

# Measurement Error, Manipulation, and the Value of Ignoring Short-Term Performance\*

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## Abstract

This paper studies the effect of measurement error and manipulation on a principal's preference for whether or not to use a short-term performance measure for firing an agent, whose competence is unknown. The short-term performance measure is an imperfect signal of the firm's unobservable long-term value, but is subject to manipulation, which, if successful, results in a favorable performance measure. A competent agent's successful manipulation is beneficial because it reduces inefficient firing, but an incompetent agent's successful manipulation is costly because of inefficient retention. A more informative signal about the competent agent's performance can either increase or decrease inefficient firing, depending on whether the agent's manipulation is successful. Thus, the principal prefers to ignore short-term performance when the signal about the competent agent's performance is neither accurate nor inaccurate. A more informative signal about the incompetent agent's performance can either increase or decrease inefficient retention, depending on whether the agent's manipulation is successful, and, thus, has a non-monotonic effect on the value of ignoring short-term performance. The results have implications for understanding how short-term performance evaluation can be detrimental to an organization's long-term value due to the costs of the firing and retention errors.

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# 1 Introduction

Many firms use short-term performance measures to evaluate and reward performance, and to make firing and retention decisions. Short-term performance may be useful as a forecast of the manager’s competence and contribution to the firm’s long-term value, but its usefulness depends on its quality, or measurement error. As Gibbons (1998) points out, it may be inherently difficult to measure the effectiveness of an individual’s inputs for long-term organizational performance. In addition, it is well known that reward-based performance can invite “gaming”, or manipulation of the performance measure, which affects its quality and effectiveness for decision-making.<sup>1</sup> As Campbell (1979, 85) notes, “(t)he more any quantitative social indicator is used for social decision-making, the more subject it will be to corruption pressures and the more apt it will be to distort and corrupt the social processes it is intended to monitor.”<sup>2</sup> This paper studies whether a firm owner finds it optimal to ignore short-term performance for decision-making, when a manager can manipulate an imperfect short-term performance measure.

The traditional view of performance measure manipulation is that it is dysfunctional, and costly because it allows an incompetent manager to fool the firm owner. Relatedly, Kerr (1975) highlights the problem of the inability to measure the performance of a particular task, i.e., that the manager will focus on the task that is being measured at the cost of other beneficial tasks.<sup>3</sup> For these and other reasons, Cable and Vermulean (2016) argue for the abolishment of performance-based pay for executives, while others have called for less frequent reporting (see Rummell 2008, for example). However, prior literature emphasizes the benefits of performance measure manipulation, including how a competent manager can use income smoothing to signal his expertise (Demski, 1998), or how earnings management can prevent a firm owner from inefficient firing due to a lack of commitment (Fudenberg and Tirole, 1995; Arya, et al., 1998). This paper highlights the costs and benefits of performance measure manipulation, and the effect of measurement error on whether a firm owner finds it valuable to use a short-term performance measure to make a firing decision, or whether it is valuable to eliminate manipulation by ignoring short-term performance.

I use a principal-agent setting with risk neutral parties, where the agent is protected by limited

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<sup>1</sup>Muller (2018) suggests that gaming performance measures is pervasive in many aspects of society and across various types of institutions, wherever performance metrics are emphasized.

<sup>2</sup>Goodhart’s law and the Lucas critique, although discussed in monetary policy, convey the same message.

<sup>3</sup>Holmström and Milgrom (1991) and Baker (1992) formalize Kerr (1975), and propose using lower-powered incentives. In related work, Feltham and Xie (1994) study how both noise and the congruence between the agent’s effect on a performance measure and the benefit to the principal affect performance measurement. Further, Demski, et al. (2009) show that with multiple tasks, it may not be optimal to use an additional, informative performance measure due to the effect on task allocation.

liability. The principal offers a contract to an agent of unknown fit with the firm. The contract specifies whether short-term performance will be measured, and the firing rule. The short-term performance measure is an imperfect signal about the firm's unobservable long-term value. After joining the firm, the agent privately learns whether he is competent or incompetent at the firm's productive task. I assume that any report by the agent about his type is unverifiable, which means that the principal cannot use it in contracting.

