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Abstract

When performance measures are used for evaluation purposes, agents have some incentives to learn how their actions affect these measures. We show that the use of imperfect performance measures can cause an agent to devote too many resources (too much effort) to acquiring information. Doing so can be costly to the principal because the agent can use information to game the performance measure to the detriment of the principal. We analyze the impact of endogenous information acquisition on the optimal incentive strength and the quality of the performance measure used.

1 Introduction

One of the main themes of the multitask agency literature is the insight that motivating desirable actions may encourage other, less desirable actions (Holmstrom and Milgrom, 1991; Feltham and Xie, 1994). In the accounting literature, one prominent example of negative activities is earnings manipulation. We argue that information acquisition, which is typically considered as a profitable action, may also belong to this class of negative activities that are hard to control.

We consider a setting in which an agent is hired to choose an action (effort level) on behalf of a principal. When the principal, who wishes the agent to work hard on his task, uses an incentive system, then the agent is encouraged to first learn how his actions will affect the underlying performance measure. This information is valuable to the agent, since from his perspective it leads to improved action choices.

When the principal's objective is available for contracting purposes, the agent's information gathering is always beneficial to the principal. It leads to improved decisions from the perspective of the agent as well as the principal. However, it is often impossible to base the contract on the principal's objective, which leads to the use of alternative performance measures (Baker, 1992; Feltham and Xie, 1994). In this case two questions arise that we address in this paper. First, when is the agent's incentive to learn more about how actions affect the performance measure beneficial and when is it detrimental to the principal? Second, how does the agent's incentive to gather information affect the optimal incentive strength and the quality of a performance measure?

To answer the first question, we show that the use of imperfect performance measures may cause the agent to spend too much of his resources on information acquisition.

From the principal's perspective, overinvestment in information gathering may arise because the agent can use information to the detriment of the principal; information might lead to actions that increase the value of the performance measure but decrease the utility of the principal. Following Baker (1992), we call this sort of behavior "gaming". Hence, the principal may be better off if the agent does not perfectly understand how his actions affect the performance measure: less information leads to less gaming.

For the second question, we find that endogenous information acquisition has an impact on the optimal design of the contract. In our model, incentives may be low-powered not only to limit the amount of distortion (incongruity), given that the agent perfectly knows how to game the performance measure (as in Baker, 1992, and Feltham and Xie, 1994) but also to reduce the agent's incentive to gather information in the first place as this information enables the agent to engage in gaming. In sum, incentives may be muted to induce the agent to pay less attention to the performance measure.

We also show that endogenous information acquisition affects the quality of performance measures. Baker (1992) and Feltham and Xie (1994) show that the quality of a performance measure depends on its distortional effects. In our model, the amount of distortion is not exogenous but instead depends on the level of information the agent has about the performance measure. If the agent does not perfectly understand how his actions affect the performance measure, he is less able to game this measure. Hence, the quality of a performance measure not only depends on its distortion, given that the agent knows how to game this measure, but also on the difficulty (cost) of obtaining this information in the first place. We show that performance measures that are difficult to "understand" may be better suited to provide the right incentives.

Closest to our paper are Baker (1992) and Bushman et al. (2000). These two papers discuss issues of performance measurement under private information. Baker focuses on incentive provision given that the agent is always (exogenously) informed about how actions affect the performance measure. Bushman et al. analyze the value of delegation by comparing the outcome of a delegation scheme in which the agent is (imperfectly) informed about the performance measure with the outcome of a centralized scheme in which this information is not available. In this setting the principal might be worse off with a delegation scheme because the agent can use his private information to shirk. Christensen (1981) analyzes a model where pre-decision information can also be negative, because it allows the agent to exert just enough effort to reach a certain target. None of these papers look at contracts designed to influence the agent's information acquisition. We extend Baker's model to analyze the impact of endogenous information gathering on incentive contracting and the quality of performance measures.

