/(\overline{p} - [2\overline{p} - 1]\theta^*)\}$ is increasing in both α and σ^2. *Q.E.D.*

[11] Observe that in any second-best equilibrium, the manager is indifferent between having a project idea and not having it because his expected utility is $\overline{p}$ in both cases. However, *if* the manager could fool the market in equilibrium and choose a θ higher than the market's conjecture of θ^*, then the manager would have a strict preference for generating project ideas.

The intuition is as follows. First, as noted previously, the manager's reputation depends positively on the precision of the signal, which means there is a private benefit to the manager from increasing this precision. There is, of course, a cost to increasing this precision, and it is reflected in the firm-value component of the manager's utility function. But as α increases, so does the weight the manager attaches to his reputation relative to firm value in his utility, causing him to invest more in signal precision. Second, even though the signal precision is unaffected by managerial ability, the probability that the manager has generated a good project does depend on his ability. Since an increase in σ^2 means greater uncertainty about managerial ability, it also implies greater uncertainty about project quality. This heightened uncertainty increases the private marginal benefit to the manager of investing more in signal precision because there is more to be gained from a good reputation.

Observe that this model admits multiple equilibria if $\overline{p} > 1/2$, whereas there is a unique equilibrium (θ^*) if $\overline{p} \leq 1/2$. To see the intuition behind the multiplicity of equilibria, note that the manager's optimal choice of precision trades off firm value against personal reputation. We have shown that in any equilibrium, the marginal firm-value component $\pi'(\theta^*) < 0$ in (9), which means that the second term in (9), reflecting the positive marginal reputational benefit to the manager of increasing his choice of θ, is positive. This reputational term is affected by the θ^* anticipated by the market, which is what creates the possibility of multiple equilibria. Whether multiple equilibria occur depends on whether the function, $\Im(\theta^*)$ = constant, that determines θ^*, is monotonic; this function is obtained by rearranging (9) and defining $\Im(\cdot)$ to include all the θ^* terms.[12] Since $\pi'(\theta^*) < 0$, we know that $\Im(\theta^*)$ will be monotonic and lead to a unique equilibrium if the second term in (9) is nonincreasing in θ^*, and it *may* be nonmonotonic and lead to multiple equilibria if the second term in (9) is increasing in θ^*. There is thus a unique equilibrium when the marginal firm value and reputational effects both change in the same direction, and multiple equilibria when they change in different directions.

So the key is to understand how the marginal reputational effect in (9) behaves with respect to changes in the market's anticipated θ^*. This reputational term is derived from the first two (of three) terms in the manager's first-order condition (8) that represent his reputational concerns. These two terms contain three conditional expectations, with only $E[p \mid s_B]$ affected by θ^*. Note that $E[p \mid s_B]$ is strictly decreasing in θ^*; the higher the market anticipates θ^* to be, the more informative about the manager's type is his decision to reject the project and the lower is his reputation conditional on receiving a bad signal and rejecting the project. Returning to the first two terms in (8), the first bracket is the marginal reputational benefit to the manager of investing in, rather than forgoing, a *good* project. This marginal benefit is increasing in θ^* because $E[p \mid s_B]$ is decreasing in θ^*. The second bracket is the manager's marginal reputational benefit of rejecting, rather than accepting, a *bad* project, which is decreasing in θ^* because $E[p \mid s_B]$ is strictly decreasing in θ^*. Thus, the effects go in opposite directions. Which one dominates depends on the prior belief over managerial ability. When $\overline{p} = 1/2$, the two effects cancel out, so the reputational term in (9) becomes independent of θ^*, causing the function $\Im(\theta^*)$ to be monotonic in θ^* because $\pi'(\theta^*) < 0$. When $\overline{p} < 1/2$, the second reputational effect in (8) dominates, and thus the manager's marginal reputational benefit in (9) is decreasing in θ^*, so $\Im(\theta^*)$ is monotonic. When $\overline{p} > 1/2$, the first reputational effect in (8) dominates and the manager's marginal reputational benefit in (9) is increasing in θ^*. This could cause $\Im(\theta^*)$ to be nonmonotonic in θ^*, opening the door for multiple equilibria.

The economic intuition behind multiple equilibria here can be further illuminated by examining how the market's expectation leads to a self-fulfilling prophecy. Suppose the market's expectation leads to a high θ^*. Then the second (reputational) term in (9), which is increasing in θ^* for $\overline{p} > 1/2$, will be large, which means $\pi'(\theta^*)$ will have a large absolute value, reflecting the fact that the manager is willing to give up more in firm value to pursue reputation. By the

[12] In our model, the function $\Im(\theta^*) \equiv \pi'(\theta^*)[\overline{p} - [2\overline{p} - 1]\theta^*] = -\alpha\sigma^2$ (constant) can be derived from (9). When $\overline{p} \leq 1/2$, $\Im(\theta^*)$ is strictly decreasing in θ^*, leading to a unique θ^* satisfying (9). With $\overline{p} > 1/2$, $\Im(\theta^*)$ may be nonmonotonic in θ^*, leading to possibly many θ^* satisfying (9). Intuition for this result is given later in this section.

concavity of π, this is consistent with a high θ^*, and the fixed point needed for (9) to hold will be the high θ^* conjectured by the market. But a fixed point may also exist for a relatively low θ^*. At a lower θ^*, the second term in (9) is smaller, reflecting a smaller benefit of pursuing reputation. The absolute value of $\pi'(\theta^*)$ is smaller, since the manager is now willing to sacrifice less in firm value to pursue reputation. This means the manager chooses a lower θ, which is consistent with a smaller θ^*, as conjectured by the market.