The firm's unobservable long-term value depends on the agent's productive effort and his competence, or fit with the firm. With high productive effort, the firm's long-term value is good, but with low effort, the firm's long-term value may be good or bad. With an incompetent agent, the firm's long-term value is always bad, regardless of productive effort. The benefit to the principal of good long-term value is sufficiently high so that the principal is willing to hire an agent of unknown type, and to motivate the competent agent to provide high effort.

The short-term performance measure is an imperfect, but informative, signal about the firm's long-term value, and its measurement error depends on whether long-term value is good or bad. In addition, either type of agent may engage in costly activities to manipulate the signal, but these activities have no effect on long-term value. If the agent's manipulation is successful, then the signal is high, but if the manipulation is unsuccessful, whether the signal is high or low depends on the extent of the signal's measurement error.

The principal commits to whether or not to fire the agent. The setting involves a typical firing rule, which, with a short-term performance measure, means that the principal fires the agent when the signal is low. When the principal fires the agent, she receives continuation profits, which could arise from either hiring another agent or liquidating the firm's assets. The continuation profits are not so large that the principal prefers to hire an agent and to always fire the agent. This means that without a short-term performance measure, the principal will optimally never fire the agent. In addition, the agent privately benefits from retaining his job, due, for example, to a higher reputation when employed, or the transaction costs of finding a new job.

The principal can make two types of costly, decision-making errors, depending on whether she uses the short-term performance measure. The principal may mistakenly fire a competent agent whose productive effort results in good long-term firm value, or she might mistakenly retain an incompetent agent, whose effort leads to bad long-term firm value. The firing error is costly because of the lost benefit of good long-term value. The principal only incurs the cost of the firing error if she uses the short-term performance measure, because without a short-term performance

measure, she never fires the agent. The cost of the retention error is due to the lost continuation profits. The principal is less likely to incur a retention cost with a short-term performance measure than without it, because she fires the agent when performance is low.

The agent's productive incentives depend on whether or not the principal uses the short-term performance measure to fire the agent when it is low. Without firing, i.e., without a short-term performance measure, because of the lack of a performance measure, the competent agent has no incentive to provide high productive effort. In contrast, the use of the short-term performance measure for firing motivates the competent agent to provide high productive effort, as long as the cost to the agent is sufficiently low.

Without manipulation, i.e., when the cost to the agent is infinitely high, the principal prefers to ignore short-term performance when the high signal is less accurate about good long-term firm value, and when the competent agent's productivity with low effort is sufficiently high. Without manipulation, a more informative short-term performance measure increases the principal's expected profits. This is because a more accurate high short-term performance measure about good long-term firm value means the principal is less likely to mistakenly fire the competent agent, which reduces the cost of the firing error. Similarly, a more accurate low short-term performance measure about bad long-term firm value reduces the cost of retention error, because the principal is more likely to correctly fire the incompetent agent. Thus, there is a threshold for the accuracy of the high short-term performance measure, above which the principal prefers to use the short-term performance measure, and which is decreasing in the accuracy of the accuracy of the low short-term performance measure.

When the agent's cost of manipulation is not infinitely high, the use of the short-term performance measure for firing encourages both types of agents to engage in manipulation, which may or may not be successful. In equilibrium, the incompetent agent's manipulation effort is higher than the competent agent's manipulation, because he is more likely to be fired. When the competent agent's manipulation is successful, the principal does not mistakenly fire the agent, and this is beneficial to the principal. In contrast, when the incompetent agent's manipulation is successful, the principal mistakenly retains the incompetent agent, and this is costly.

The principal prefers to ignore short-term performance with manipulation for an intermediate level of the accuracy of the high short-term performance measure. This is driven by the impact of the accuracy of the short-term performance measure on the agent's manipulation. With manipulation, a more accurate high signal has two opposing effects on the principal's expected profits. First, when

the competent agent's manipulation is unsuccessful, a more accurate high short-term performance measure means the principal is less likely to fire the agent, which increases her expected profits. Second, a more accurate high short-term performance measure causes the competent agent to decrease his optimal manipulation, which means that it is less likely to be successful and decreases the principal's expected profits. Which effect dominates depends on the accuracy of the high short-term performance measure relative to the agent's cost of manipulation. For a given manipulation cost, with a less accurate high short-term performance measure, the second effect dominates, while with a more accurate high short-term performance measure, the first effect dominates. Together, this implies that the principal's expected profits are U-shaped in the accuracy of the high short-term performance measure. Thus, for a less accurate or a more accurate short-term performance measure, the principal prefers to use the short-term performance measure for the firing decision.