This paper is also linked to recent studies on the role of information acquisition in principal-agent relations. This literature typically analyzes how agents can best be motivated to gather decision-relevant, i.e., valuable, information (Lambert, 1986; Demski and Sappington, 1987; Lewis and Sappington, 1997). There are only a few papers that discuss situations in which the agent's information acquisition is detrimental to the principal (e.g., Cremer and Khalil, 1992; Cremer et al., 1998). In these contributions, information acquisition is prior to contracting. The agent benefits from pre-contract private information because he can use this information to extract information rents. In our setting, the reason why information acquisition may be detrimental is not based on information rents, but on the fact that additional information may lead to inefficient actions. The main difference between our paper and these cited papers is our focus on performance measurement.

The paper proceeds as follows. In Section 2 we outline the basic model. In Section 3 we discuss a benchmark setting in which the agent is exogenously informed. Section 4 introduces endogenous information acquisition. Section 5 provides an example for the negative effect of information acquisition. Section 6 concludes.

2 The Model

In our model there are two risk-neutral parties, a principal and an agent. The principal delegates a decision to the agent. We model this decision as effort choice $e \in [0, \infty)$. The principal's utility

$$V(e, \theta) = v(\theta)e$$

depends on the chosen effort level, e, and the productivity of effort, $v(\theta) > 0$. Productivity depends on the realized state of nature, θ, which is a random variable. Hence, productivity is also random and its expected value is $E[v(\theta)]$. The agent's effort choice is unobservable to the principal and is associated with cost $0.5e^2$. The utility of the principal is not contractible and not transferable. However, there exists a performance measure on which the agent's pay can be based on:

$$Y(e, \theta) = y(\theta)e,$$

where $y(\theta) > 0$ is the marginal product of effort on the performance measure. Without loss of generality, $E[v(\theta)] = E[y(\theta)] = \mu$.[1] We assume that the expected productivity, μ, the correlation between $y(\theta)$ and $v(\theta)$, denoted ρ, and the variances $Var(y(\theta))$ and $Var(v(\theta))$ are common knowledge.

We consider only linear incentive schemes. The agent's pay is

$$w(e, \theta) = bY(e, \theta) - F,$$

where b is the bonus coefficient and F is a fixed transfer from the agent to the principal.

The principal proposes an incentive system as a take-it-or-leave-it offer; the agent's reservation utility is zero. At the time of contracting, neither the agent nor the principal know θ. After signing the contract but before choosing e, the agent observes θ with probability $p \in [0, 1]$. θ is soft information and cannot be

[1] It is possible to adjust the performance measure so that the expected payoffs are identical. See Baker (1992) for a discussion of this assumption and the example in this paper.

transferred to the principal. Indeed, the principal does not know whether the agent is informed or not.

If the agent observes θ, he knows $v(\theta)$ and $y(\theta)$. If not, he knows only μ. Depending on his information, the agent chooses the action that maximizes his utility. The principal's utility in state θ is $V(e,\theta) - w(e,\theta)$ and the agent's utility is $w(e,\theta) - \frac{1}{2}e^2$.

The first-best level of effort is $e^{fb} = \mu$ without information about θ and $e^{fb} = v(\theta)$ if θ is known. For clarity, in the remainder of the paper, we write v and y instead of $v(\theta)$ and $y(\theta)$, respectively.

In addition to agents being risk neutral, we assume that there are no wealth constraints. Therefore, all distortions arise solely because the performance measure is not a perfect proxy for the principal's objective. However, we note that all qualitative results extend to the case in which the agent is wealth constrained (limited liability).

3 Exogenous Information

As a benchmark, we consider a setting where p is exogenously given and common knowledge. The agent chooses his effort level to maximize the expected payoff subject to his information. The effort is $e_0 = b\mu$ without information and $e_1 = by$ with information.