Multiple equilibria arise for a different reason in Dewatripont, Jewitt, and Tirole's (1999a, 1999b) career-concerns model. The reason for the multiplicity there is that managerial talent and effort are (multiplicative) complements. Given this complementarity, the signal-to-noise ratio depends on the manager's effort, which he can control. On the contrary, if talent and effort are additive, the signal-to-noise ratio is independent of effort and there is a unique equilibrium. Thus, if the market expects high effort in equilibrium, it attaches a greater weight to the performance measure, and the manager responds with high effort. But if the market expects low effort, it attaches lesser weight to the performance measure, and the manager chooses lower effort.

Our last result builds on the manager's inclination to increase signal precision and the effect of this on the variance of firm value.

Theorem 3. For all equilibrium θ^* satisfying (9), the variance of firm value as of $t = 0$—given that the firm invests only if the signal $s = s_G$ is observed at $t = 1$—is strictly decreasing in both σ^2 and α for all $\overline{p} \geq 1/2$ and can be decreasing for some $\overline{p} < 1/2$ if θ^* is sufficiently high. For $\overline{p}$ sufficiently low, the variance is increasing in σ^2 and α.

Proof. See the Appendix.

This result says that greater uncertainty about the ability of the manager often leads to a *lower* variance of firm value. Strictly speaking, our analysis refers to individual project payoffs, whereas we extend its implications to firm profits when we discuss empirical implications. The implicit assumption is that there are sufficiently many projects of the sort we consider so that changes in project payoff variance are visible in changes in the variance of firm profits, but that changes in investment in signal precision cannot be inferred from changes in the distribution of firm profits.[13]

The intuition behind this somewhat surprising result is that as uncertainty about managerial ability increases, each manager responds by increasing signal precision (Theorem 2). This reduces the probabilities of both Type-I and Type-II errors, leading the firm to increase the likelihoods of investing in a good project and forgoing a bad one. The effect of signal precision on the variance of firm value, however, is nonmonotonic for the following reason.[14] The three outcomes are: project accepted and succeeds ($\{s_G, G\}$), project accepted and fails ($\{s_G, B\}$), and project rejected ($\{s_B\}$). The probabilities of these three states are $\overline{p}\theta$, $[1-\overline{p}][1-\theta]$, and $\overline{p}-\theta[2\overline{p}-1]$, respectively. For all $\overline{p} \geq 1/2$, the variance of firm value is strictly decreasing in σ^2 and α. The reason is that for relatively high values of $\overline{p}$, most of the probability mass is on the $\{s_G, G\}$ state. An increase in θ puts even more probability mass here, diminishing the mass on the other two states. Thus, the variance falls. For $\overline{p}$ very low, most of the probability mass is on $\{s_G, B\}$ and $\{s_B\}$. An increase in θ reduces the mass on $\{s_G, B\}$ and shifts it to $\{s_B\}$ and $\{s_G, G\}$. Thus, the variance increases. For values of $\overline{p}$ close to but less than $1/2$, the probability mass is more uniformly smeared across the three outcomes. For θ sufficiently high, an increase in θ then shifts some mass from $\{s_G, B\}$, which occurs with probability $[1-\overline{p}][1-\theta]$, to $\{s_B\}$ and $\{s_G, G\}$, thereby reducing the variance for θ high enough.

[13] One justification for continuing with the assumption that signal precision cannot be inferred from observable variables in this setting is that the resources needed for improving signal precision may simply be redirected from other corporate uses not directly linked to the projects in question, thereby still honoring the total budget constraint on corporate expenses. Consequently, while such reallocations may create long-term inefficiencies, they may have no visible impact on the distribution of firm profits in the short run.

[14] Observe that for $\overline{p} \in (3/4 - [1/4]\sqrt{5}, 1/2)$, the variance of firm value is also strictly decreasing in both σ^2 and α for all $\theta^* > \widehat{\theta}$, and strictly increasing otherwise, where $\widehat{\theta} = [1 - 4\overline{p}^2 + 2\overline{p}]/[8[1-\overline{p}]]$. Lastly, if $\overline{p} \leq 3/4 - (1/4)\sqrt{5}$, the variance is strictly increasing in both σ^2 and α.

4. Implications of alternative assumptions

■ We have made numerous assumptions in our analysis. To deepen our understanding of the role these assumptions play and to further clarify the intuition underlying our analysis, we now examine the implications of changing the key assumptions. Note that the implications that emerge from this analysis also represent features that significantly distinguish our contribution from others in the career-concerns literature, such as Holmström (1982, 1999).

□ **Introducing symmetry in the observability of project payoffs.** We have assumed that the terminal payoff can be observed only for projects that are accepted (i.e., in which investments are made). What if one could also observe the payoff on a rejected project? The idea here is that even though the firm does not invest in the project, some other firm might decide to take it, which would permit the firm that passed on it to see how the project performed. In this case, we have the following result.

Theorem 4. If the terminal payoffs on rejected projects as well as those on accepted projects are observed, then there is no distortion in the second-best equilibrium, i.e., $\theta^* = \theta^{fb}$.

Proof. See the Appendix.