An increase in the accuracy of the low signal can mean that it is more likely that the principal prefers to ignore the short-term performance measure, but only when the low signal is sufficiently accurate. A more accurate low short-term performance measure also has two opposing effects on the principal's expected profits, due to the incompetent agent's manipulation. When the incompetent agent's manipulation is unsuccessful, a more accurate low short-term performance increases the principal's expected profits, because she is more likely to fire the incompetent agent. However, an increase in the accuracy of the low short-term performance measure causes the incompetent agent to increase his manipulation effort, and the principal is less likely to fire the incompetent agent, which decreases her expected profits. The first effect dominates with a less accurate low short-term performance measure, and the second effect dominates with a more accurate low short-term performance measure. Together this implies that the principal's expected profits are hump-shaped in the accuracy of the low short-term performance measure.

The results about the value of ignoring short-term performance with manipulation imply that the informativeness of the short-term performance measure has a non-monotonic effect on the total costs of the firing and retention errors. Specifically, the accuracy of the low short-term performance measure only affects the cost of mistakenly retaining an incompetent agent, and the accuracy of the high short-term performance measure only affects the cost of mistakenly firing the competent agent. Given the agent's manipulation, a more informative high signal can increase or decrease the cost of the firing error, and a more informative low signal can increase or decrease the cost of the retention error.

The principal can take measures to increase the cost of an agent's manipulation, e.g., through

tighter internal controls. A higher manipulation cost reduces the agent’s manipulation effort, but the effect on the principal’s expected profits depends on the informativeness of the short-term performance measure. Less manipulation on the part of the competent agent is costly to the principal because she is more likely to incur the cost of a firing error. In contrast, less manipulation on the part of the incompetent agent is beneficial to the principal because of a lower cost of the retention error. Which of these effects dominates depends on the informativeness of the short-term performance measure. With a less informative short-term performance measure, the increase in the firing cost dominates the reduction in the retention cost. This is because the competent agent’s manipulation is especially important due to less inefficient firing, and the decrease in the incompetent agent’s manipulation has a small impact.

This paper is related to work that studies whether short-term performance should be measured. Gigler, et al. (2014) study a manager’s incentive to focus on short-term performance that improves market prices at the expense of the firm’s long-term performance. Hofmann and Rothenberg (2014) study the effect of private information on the production and dissemination of an interim performance measure, and show that the owner prefers not to measure interim performance when it is too forward-looking, which increases the cost of effort incentives for the downstream manager. This paper also shows that a firm owner may prefer not to measure short-term performance because of the impact of measurement error and manipulation on the costs of firing and retention errors.

The results contribute to prior work on the effect of performance measurement quality on manipulation. For example, Bertomeu et al. (2017) show how a conservatively biased performance measure increases manipulation, when the performance measure is used to motivate and reward the agent. Caskey and Laux (2017) also show how a conservatively biased signal increases manipulation, but consider a setting where the principal (i.e., the board) makes an investment decision. Relatedly, Feltham and Xie (1994) considers performance measure and incentive effects when an agent can engage in window-dressing activities; however, in their setting, manipulation is always costly to the principal. This paper highlights the benefits and the costs of performance measure manipulation, as well as the impact of measurement error in a principal’s decision of whether to fire an agent, but considers that the principal may wish to ignore the performance measure.

Prior work has also studied how accuracy and bias of the performance measure affects decision-making, but without considering manipulation. Gao and Wagenhofer (2013) study how bias affects a principal’s decision to monitor and to fire or retain an agent. Balakrishnan, et al. (2019) study how performance measure bias affects the use of the performance measure for both the provision of

productive incentives and for a firing decision. This paper also studies how bias and measurement error affects a principal's choice of firing an agent, but considers an agent's manipulation, and shows that it may be optimal to forego the use of the performance measure.