The principal's problem is

$$\max_{b,e_0,e_1,F} (1-p)(\mu e_0 - b\mu e_0) + p(E[ve_1] - bE[ye_1]) + F \tag{1}$$

subject to

$$\begin{aligned} e_0 &= b\mu, && (2)\\ e_1 &= by, && (3)\\ F &\leq (1-p)\left(b\mu e_0 - \frac{1}{2}e_0^2\right) + pE\left[bye_1 - \frac{1}{2}e_1^2\right]. && (4) \end{aligned}$$

The principal chooses the incentive system to maximize her expected utility. The incentive constraints (2) and (3) characterize the agent's optimal action choices without and with information, respectively. The participation constraint (4) ensures that the agent accepts the contract. For the optimal F, the constraint is binding. Using these constraints, the principal's utility for a given p can be defined as a function of b,

$$\pi_p(b) \equiv (1-p)\pi_0(b) + p\pi_1(b),$$

where $\pi_0(b) \equiv b\mu^2 - \frac{1}{2}b^2\mu^2$ and $\pi_1(b) \equiv bE[yv] - \frac{1}{2}b^2E[y^2]$ denote the principal's expected utilities if the agent is uninformed and informed, respectively.

Maximizing this expression for b yields

$$b_p^* = \frac{pCov(v,y) + \mu^2}{pVar(y) + \mu^2}$$

and the principal's utility is

$$\pi_p^* = \frac{1}{2}\frac{(pCov(v,y) + \mu^2)^2}{pVar(y) + \mu^2}.$$

We distinguish two special cases in which the agent is either never informed ($p = 0$) or always informed ($p = 1$).

Case $\mathbf{p = 0}$. Given that there is no information about the realized state θ, the performance measure is a perfect proxy for the principal's utility. In this case there are no frictions, and the first-best effort is implemented. The optimal incentive intensity is $b_0^* = 1$ and the principal's utility is $\pi_0^* = \frac{1}{2}\mu^2$.

Case $\mathbf{p = 1}$. For $p = 1$ the model resembles the model analyzed by Baker (1992). The optimal bonus coefficient is

$$b_1^* = \frac{E[yv]}{E[y^2]} = \frac{Cov(v,y) + \mu^2}{Var(y) + \mu^2} \tag{5}$$

and the expected utility of the principal becomes

$$\pi_1^* = \frac{1}{2}\frac{E[yv]^2}{E[y^2]} = \frac{1}{2}\frac{\left(Cov(v,y) + \mu^2\right)^2}{Var(y) + \mu^2}.$$

If the correlation between y and v is one and $Var(y) = Var(v)$, then the performance measure is a perfect proxy for the principal's objective. Thus, $b_1^* = 1$ and the principal achieves the first best outcome. In all other cases, the performance measure is distorted, in the sense that it does not motivate the right behavior. That is, the agent allocates effort inefficiently across different states of the world. (In contrast, in the multi-task models of Feltham and Xie (1994), Datar et al. (2001), and Baker (2002) the agent allocates effort inefficiently across different tasks.)

We define $\beta = Cov(v, y)/Var(y)$ and note that from (5) it follows directly that $b_1^* < 1 \Leftrightarrow \beta < 1$ and $b_1^* > 1 \Leftrightarrow \beta > 1$. For the sake of providing the intuition it is useful to assume that the two variables are normally distributed. In this case $E[v|y] - \mu = \beta(y - \mu)$. β is a measure for the conditional expected deviation of v from μ relative to a deviation of y from μ. $\beta < 1$ implies that the expected deviation of the principal's utility is lower than the deviation of the performance measure. Since the agent bases his effort on the performance measure, the agent's reaction to realizations of the performance measure is too strong from the principal's perspective, for $b = 1$. To counteract this effect, the principal finds it beneficial to choose an incentive intensity lower than one. But reducing b comes at a the cost of reducing the agent's expected effort. An extreme situation of misallocation arises, e.g., if the correlation between v and y is negative. The agent will then choose a high level of effort when a low level is desirable, and vice versa.

In contrast, for $\beta > 1$, the conditional expected change in the principal's objective exceeds changes in the performance measure. Therefore, for $b = 1$, the agent's reaction to variations in θ is too weak. The agent pays too little attention to his private information. The principal counteracts by choosing $b > 1$, with the cost that the agent's expected effort is too high.

We note that even when the correlation between v and y is perfect and $b = 1$, incentives are distorted for $Var(v) \neq Var(y)$ because the agent either over- or underreacts to his private information.

In sum, the bonus coefficient serves two roles. It motivates the agent to work hard and to allocate effort efficiently across different states of the world. The principal must trade off these two goals when choosing the incentive intensity of the contract.