In our main model, the manager wants to overinvest in information because he improves the probability of detecting a bad project. Such projects can consequently be rejected with a higher probability, thereby diminishing the likelihood of bad payoffs being observed. But when project payoffs can be observed independently of the manager's accept/reject decision, which is itself an outcome of the signal everybody sees, there is no reputational benefit to the manager from improving the precision of the signal. In other words, since the terminal project payoff is a sufficient statistic for managerial ability, p, there is no value to the manager in hiding the precision of the signal.

□ **What if information were revealed only on the rejected project?** Now suppose we reverse our informational assumption and allow the terminal payoff to be observed only on rejected projects. Nothing is observed on an accepted project after the signal is observed, but a rejected project will reveal whether it is type G or B. While at first blush this might appear unrealistic, there are situations in which we learn whether the idea is good or bad only if we reject it. An example is investing in machine maintenance, where the manager's ability relates to his talent in discovering when maintenance is really needed. If he invests in maintenance, the machine doesn't break down, but whether it would have broken down without the maintenance is unobservable. However, this will be observable if he stops investing and the machine does break down. In this case, what is reputationally advantageous for the manager is to identify a machine in need of maintenance, stop maintenance (reject project) because of an erroneous signal, and then have a machine breakdown, confirming that he had in fact identified the problem correctly.

There are now three relevant reputational states: $E[p \mid s_G]$, $E[p \mid s_B, G]$, and $E[p \mid s_B, B]$. We solve for these reputations to show that $E[p \mid s_B, B] < E[p] = \overline{p} < E[p \mid s_G] < E[p \mid s_B, G]$ and establish the following result.

Theorem 5. If the terminal payoff can be observed only on a rejected project but not on an accepted project, then there exists at least one second-best equilibrium choice of precision, θ^*, and in any equilibrium this choice is below first best, $\theta^* < \theta^{fb}$.

Proof. See the Appendix.

The intuition is that the manager improves his reputation when the project turns out to be good, since this is the most direct link to his ability. Since project values are observed here only if they are rejected, what the manager really wants is for a *good* project to be erroneously rejected because a signal s_B was observed (which happens with probability $p[1-\theta]$). This is the only way its payoff will be observed, providing a boost to the manager's reputation. Thus, the manager is better off whenever the signal is wrong. This leads to underinvestment in signal precision.

□ **What if the manager bore a personal cost for increasing precision?** We have assumed that the cost of increasing θ is borne by the firm and that this is unobservable to everyone except the manager. Suppose now that in addition to the firm's cost $C(\theta)$, the manager also bears a personal cost of precision, $C_M(\theta)$, which is increasing and convex with Iñada conditions of $C'_M(1/2) = 0$ and $C'_M(1) = \infty$. What happens to his incentive to overinvest in signal precision?

The first best, θ^{fb}, is obtained when the firm maximizes its value net of the corporate and managerial costs of improving signal precision. If the manager has no career concerns, then he maximizes the same objective function and chooses $\theta = \theta^{fb}$. But if the manager has career concerns, he will again choose a θ higher than first best. This means our results are not sensitive to the maintained assumption that the cost of precision is borne entirely by the firm; even if the manager shares the cost, career concerns will cause his investment in signal precision to exceed first best.

The reason, of course, is that we are treating the manager as sole owner of the firm; his payoff includes the entire firm value π. Without career concerns, he has no incentive to deviate from the first best. Thus, one way that $C_M(\theta)$ can affect the results is if we assume that the manager receives only some fraction $\xi \in (0, 1)$ of firm value but bears the full personal cost of information. In this case, it is easy to show that the manager will choose θ, say $\widehat{\theta}$, lower than, θ^{fb}. Now the manager *underinvests* in information, since the weight he attaches to firm value is less than in the first-best case, but the weight he attaches to his personal cost of $C_M(\theta)$ is the same as in the first-best case. A moral hazard problem arises, but in the opposite direction, as the firm wishes the manager would invest more in information.[15]

Now, along the lines of Fama (1980) and Holmström (1982, 1999), career concerns may actually help to move the manager toward first best. If the manager cares about his reputation in addition to firm value and the personal cost of information, he will maximize the following:

$$\max_{\theta} E[U] = \alpha\overline{p}\theta E[p \mid s_G, G] + \alpha\,[1-\theta]\,[1-\overline{p}]\,E[p \mid s_G, B] \\ + \alpha\,[\theta\,[1-\overline{p}] + [1-\theta]\,\overline{p}]\,E[p \mid s_B] + \xi\pi(\theta) - C_M(\theta).$$

It is straightforward to show that we could have either $\theta^* < \theta^{fb}$ or $\theta^* > \theta^{fb}$. As Holmström (1982, 1999) concludes, career concerns can help attenuate moral hazard but may also cause the manager to overcompensate.

We can now pull together the results in Theorems 1, 4, and 5 and the analysis in this section to state the following result that clarifies the roles of the key assumptions.

Theorem 6. The manager's privately optimal choice of precision, θ^*, in a career-concerns equilibrium will be more than the first best, θ^{fb}, as long as

(i) the cost of the precision is borne entirely by the firm, not the manager, or the manager bears a personal cost of precision but receives the entire firm value net of corporate costs, and

(ii) the terminal project payoff is observed only if the project is accepted.

If (i) is relaxed so that the manager bears a personal cost of increasing the precision and receives only a fraction of net firm value, his privately optimal choice may be more than, equal to, or less than the first-best precision. Suppose (i) holds, but (ii) is relaxed. Then, if the terminal project payoff is observed only if the project is rejected, we have $\theta^* < \theta^{fb}$. And if the terminal project payoff is observed regardless of whether the project is accepted or rejected, then $\theta^* = \theta^{fb}$, and there is no distortion in the second-best equilibrium.