## 2 Model

A risk neutral principal of a firm contracts with a risk neutral agent with limited liability to provide costly productive effort that impacts the firm's actual, but unobservable, long-term value. The firm's long-term value is denoted  $x$ , and can be good or bad, i.e.,  $x \in \{x_g, x_b\}$ , and, without loss of generality, I assume that  $x_g > 0$  and  $x_b = 0$ . I also assume that the principal benefits from good long-term firm value, and that  $x_g$  is sufficiently large so that the principal prefers to hire an agent rather than to never hire an agent. Whether the firm's long-term value is good or bad depends on the agent's productive effort and fit with the firm. At the time of contracting, neither the principal nor the agent knows whether the agent is competent or incompetent at the firm's productive task. Denote the competent agent as  $A^C$  and the incompetent agent as  $A^I$ , where the common prior belief that an agent is competent is  $\Pr(A^C) = \theta$ .

After joining the firm, the agent learns whether he is competent or incompetent at the firm's productive task. I assume that any report by the agent to the principal about his type is not contractible, i.e., it is unverifiable. After contracting and learning his type, the agent privately chooses productive effort, denoted  $e$ , where  $e \in \{e_H, e_L\}$ , with a cost of  $c(e)$ , where  $c(e_H) = c > 0$ , and  $c(e_L) = 0$ . If the agent is competent, the firm's actual, but unobservable, long-term value is good if he provides high effort, and can be good or bad if he provides low effort. If the agent is incompetent, the firm's long-term value is bad regardless of his effort.<sup>4</sup> Specifically, the likelihood of good long-term value depends on the competent agent's effort as follows,

$$\Pr(x_g|e_H; A^C) = 1, \Pr(x_g|e_L; A^C) = q, \text{ where } q \in (0, 1). \quad (1)$$

For an incompetent agent, the likelihood of good long-term performance is zero regardless of effort, or,

$$\Pr(x_g|e_H; A^I) = \Pr(x_g|e_L; A^I) = 0. \quad (2)$$

The principal's contract with the agent specifies whether or not short-term performance will

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<sup>4</sup>This is similar to the setting in Mailath and Samuelson (2001), but I do not focus on reputation effects over multiple periods.

be measured and used in the decision of whether to fire or retain the agent. The short-term performance measure is denoted  $y$ , and can be high or low, i.e.,  $y \in \{y_h, y_\ell\}$ . If it is produced, it is publicly observed after the agent provides effort, and is an imperfect forecast of the firm's long-term value. The accuracy of the short-term performance measure about long-term performance is,

$$\Pr(y_h|x_g) = \lambda_g \in (0, 1), \text{ and } \Pr(y_\ell|x_b) = \lambda_b \in (0, 1). \quad (3)$$

The short-term performance measure is informative about long-term value, which implies,

$$\Pr(y_h|x_g) > \Pr(y_\ell|x_g), \text{ and } \Pr(y_\ell|x_b) > \Pr(y_h|x_b), \text{ or,} \\ \lambda_g + \lambda_b - 1 > 0. \quad (4)$$

With the short-term performance measure, I focus on a typical firing rule, which is to fire the agent if short-term performance is low, i.e., if  $y_\ell$  is observed. If the principal fires the agent, then she loses the value of the agent's productive effort,  $x$ , but receives continuation profits  $\phi \in (0, x_g)$ . These continuation profits can be from hiring another agent of an unknown type to provide productive effort, or shutting down the firm and liquidating the firm's assets.<sup>5</sup> Without a short-term performance measure, the agent's production is sufficiently beneficial (even with low effort) so that the principal prefers to always retain the agent.

Either type of agent has a benefit,  $\pi$ , if he is retained. This means that either type of agent has an incentive to stay on the job, and if fired, the loss of this benefit is similar to a cost that would reduce his outside option, i.e., the transaction costs of finding a new job, or a reputation cost from being fired for low performance.

In addition to productive effort, either type of agent may also engage in costly, non-productive effort to manipulate the short-term performance measure. The agent's manipulation effort is denoted  $m$ , with  $m \in [0, 1]$ , and the cost to agent is  $\frac{\kappa}{2}m^2$ , where  $\kappa > 0$ . The agent's manipulation only affects the reported high short-term performance, and has no effect on the firm's long-term value. With probability  $m$ , the agent's manipulation is successful and the short-term performance measure is high, but if the agent's manipulation is unsuccessful, the likelihood of a mistaken high short-term performance measure depends on the error in the short-term performance measure.