Lemma 1 *Given $Var(v)$, the principal's utility depends on ρ and $Var(y)$:*

$$\frac{\partial \pi_1^*}{\partial \rho} > 0,$$

$$\frac{\partial \pi_1^*}{\partial Var(y)} \begin{cases} > 0 & \text{if } \beta > 1 \\ < 0 & \text{if } \beta < 1. \end{cases}$$

An increasing correlation ρ leads to less distorted incentives. Therefore, the principal's utility increases with ρ. Moreover, the principal's utility increases as β converges to one, because the agent's action choice is either too responsive or not responsive enough for $\beta \neq 1$.

Is the principal better off with an informed or an uninformed agent? The value of an informed agent to the principal is

$$\pi_1^* - \pi_0^* = \frac{1}{2}\frac{(Cov(v,y) + \mu^2)^2}{Var(y) + \mu^2} - \frac{1}{2}\mu^2.$$

We refer to this difference as the value of information.

Lemma 2 *The value of information is negative whenever*

$$Cov(v,y)^2 < (Var(y) - 2Cov(v,y))\mu^2. \tag{6}$$

If (6) holds, the principal prefers the agent to be uninformed about θ. When the value of information is negative, the agent's reaction to his private information is detrimental to the principal. That is, from the principal's perspective, additional information does not improve decision making but makes it worse. Clearly, for $\rho \leq 0$, the value of information is always negative. To see this, rearrange (6) to $Cov(v,y)(Cov(v,y) + 2\mu^2) < Var(y)\mu^2$. Since $Cov(v,y) + \mu^2 = E[vy] > 0$, (6) is always satisfied for $\rho \leq 0$. But the value of information can also be negative if

$\rho = 1$ and $Var(y)$ is much larger than $Var(v)$. The reason for this result is that when $Var(y) > Var(v)$, the agent's reaction to variations in θ is too strong. This overreaction is costly to the principal since the agent's cost function is convex.

The comparative statics in Lemma 1 (for $p = 1$) also hold for any intermediate probability $p \in (0, 1)$. The principal's expected utility increases when ρ becomes large and when $Var(y)$ converges to $Cov(v, y)$ (β converges to 1). If the principal could choose p, she would choose $p = 0$ if (6) holds and $p = 1$ otherwise.

4 Endogenous Information Acquisition

We now examine the case in which information acquisition is endogenous. After signing the contract but before making the action choice e, the agent can acquire information. The agent chooses the probability of becoming informed, p, at a personal cost $k(p)$, where $k(0) = 0$, $k'(0) = 0$, $k'(p) > 0$ for $p > 0$, $k''(p) > 0$, and $\lim_{p \to 1} k'(p) = \infty$. That is, the higher the probability of obtaining information, the higher the cost the agent must incur. The agent's choice of p is unobservable to the principal and solves

$$\max_{p} \; (1 - p) \left(b\mu e_0 - \frac{1}{2} e_0^2 \right) + pE \left[bye_1 - \frac{1}{2} e_1^2 \right] - k(p)$$

with $e_0 = b\mu$ and $e_1 = by$. The first-order condition for p is

$$\frac{1}{2} b^2 Var(y) - k'(p) = 0. \tag{7}$$

A positive bonus coefficient b, which provides the agent with incentives to exert effort e, simultaneously generates incentives for the agent to gather information. The chosen p increases in b and $Var(y)$. Intuitively, when $Var(y)$ becomes large, the information becomes more valuable to the agent so that he works harder on information production.