Proof. The proof is immediate given earlier results.

[15] It is important to note that the assumption that the manager bears a personal cost $C_M(\theta)$ is crucial to the result that allowing the manager to receive only a fraction ξ of firm value actually makes a difference. Without $C_M(\theta)$ and career concerns, the manager would maximize $\xi\pi(\theta)$, which would lead to a θ^* coinciding with θ^{fb}. Thus, *both* $\xi \in (0, 1)$ and $C_M(\theta)$ are needed to alter our results. If either assumption is introduced in isolation, nothing changes.

□ **What if unconditional NPV $\neq 0$?** A seemingly strong assumption in our analysis is that the unconditional NPV of the project is zero. What if $E[NPV] = \overline{p}G + [1 - \overline{p}]B - I \neq 0$? To characterize the effect of this, we examine changes in the prior $\overline{p}$ while holding everything else fixed. As $\overline{p}$ changes, the firm's optimal response to the signal at $t = 1$ may change. The posterior belief on the quality of the project after observing s_G is

$$\Pr[G \mid s_G] = \frac{\overline{p}\theta^*}{\overline{p}\theta^* + [1 - \overline{p}][1 - \theta^*]}.$$

The firm will invest after s_G if and only if

$$E[NPV] = \Pr[G \mid s_G] \times G + [1 - \Pr[G \mid s_G]] \times B - I > 0,$$

and it will not invest after s_B as long as

$$E[NPV] = \Pr[G \mid s_B] \times G + [1 - \Pr[G \mid s_B]] \times B - I < 0.$$

Both $\Pr[G \mid s_G]$ and $\Pr[G \mid s_B]$ are increasing in $\overline{p}$, so there are three relevant regions of $\overline{p}$. If $\overline{p}$ is very low, the conditional NPV will be negative even for the signal s_G. If $\overline{p}$ is very high, the conditional NPV will be positive even for the signal s_B. In both of these cases, there is no value to the signal and the firm would simply force investment in the project based solely on the prior belief. This is optimal, since investigation is costly to the firm, directly through $C(\theta)$ and indirectly through the manager's career concerns. Therefore, only projects for which the firm will follow the signal could ever be worthwhile to delegate. For these projects, our analysis remains unchanged.

5. Applications of the analysis

■ In this section we discuss how our analysis could be applied to illuminate some interesting issues.

□ **Banking and federal deposit insurance.** In the United States and many other countries, commercial bank deposits are federally insured up to a certain amount. There is a voluminous literature on the incentive problems this causes.[16] The crux of this literature is that deposit insurance gives banks a put option on their own assets. With imperfect *ex post* "settling up" that fails to ensure that the deposit insurance premium is commensurate with the bank's privately optimal risk choices that may became evident *ex post*, banks are prone to choose excessive risk relative to the social optimum. Moreover, banks' privately optimal risk choices also diverge from the social optimum because banks do not internalize the contagion effects of their risk choices. The issue of how deposit insurance affects bank portfolio risk has two dimensions. One is that banks will deliberately choose riskier projects. The other is that they will simply devote less resources to credit analysis. Our model does not speak to the first issue. On the second issue, however, it suggests that the career concerns of bank managers will induce them to decrease the likelihood of bad loans by devoting more resources to credit analysis than would be optimal from the standpoint of a bank that wants to maximize the value of the deposit insurance put option. This will move the bank's choice of investment in credit information closer to what the deposit insurer desires. Because banks' portfolio choices will become more cautious, overall banking risk will diminish, also leading to a decline in the probability of runs.[17]

□ **Mutual fund managers.** In an interesting article, Chevalier and Ellison (1999) make the empirical observation that younger fund managers appear to be given less discretion in the

[16] See Bhattacharya and Thakor (1993) for a review.

[17] See Chari and Jagannathan (1988) for a model in which bad news about banks' asset portfolios triggers runs.

management of their funds. They are more likely than more reputable, older managers to lose their jobs if their fund's systematic or unsystematic risk deviates from the mean for their fund's objective group. They find that as a consequence of this, young mutual fund managers choose portfolios with less unsystematic risk and deviate less from the mean risk levels and sector weightings than their older counterparts.

Our model suggests that the career concerns of young fund managers will cause them to invest more in information about the securities to include in their portfolios. We know by Theorem 2 that the manager invests more in signal precision when the variance in managerial ability is higher, and that this leads to a lower variance of firm value when the prior belief about managerial ability is sufficiently high.[18] Since we would expect a higher cross-sectional variance in the prior distribution of managerial ability for younger managers, the prediction of our model is consistent with the Chevalier and Ellison finding.

□ **Product-development cycle time.** Suppose we interpret the cycle time[19] involved in developing a new product as being affected by the manager's investment in information—with the cycle time being random but having a mean that is higher the greater the investment in information—along with other factors that may be beyond the manager's control. The idea is that the more you want to learn about whether a product will succeed in the market, the longer it takes *on average* to develop and launch it. We could then view the manager's investment in information as being unobservable (or imperfectly observable) and cycle time as being lengthened by the manager's career concerns.

The strategy literature discusses how product-development cycle time is one of the keys to "time-based" competition (see Stalk, 1988). If managerial career concerns lengthen this cycle time and reduce competitiveness, potential remedies may include those aimed at reducing uncertainty about managerial ability. Examples are improved screening and training of managers as well as relative performance evaluation, including tournaments. This is a sense in which the implications of our analysis differ from the career-concerns literature, where the problem is to motivate the manager to work harder, and stronger career concerns move the manager's effort choice closer to first best. In that setting, as Meyer and Vickers (1997) point out, relative performance evaluation may be undesirable in the presence of career concerns. The opposite is true here.

□ **Managerial asset divestiture decisions.** It has been observed that firms are too slow in divesting unproductive assets that would be more highly valued elsewhere. Boot (1992) develops a model in which this happens because of the reputational concerns of the CEO for whom the divestiture of an unproductive asset would be an admission of error in acquiring the asset in the first place, thereby lowering her reputation.

Consider an augmented version of our model in which the manager can choose the timing of the divestiture of a bad project. The manager privately learns (for sure) whether the project is good or bad at some date $t = 1.5$, which is before $t = 2$ when the market observes the project payoff. If divested early at $t = 1.5$, the bad project's cash flow is B. If the divestiture is forgone, the bad project will have a cash flow of G at $t = 2$ with probability q and B' with probability $1 - q$, where $qG + [1 - q]B' < B$. Thus, if the divestiture is delayed, the market may never find out the bad project was chosen, but the expected cash flow is smaller.

In this case, the first-best signal precision, θ^{fb}, obtains when the market can observe both the manager's investment in signal precision and whether the project is good or bad at $t = 1.5$. Let θ^{sb} be the second-best precision when the market can observe the manager's investment in signal precision, but not whether the project is good or bad at $t = 1.5$. It can be shown that $\theta^{sb} > \theta^{fb}$. The reason is as follows. Think of θ^{sb} as the value of the signal precision that maximizes firm value when the manager can influence the expected value of the bad project. That is, although the

[18] If the prior belief on managerial ability is very low, the result can go the other way.

[19] Product-development cycle time refers to the amount of time it takes a firm to develop a product from the time the idea is first generated to the time production commences. This should be distinguished from production cycle time, which refers to how long it takes for a product to be manufactured.

firm cannot control the manager's divestiture decision, it can dictate the choice of signal precision, so it can force the manager to choose the value-maximizing signal precision given the *manager's* choice of the expected value of the bad project. From Boot's (1992) analysis, we know that the manager's career concerns will induce him to delay divestiture, worsening the expected value of the bad project relative to the case in which the manager cannot delay divestiture because the project payoff is observable to the market at $t = 1.5$. This lower expected value of the bad project makes it more valuable for the firm to eliminate the possibility of the manager investing in the bad project at $t = 1$. Consequently, the value-maximizing signal precision increases as we lower the payoff of the bad project relative to that of the good project. This means that $\theta^{sb} > \theta^{fb}$.

When the market can observe neither the signal precision nor project quality at $t = 1.5$, the manager privately chooses precision θ^*. Our analysis indicates that $\theta^* > \theta^{sb} > \theta^{fb}$. Thus, the distortion remains. What is interesting is that as the manager becomes more reputation conscious, he invests more in signal precision. This implies a lower probability that a bad project is selected in the first place, which diminishes the likelihood the manager will be in a position to delay divestiture.

6. Conclusion

■ We have shown that the career concerns of managers will induce them to overinvest in information about investment projects. The reason is that the market cannot observe how thoroughly the project was investigated, and the manager is rewarded for developing a reputation for choosing successful projects. Investigating a project more thoroughly increases the chances that a good project will not be overlooked and that a bad project will not be taken.

There are four key conditions needed to obtain this result: the signal the manager sees about project quality is also observed by the market; higher-ability managers are more likely to generate good projects; further information about the project after the manager makes his recommendation is revealed only if the project is chosen and not if it is rejected; and the manager's choice of signal precision is unobservable to the market.

The empirical predictions of our analysis are as follows:

(i) The greater the uncertainty in perceived managerial abilities, the greater will be the distortion in information acquisition away from first best.

(ii) The greater the uncertainty in perceived managerial abilities, the lower the risk in project selection and hence the smaller the variance of firm value, as long as managers are *a priori* believed to be sufficiently talented. This implies that the variance of projects run by young managers, about whose abilities there is greater uncertainty, will be lower.

(iii) The greater the link between the manager's compensation and firm value (through equity ownership, for example), the smaller will be the distortion in information acquisition away from first best and the higher will be the variance in firm value.[20]

Our contribution to the career-concerns literature is the result that there is a link between how much an agent *learns* about an initiative and how this learning affects the likelihood that the market will observe the various states in which it can form differing assessments of the manager's ability. When the market can see the payoffs only on accepted projects, the manager overinvests in learning. When the market can see the payoffs only on rejected projects, the manager underinvests in learning. Finally, when the market can observe the payoffs on all projects, there is no distortion.

Appendix

■ Proofs for Lemma 1 and Theorems 1, 3, 4, and 5 follow.

[20] This prediction is based on our comparative-static result that θ^* is increasing in α and the interpretation that the manager reduces α as he attaches more weight to firm value through a more performance-sensitive compensation contract. Since $C(\theta)$ is unobservable to the market, the market value of the firm—which forms the basis for the manager's compensation—will not be the $\pi(\tilde{\theta})$ based on the $\tilde{\theta}$ actually chosen by the manager, but rather the $\pi(\theta^*)$ based on the θ^* conjectured by the market. Of course, in equilibrium, $\tilde{\theta} = \theta^*$.