The principal's problem is

$$\max_{p,e_0,e_1,F,b} (1-p)E[ve_0 - bye_0] + pE[ve_1 - bye_1] + F$$

subject to (2), (3), (7) and

$$F \leq (1-p)\left(b\mu e_0 - \frac{1}{2}e_0^2\right) + pE\left[bye_1 - \frac{1}{2}e_1^2\right] - k(p). \tag{8}$$

The participation constraint (8) is again binding at the optimum. We can use constraints (2), (3) and (8) to rewrite the principal's objective function. The objective function is identical to the one with exogenous information net of $k(p)$. But now the principal, by choosing b, also determines p. The maximization problem subject to the remaining incentive constraint (7) can be written as Lagrangian

$$\begin{aligned}\max_{p,b,\lambda} L &= pb\left(Cov(v,y) - \frac{1}{2}bVar(y)\right) + b\mu^2\left(1 - \frac{1}{2}b\right) \\ &\quad -k(p) + \lambda\left(\frac{1}{2}b^2Var(y) - k'(p)\right),\end{aligned}$$

with λ as Lagrangian-multiplier. The first-order conditions for an optimum include

$$\frac{\partial L}{\partial b} = pCov(v,y) - pbVar(y) + \mu^2(1-b) + \lambda bVar(y) = 0, \tag{9}$$

$$\frac{\partial L}{\partial p} = bCov(v,y) - \frac{1}{2}b^2Var(y) - k'(p) - \lambda k''(p) = 0. \tag{10}$$

Equations (10) and (7) yield

$$\lambda = \frac{bCov(v,y) - b^2Var(y)}{k''(p)}. \tag{11}$$

Substituting (11) into (9) and using (7) yields

$$b^*(p) = \frac{Cov(v,y)\left(p + 2\frac{k'(p)}{k''(p)}\right) + \mu^2}{Var(y)\left(p + 2\frac{k'(p)}{k''(p)}\right) + \mu^2}. \tag{12}$$

b^* and p^* are determined by (12) and (7). For $\rho = 1$ and $Var(v) = Var(y)$ we again obtain the first-best solution with $b^* = 1$.

In most other cases the agent's choice of p is not optimal from the perspective of the principal. A positive (negative) λ implies that, in equilibrium, a marginal increase in p increases (decreases) the principal's utility. For a given incentive intensity, b, λ is positive if

$$\beta > b. \tag{13}$$

Substituting (12) into (13) and rearranging yields Proposition 1.

Proposition 1 *From the principal's perspective, in equilibrium, the agent underinvests in information if*

$$\beta > 1 \tag{14}$$

and overinvests in information if the inequality is reversed.

Proposition 1 implies that whenever $\beta \neq 1$, the agent's level of information acquisition is not in the best interest of the principal.

If $\beta > 1$, additional information is more valuable to the principal than to the agent. Hence, in the optimal solution, the agent devotes too few resources to acquiring information. A better-informed agent is beneficial to the principal, since the agent will use this information to make a better action choice e. This case is in the spirit of the traditional information acquisition literature (Lambert, 1986), where information gathering is motivated in order to obtain better-informed decision making.

In contrast, if $\beta < 1$, additional information is relatively more valuable to the agent than to the principal. Hence, the agent devotes too much effort to acquiring information. Rewriting the condition as $\rho\sigma_v < \sigma_y$ we see that if ρ and σ_v are small, the agent's private information has low value to the principal, but when σ_y is large, additional information about y is relatively important to the agent. Consequently, the agent overinvests in information.

The agent's information acquisition is costly to the principal for two reasons. First, the agent will use his private information to game the performance measure to the detriment of the principal (as noted in Section 3). Second, information acquisition is costly to the principal, since she must compensate the agent for his effort (participation constraint is binding). We note that a negative value of information is a sufficient, but not a necessary, condition for overinvestment in information to occur.

By her choice of b, the principal can control the agent's information acquisition. In most circumstances, the principal will not find it beneficial to completely resolve the over- or underinvestment problem. Distortions arise because the principal must take care of three control problems: she wishes to induce the agent to work hard on the production task, to control how much attention the agent pays to his private information (if he has any private information), and to control the agent's incentive to gather information.

It is worthwhile to compare the optimal incentive intensity under endogenous information acquisition with the incentive that is optimal for exogenous information. Endogenous information acquisition generally leads to an incentive intensity that diverges from the optimal ex post intensity (i.e., the level of b that is optimal when p is given) in order to steer the agent's information gathering in the right direction.