Proof of Lemma 1. We calculate each of the reputational assessments in order. First, we calculate $E[p \mid s_G, G] = \int_0^1 pf(p \mid s_G, G)dp$, where

$$f(p \mid s_G, G) = \frac{f(s_G, G \mid p)f(p)}{\int_0^1 f(s_G, G \mid p)f(p)dp} = \frac{p\theta^* f(p)}{\overline{p}\theta^*} = \frac{pf(p)}{\overline{p}}.$$

Thus, we can evaluate

$$E[p \mid s_G, G] = \int_0^1 p\frac{pf(p)}{\overline{p}}dp = \overline{p} + \frac{\sigma^2}{\overline{p}},$$

where we have used the fact that $\int_0^1 p^2 f(p)dp = \sigma^2 + \overline{p}^2$.

In a similar fashion, we calculate $E[p \mid s_G, B] = \int_0^1 pf(p \mid s_G, B)dp$, where

$$f(p \mid s_G, B) = \frac{f(s_G, B \mid p)f(p)}{\int_0^1 f(s_G, B \mid p)f(p)dp} = \frac{[1-p][1-\theta^*]f(p)}{[1-\overline{p}][1-\theta^*]} = \frac{[1-p]f(p)}{[1-\overline{p}]}.$$

Thus, we can evaluate

$$E[p \mid s_G, B] = \int_0^1 p\frac{[1-p]f(p)}{1-\overline{p}}dp = \overline{p} - \frac{\sigma^2}{1-\overline{p}}.$$

Lastly, we calculate $E[p \mid s_B] = \int_0^1 pf(p \mid s_B)dp$, where

$$f(p \mid s_B) = \frac{f(s_B \mid p)f(p)}{\int_0^1 f(s_B \mid p)f(p)dp} = \frac{[p[1-\theta^*] + [1-p]\theta^*]f(p)}{\overline{p}[1-\theta^*] + [1-\overline{p}]\theta^*}.$$

Thus, we can evaluate

$$E[p \mid s_B] = \int_0^1 p\frac{[p[1-\theta^*] + [1-p]\theta^*]f(p)}{\overline{p}[1-\theta^*] + [1-\overline{p}]\theta^*}dp = \overline{p} - \frac{\sigma^2[2\theta^*-1]}{\overline{p} - [2\overline{p}-1]\theta^*}.$$

With the three reputational assessments in hand, it is easy to see that

$$E[p \mid s_G, B] < E[p \mid s_B] < E[p] = \overline{p} < E[p \mid s_G, G].$$

Q.E.D.

Proof of Theorem 1. Note that $E[U]$ is a function of θ (the manager's choice of signal precision) and θ^* (the equilibrium choice assumed by the market). Because $C(\theta)$ is strictly convex, $\pi(\theta)$ and hence $E[U]$ are strictly concave functions of θ. Then given the Iñada conditions on $\pi(\theta)$ (via $C(\theta)$), we know that the manager's optimal choice of θ, say $\widetilde{\theta}$, is an interior solution. It follows that $\widetilde{\theta}$ is uniquely determined by the first-order condition

$$\Psi(\widetilde{\theta}, \theta^*) = \pi'(\widetilde{\theta}) + \alpha\sigma^2\frac{1}{[\overline{p} - [2\overline{p}-1]\theta^*]} = 0.$$

An equilibrium is then a fixed point of Ψ, i.e., $\Psi(\theta^*, \theta^*) = 0$, which is (9). The existence of an equilibrium is guaranteed by the Iñada conditions and continuity.

If $\overline{p} \leq 1/2$, the equilibrium is unique because $\Psi(\theta^*, \theta^*)$ is monotonic in θ^*. For $\overline{p} \in (1/2, 1]$, we could have an odd number of equilibria (see Harsanyi, 1973 and Wilson, 1971). However, the second term in (9) is always positive in all these equilibria, and thus it is always true that $\theta^* > \theta^{fb}$. *Q.E.D.*

Proof of Theorem 3. Let V be the NPV of the firm, where $V \in \{NPV_G, NPV_B, 0\}$. The expected value of the firm is

$$\begin{aligned} E[V] &= \Pr[s_G \mid G]\Pr[G][G-I] + \Pr[s_G \mid B]\Pr[B][B-I] + \Pr[s_B][0] \\ &= \overline{p}[1-\overline{p}][G-B][2\theta^*-1], \end{aligned}$$

where the second equality derives from the fact that the unconditional, no-information NPV is zero. Observe that $E[V]$ is strictly increasing in θ^*.

The variance can then be calculated as

$$\begin{aligned}\mathrm{Var}[V] &= \Pr[s_G \mid G]\Pr[G][G - I - E[V]]^2 + \Pr[s_G \mid B]\Pr[B][B - I - E[V]]^2 \\ &\quad + \Pr[s_B][0 - E[V]]^2 \\ &= \overline{p}[1-\overline{p}][G-B]^2 \begin{bmatrix} [1-\overline{p}]\theta^*[1-\overline{p}[2\theta^*-1]]^2 \\ +\overline{p}[1-\theta^*][2\theta^* - \overline{p}[2\theta^*-1]]^2 \\ +p[1-p][p[1-\theta^*]+[1-p]\theta^*][2\theta^*-1]^2 \end{bmatrix}.\end{aligned}$$

We can now take the partial derivative of the variance with respect to θ^*, which yields

$$\frac{\partial \mathrm{Var}[V]}{\partial \theta^*} = \overline{p}[1-\overline{p}][G-B]^2\left[1 - 4p^2 + 8p^2\theta^* + 2p - 8p\theta^*\right].$$

It can be seen that for $\overline{p} \geq 1/2$, $\partial \mathrm{Var}[V]/\partial\theta^* < 0$ for all θ^*. From Theorem 2 we know that θ^* is increasing in both σ^2 and α. Thus, Var(V) is strictly decreasing in both σ^2 and α for $\overline{p} \geq 1/2$.

For $\overline{p} \in (3/4 - [1/4]\sqrt{5}, 1/2)$, it can be shown that $\partial \mathrm{Var}[V]/\partial\theta^* < 0$ for all $\theta^* > \widehat{\theta} = [1 - 4\overline{p}^2 + 2\overline{p}]/[8[1-\overline{p}]]$. If $\overline{p} \leq 3/4 - (1/4)\sqrt{5}$, $\partial \mathrm{Var}[V]/\partial\theta^* > 0$ for all θ^*. *Q.E.D.*

Proof of Theorem 4. Observe that if the payoff can be observed on both accepted and rejected projects, there are then four possible reputational assessments: $E[p \mid s_G, G]$, $E[p \mid s_G, B]$, $E[p \mid s_B, G]$, and $E[p \mid s_B, B]$. Thus, the manager faces

$$\begin{aligned}\max_\theta E[U] &= \alpha\overline{p}\theta E[p \mid s_G, G] + \alpha\,[1-\overline{p}]\,[1-\theta]\,E[p \mid s_G, B] \\ &\quad + \alpha\overline{p}\,[1-\theta]\,E[p \mid s_B, G] + \alpha\,[1-\overline{p}]\,\theta E[p \mid s_B, B] + \pi(\theta).\end{aligned}$$

First, we calculate $E[p \mid s_B, G] = \int_0^1 pf(p \mid s_B, G)dp$, where

$$f(p \mid s_B, G) = \frac{f(s_B, G \mid p)f(p)}{\int_0^1 f(s_B, G \mid p)f(p)dp} = \frac{p\,[1-\theta^*]\,f(p)}{\overline{p}\,[1-\theta^*]} = \frac{pf(p)}{\overline{p}}.$$

Thus, we can evaluate

$$E[p \mid s_B, G] = \int_0^1 p\frac{pf(p)}{\overline{p}}dp = \overline{p} + \frac{\sigma^2}{\overline{p}} = E[p \mid s_G, G].$$

In a similar fashion, we calculate $E[p \mid s_B, B] = \int_0^1 pf(p \mid s_B, B)dp$, where

$$f(p \mid s_B, B) = \frac{f(s_B, B \mid p)f(p)}{\int_0^1 f(s_B, B \mid p)f(p)dp} = \frac{[1-p]\,\theta^* f(p)}{[1-\overline{p}]\,\theta^*} = \frac{[1-p]\,f(p)}{[1-\overline{p}]}.$$

Thus, we can evaluate

$$E[p \mid s_B, B] = \int_0^1 p\frac{[1-p]\,f(p)}{1-\overline{p}}dp = \overline{p} - \frac{\sigma^2}{1-\overline{p}} = E[p \mid s_G, B].$$

The objective function can be simplified by observing that $E[p \mid s_G, G] = E[p \mid s_B, G]$ and $E[p \mid s_G, B] = E[p \mid s_B, B]$. Given this, we have

$$\max_\theta E[U] = \alpha\overline{p} + \pi(\theta).$$

The manager's first-order condition is then $\partial E[U]/\partial\theta = \pi'(\theta)$. This is identical to the firm's problem, and so $\theta^* = \theta^{fb}$. Therefore, there is no distortion in investments in information. *Q.E.D.*

Proof of Theorem 5. Since we already derived $E[p \mid s_B, G] = \overline{p} + \sigma^2/\overline{p}$ and $E[p \mid s_B, B] = \overline{p} - \sigma^2/[1-\overline{p}]$, we need only calculate $E[p \mid s_G] = \int_0^1 pf(p \mid s_G)dp$, where

$$f(p \mid s_G) = \frac{f(s_G \mid p)f(p)}{\int_0^1 f(s_G \mid p)f(p)dp} = \frac{[p\theta^* + [1-p]\,[1-\theta^*]]\,f(p)}{\overline{p}\theta^* + [1-\overline{p}]\,[1-\theta^*]}.$$

Thus, we can evaluate

$$E[p \mid s_G] = \int_0^1 p \frac{[p\theta^* + [1-p][1-\theta^*]] f(p)}{\overline{p}\theta^* + [1-\overline{p}][1-\theta^*]} dp = \overline{p} + \frac{\sigma^2[2\theta^* - 1]}{[1-\overline{p}] + [2\overline{p} - 1]\theta^*}.$$

With the three reputational assessments in hand, it is easy to show that

$$E[p \mid s_B, B] < E[p] = \overline{p} < E[p \mid s_G] < E[p \mid s_B, G].$$

Now, what happens to the manager's choice of θ? We can see this by examining the manager's solution to

$$\max_{\theta} E[U] = \alpha\overline{p}\,[1-\theta]\,E[p \mid s_B, G] + \alpha\theta\,[1-\overline{p}]\,E[p \mid s_B, B] \\ + \alpha\,[\theta\overline{p} + [1-\theta][1-\overline{p}]]\,E[p \mid s_G] + \pi(\theta).$$