Proposition 2 *When $\beta > 1$ ($\beta < 1$), to provide the agent with stronger (weaker) incentives to acquire information, the principal increases (reduces) the incentive intensity compared to the ex post efficient level.*

Proof. We compare the (ex post) optimal bonus coefficient for a given probability p, b_p^*, with the ex ante optimal bonus $b^*(p)$. $b^*(p)$ is greater than b_p^* if $Cov(v, y) > Var(y)$ and smaller than b_p^* if $Cov(v, y) < Var(y)$. ■

Incentive contracts might be low powered, not only to reduce the amount of distortion, given that the agent knows how to game the performance measure (as in Baker, 1992, and Feltham and Xie, 1994) but also to reduce the agent's incentive to become informed in the first place since this information enables the agent to engage in gaming. Hence, to induce the agent to pay less attention to the performance measure, his incentives might be muted.

To analyze the effect of changes in the performance measure's characteristics on the principal's utility, for tractability, we assume that $k(p) = \frac{1}{2}Kp^2$. (We drop the assumption $\lim_{p\to 1} k'(p) = \infty$ and assume only that K is sufficiently high to assure an internal solution for the choice of p.) Substituting this cost function into (7) and (12), we obtain

$$b^* = \frac{3p^*Cov(v,y) + \mu^2}{3p^*Var(y) + \mu^2}, \tag{15}$$

$$p^* = \frac{1}{2}b^{*2}\frac{Var(y)}{K}. \tag{16}$$

We provide the proof of the next proposition in the appendix.

Proposition 3 *Let π^* denote the principal's utility in the optimal solution. Given $Var(v)$, the performance measure's quality depends on ρ, $Var(y)$ and K :*

$$\frac{\partial \pi^*}{\partial \rho} > 0,$$

$$\frac{\partial \pi^*}{\partial Var(y)} \begin{cases} > 0, & \text{if } \beta > 1 \\ < 0, & \text{if } \beta < 1 \end{cases},$$

$$\frac{\partial \pi^*}{\partial K} \begin{cases} < 0, & \text{if } \beta \geq 1 \\ \lesseqgtr 0, & \text{if } \beta < 1 \end{cases}.$$

Again, the principal's utility increases with the correlation coefficient ρ.

For $\beta > 1$, the principal's utility increases with $Var(y)$. There are now two reasons: First, given that the agent is informed, the amount of distortion in the effort choice e decreases (as discussed in Section 3). Second, the agent's incentive to obtain information increases, which in this case is beneficial to the principal. In contrast, the principal's utility decreases with $Var(y)$ if $\beta < 1$. A larger $Var(y)$ means a higher distortion in e and a stronger incentive to acquire information, which in this case is detrimental to the principal. Hence, if β converges to one, there will be less distortion in both the effort choice e and the information acquisition choice p.

An increase in K has two effects. First, for a given p, the cost of information acquisition, which is borne by the principal, increases. Second, all else equal, the agent chooses a lower p. The first effect is unambiguously negative for the principal. The second effect may be positive or negative, depending on whether β is higher or lower than one. For $\beta > 1$, these two effects reinforce each other and the principal is worse off for higher levels of K. If $\beta < 1$, the sign of $\frac{\partial \pi^*}{\partial K}$ depends on which effect dominates: increased cost of information acquisition or the benefit of a reduced information gathering.

The broader point here is that the quality of a performance measure not only depends on the amount of distortion, assuming the agent knows how to game the performance measure, but also on the difficulty (cost) of obtaining this information as this information opens the door for gaming.

5 Example

As an example, we assume that the principal is concerned about the present value of future cash flows from operations but that long-term performance evaluation is not possible. Instead, the manager's pay is based only on period 1 cash flows.

In a simple setting, there are two time periods and the manager chooses an effort level prior to the realization of first-period cash flows. Let the present value of total cash flow be $PV(CF) = (c_1 + c_2)e$, where $c_1 e$ and $c_2 e$ are first- and second-period cash flows, respectively. Hence, $v = c_1 + c_2$, $\mu = E[c_1] + E[c_2]$, and $Var(v) = Var(c_1) + Var(c_2) + 2Cov(c_1, c_2)$. Only first-period cash flows $c_1 e$ are available as a performance measure; long-term incentive contracts based on second-period cash flows $c_2 e$ are infeasible. Alternatively, we can interpret $c_2 e$ as the nonverifiable part of cash flows or private benefits accruing directly to the principal.

We adjust the performance measure and define $y = \alpha c_1$, with $\alpha = \mu / E[c_1]$, to obtain $E[y] = \mu$ and $Var(y) = \alpha^2 Var(c_1)$. Hence, $Cov(v, y) = Cov(\alpha c_1, c_1 + c_2) = \alpha Var(c_1) + \alpha Cov(c_1, c_2)$. If the agent is informed, he knows c_1 and c_2. Without information, the agent knows only μ. Applying Proposition 1, we can state

Lemma 3 *The agent overinvests in information if*

$$\rho(c_1, c_2) \frac{\sigma(c_2)}{E[c_2]} < \frac{\sigma(c_1)}{E[c_1]}$$

and underinvests if the inequality is reversed.

To discuss Lemma 3, we first assume that the two periods are symmetric with $E[c_1] = E[c_2]$ and $\sigma(c_1) = \sigma(c_2)$. In this case, unless $\rho(c_1, c_2) = 1$, the agent invests too much in information for $b = 1$ as $\beta < 1$. From the principal's perspective, the problem is that the performance measure is too volatile, making information more valuable for the agent than for the principal.

Lemma 4 *Changing parameters, starting from* $E[c_1] = E[c_2]$, $\sigma(c_1) = \sigma(c_2)$, *and* $\rho(c_1, c_2) = 1$, *we obtain:*

- $\beta < 1 \Leftrightarrow \rho(c_1, c_2) < 1$.
- $\beta < 1$ $(\beta > 1) \Leftrightarrow \sigma(c_2) < \sigma(c_1)$ $(\sigma(c_2) > \sigma(c_1))$.
- $\beta < 1$ $(\beta > 1) \Leftrightarrow E[c_2] > E[c_1]$ $(E[c_2] < E[c_1])$.

Ceteris paribus, we expect higher powered incentives if second-period cash flows (nonverifiable cash flows or private benefits) have higher variance or lower expected value relative to first-period cash flows (verifiable cash flows), and if the correlation between both is high. Incentives are reduced if the opposite holds.

6 Conclusion

When performance pay is used to encourage agents to work on productive tasks, agents also have incentives to obtain information about the impact of their actions on the performance measure. The desire to obtain information increases as the strength of the incentive contract increases.

We find that the quality of a performance measure depends on the agent's information about the impact of his action on this measure. The principal might be better off if the agent does not perfectly understand how his action affects the performance measure. Baker (2002) and Heckman, Heinrich and Smith (1997) discuss an example where this problem arises. Members of the *Job Training Partnership Act* (JTPA) train the disadvantaged for the job market. JTPA centers are rewarded for successfully placing their clients. This incentive system induces gaming in the sense that only the less disadvantaged are accepted into the program.

Put differently, JTPA employees choose a high effort level for those clients for which the marginal productivity is high (i.e., for those who can be placed well with higher probability for any effort level) and choose zero effort for those clients for which the marginal productivity is low. As Baker (2002) argues, the performance measure is poor since it induces the wrong behavior. The analysis in our paper illustrates another important aspect of the problem. Agents can (easily) distinguish the most disadvantaged from the less disadvantaged, i.e., the cost of information acquisition is low. This information makes it possible for agents to engage in gaming. If the objective is to take the same high level of care for all disadvantaged, the performance measure would be more powerful in providing the right incentives if agents were uninformed about clients' abilities. This example shows that the quality of a performance measure does not only depend on the gaming possibilities of an informed agent, but also on the cost of acquiring information since this information opens the door for gaming.