The manager's first-order condition is then

$$\frac{\partial E[U]}{\partial\theta} = \alpha\overline{p}\,\{E[p \mid s_G] - E[p \mid s_B, G]\} + \alpha\,[1-\overline{p}]\,\{E[p \mid s_B, B] - E[p \mid s_G]\} + \pi'(\theta) = 0.$$

This can be simplified to write

$$\Psi(\widetilde{\theta}, \theta^*) = \pi'(\widetilde{\theta}) - \frac{\alpha\sigma^2}{[1-\overline{p}] + [2\overline{p} - 1]\theta^*} = 0,$$

where $\widetilde{\theta}$ is the manager's privately optimal choice of θ and θ^* is what the market expects in equilibrium. Using previous arguments (see the proof of Theorem 1), it follows that $\widetilde{\theta}$ is uniquely determined by the above condition and that an equilibrium exists and is a fixed point of $\Psi(\cdot, \cdot)$, i.e.,

$$\Psi(\theta^*, \theta^*) = \pi'(\theta^*) - \frac{\alpha\sigma^2}{[1-\overline{p}] + [2\overline{p} - 1]\theta^*} = 0.$$

Since $-\alpha\sigma^2/\{[1-\overline{p}] + [2\overline{p} - 1]\theta^*\} < 0$, it follows that $\pi'(\theta^*) > 0$ in any equilibrium. Thus, $\theta^* < \theta^{fb}$. *Q.E.D.*

References

AGHION, P. AND TIROLE, J. "Formal and Real Authority in Organizations." *Journal of Political Economy*, Vol. 105 (1997), pp. 1–29.

BHATTACHARYA, S. AND THAKOR, A.V. "Contemporary Banking Theory." *Journal of Financial Intermediation*, Vol. 3 (1993), pp. 2–50.

BOOT, A.W.A. "Why Hang on to Losers? Divestitures and Takeovers." *Journal of Finance*, Vol. 47 (1992), pp. 1401–1423.

CHARI, V.V. AND JAGANNATHAN, R. "Banking Panics, Information, and Rational Expectations Equilibrium." *Journal of Finance*, Vol. 43 (1988), pp. 749–761.

CHEVALIER, J.A. AND ELLISON, G. "Career Concerns and Mutual Fund Managers." *Quarterly Journal of Economics*, Vol. 114 (1999), pp. 389–432.

DEWATRIPONT, M., JEWITT, I., AND TIROLE, J. "The Economics of Career Concerns, Part I: Comparing Information Structures." *Review of Economic Studies*, Vol. 66 (1999a), pp. 183–198.

———, ———, AND ———. "The Economics of Career Concerns, Part II: Application to Missions and Accountability of Government Agencies." *Review of Economic Studies*, Vol. 66 (1999b), pp. 199–218.

FAMA, E.F. "Agency Problems and the Theory of the Firm." *Journal of Political Economy*, Vol. 88 (1980), pp. 288–307.

HARSANYI, J. "Oddness of the Number of Equilibrium Points: A New Proof." *International Journal of Game Theory*, Vol. 2 (1973), pp. 235–250.

HERMALIN, B.E. "Managerial Preferences Concerning Risky Projects." *Journal of Law and Economics*, Vol. 9 (1993), pp. 127–136.

HIRSHLEIFER, D.A. AND CHORDIA, T. "Firm and Managerial Incentives to Manipulate the Timing of Project Resolution." Mimeo, Department of Finance, Ohio State University, 2000.

——— AND THAKOR, A.V. "Managerial Conservatism, Project Choice, and Debt." *Review of Financial Studies*, Vol. 5 (1992), pp. 437–470.

HOLMSTRÖM, B. "Managerial Incentive Problems: A Dynamic Perspective." In *Essays in Economics and Management in Honour of Lars Wahlbeck*. Helsinki: Swedish School of Economics, 1982.

——— "Managerial Incentive Problems: A Dynamic Perspective." *Review of Economic Studies*, Vol. 66 (1999), pp. 169–182.

——— AND RICART I COSTA, J. "Managerial Incentives and Capital Management." *Quarterly Journal of Economics*, Vol. 101 (1986), pp. 835–860.

LAMBERT, R.A. "Executive Effort and Selection of Risky Projects." *RAND Journal of Economics*, Vol. 17 (1986), pp. 77–88.

MEYER, M.A. AND VICKERS, J. "Performance Comparisons and Dynamic Incentives." *Journal of Political Economy*, Vol. 105 (1997), pp. 547–581.

NARAYANAN, M.P. "Observability and the Payback Criterion." *Journal of Business*, Vol. 58 (1985), pp. 309–323.

PRENDERGAST, C.J. AND STOLE, L.A. "Impetuous Youngsters and Jaded Old-timers: Acquiring a Reputation for Learning." *Journal of Political Economy*, Vol. 104 (1996), pp. 1105–1134.

SCHARFSTEIN, D.S. AND STEIN, J.C. "Herd Behavior and Investment." *American Economic Review*, Vol. 80 (1990), pp 465–479.

STALK, G. "Time—The Next Source of Competitive Advantage." *Harvard Business Review*, Vol. 66 (1988), pp. 41–53.

WILSON, R.B. "Computing Equilibria of *n*-person Games." *SIAM Journal of Applied Mathematics*, Vol. 21 (1971), pp. 80–87.