Appendix

The effect of a marginal change of $x \in \{Var(y), \rho, K\}$ on the principal's expected utility is

$$\pi = p\left(bE[vy] - \frac{1}{2}b^2E[y^2]\right) + (1-p)\left(b\mu^2 - \frac{1}{2}b^2\mu^2\right) - \frac{1}{2}Kp^2$$

where $p = \frac{1}{2}b^2\frac{Var(y)}{K}$. Rearranging yields

$$\pi = pbCov(v,y) - \frac{1}{2}pb^2Var(y) + b\mu^2 - \frac{1}{2}\mu^2b^2 - \frac{1}{2}Kp^2.$$

Moreover,

$$\begin{aligned}\frac{d\pi}{dx} &= \frac{\partial\pi}{\partial b}\frac{\partial b}{\partial x} + \frac{\partial\pi}{\partial p}\left(\frac{\partial p}{\partial x} + \frac{\partial p}{\partial b}\frac{\partial b}{\partial x}\right) + \frac{\partial\pi}{\partial x} \\ &= \frac{\partial\pi}{\partial p}\frac{\partial p}{\partial x} + \frac{\partial\pi}{\partial x},\end{aligned}$$

since in equilibrium, b is chosen such that $\frac{\partial\pi}{\partial b} + \frac{\partial\pi}{\partial p}\frac{\partial p}{\partial b} = 0$.

In addition,

$$\frac{\partial\pi}{\partial p} = bCov(v,y) - \frac{1}{2}b^2Var(y) - Kp$$

and because of (16),

$$\frac{\partial\pi}{\partial p} = b\left(Cov(v,y) - bVar(y)\right).$$

Hence,

$$\frac{d\pi}{dx} = b\left(Cov(v,y) - bVar(y)\right)\frac{\partial p}{\partial x} + \frac{\partial\pi}{\partial x}. \tag{17}$$

Variation of σ_y Substituting σ_y into (17) yields

$$\frac{d\pi}{d\sigma_y} = b\left(Cov(v,y) - bVar(y)\right)\frac{\partial p}{\partial\sigma_y} + \frac{\partial\pi}{\partial\sigma_y}$$

and, hence,

$$\frac{d\pi}{d\sigma_y} = b\left(Cov(v,y) - bVar(y)\right)\left(\frac{b^2Var(y)}{\sigma_yK}\right) + \frac{pb}{\sigma_y}\left(Cov(v,y) - bVar(y)\right).$$

From (16) one obtains

$$\frac{d\pi}{d\sigma_y} = 3\frac{pb}{\sigma_y}\left(Cov(v,y) - bVar(y)\right).$$

Therefore, in equilibrium we have $\frac{d\pi}{d\sigma_y} > 0$ if $Cov(v,y) > Var(y)$ and $\frac{d\pi}{d\sigma_y} < 0$ if $Cov(v,y) < Var(y)$.

Variation of ρ **:** Using (17) we have now

$$\frac{d\pi}{d\rho} = b\left(Cov(v,y) - bVar(y)\right)\frac{\partial p}{\partial \rho} + \frac{\partial \pi}{\partial \rho}.$$

Since $\frac{\partial p}{\partial \rho} = 0$,

$$\frac{d\pi}{d\rho} = pb\sigma_v\sigma_y,$$

which is positive.

Variation of K **:** From (17),

$$\frac{d\pi}{dK} = b\left(Cov(v,y) - bVar(y)\right)\frac{\partial p}{\partial K} + \frac{\partial \pi}{\partial K}.$$

Because of $\frac{\partial p}{\partial K} = -\frac{1}{2}b^2\frac{Var(y)}{K^2} = -\frac{p}{K}$ and $\frac{\partial \pi}{\partial K} = -\frac{1}{2}p^2$,

$$\frac{d\pi}{dK} = -\frac{pb}{K}\left(Cov(v,y) - bVar(y)\right) - \frac{1}{2}p^2.$$

Using (16), this can be rewritten as

$$\frac{d\pi}{dK} = -\frac{pb}{K}\left(Cov(v,y) - \frac{3}{4}bVar(y)\right).$$

$Cov(v,y) > \frac{3}{4}bVar(y)$ always holds whenever $Cov(v,y) > bVar(y)$. $Cov(v,y) > bVar(y)$ always holds for b^* whenever $Cov(v,y) > Var(y)$. Therefore, in equilibrium the sign of the derivative is negative for $Cov(v,y) \geq Var(y)$. For $Cov(v,y) < Var(y)$ the sign of the derivative may be positive or negative.

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