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<sup>5</sup>I do not explicitly model a second period in which an agent (either the incumbent or newly hired) provides productive effort. However, the assumption that the principal loses the value of the agent's productive effort when she fires the agent is consistent with the idea of firm-specific human capital, which the firm and the worker both lose upon worker separation from the firm.



For the competent agent, manipulation effort is denoted  $m_H^C$  with high productive effort. The likelihood that the agent's short-term performance measure is high with high effort is,

$$\Pr(y_h|e_H; A^C) = m_H^C + \lambda_g(1 - m_H^C). \quad (5)$$

With low productive effort, the competent agent's manipulation effort is denoted  $m_L^C$ . Then, the likelihood that the competent agent's short-term performance measure is high with low effort is,

$$\Pr(y_h|e_L; A^C) = q[m_L^C + \lambda_g(1 - m_L^C)] + (1 - q)[m_L^C + (1 - \lambda_b)(1 - m_L^C)]. \quad (6)$$

Figure 2 shows the relationship between the short-term performance measure and long-term performance, depending on the competent agent's productive effort and manipulation effort.

Insert Figure 2

For an incompetent agent, manipulation effort is denoted  $m^I$ , and the likelihood that the incompetent agent's short-term performance measure is high is,

$$\Pr(y_h|e; A^I) = m^I + (1 - \lambda_b)(1 - m^I). \quad (7)$$

Figure 3 shows the relationship between the short-term performance measure and long-term performance, given the incompetent agent's productive effort and manipulation effort.

Insert Figure 3

Overall, the updated belief that long-term value is good, given the high short-term performance measure, and assuming the competent agent works hard, is,

$$\Pr(x_g|y_h) = \frac{\theta[m_H^C + \lambda_g(1 - m_H^C)]}{\theta[m_H^C + \lambda_g(1 - m_H^C)] + (1 - \theta)[m^I + (1 - \lambda_b)(1 - m^I)]}. \quad (8)$$

The updated belief that long-term performance is bad, given the low short-term performance measure is,

$$\Pr(x_b|y_\ell) = \frac{(1 - \theta)\lambda_b(1 - m^I)}{\theta(1 - \lambda_g)(1 - m_H^C) + (1 - \theta)\lambda_b(1 - m^I)}. \quad (9)$$

Given the agent's manipulation, these posterior beliefs about long-term value, i.e.,  $\Pr(x_g|y_h)$  and  $\Pr(x_b|y_\ell)$ , are increasing in the informativeness of the short-term performance measure,  $\lambda_g$  and  $\lambda_b$ .

The sequence of events is as follows:

1. The principal offers a contract to the agent, who can accept or reject the contract; neither party knows whether the agent is competent or incompetent. If the agent rejects the contract, the game ends. The contract specifies whether a short-term performance measure,  $y$ , will be produced, and if so, how it will be used in the firing decision.
2. If the agent accepts the contract and joins the firm, he privately learns whether he is competent or incompetent.
3. The agent privately chooses productive effort,  $e$ , and manipulation effort,  $m$ .
4. If the contract specified that short-term performance measure is produced, then it is publicly observed, and the agent is fired if performance is low,  $y_\ell$ . If the agent is fired, the principal earns continuation profits  $\phi$ .
5. Without a short-term performance measure, the agent is not fired.

I focus on a Bayes-Nash Equilibrium, in which the principal offers a contract that maximizes her expected profits,  $U^P$ , by choosing whether or not to measure short-term performance and to fire the agent if it is low, given her prior beliefs about the agent's type,  $\theta$ , the agent's choice of productive effort,  $e$ , and manipulation effort,  $m$ .<sup>6</sup> An agent of unknown type must be willing to join the firm, which means that his expected payoff from joining the firm,  $U^A$ , is at least as large as his reservation wage, which is normalized to zero. After the agent joins the firm, he maximizes his expected payoff given his private information about his type by choosing productive effort,  $e$ , and the amount of manipulation effort,  $m$ .

### 3 Benchmark-No Manipulation

In this section, I consider a benchmark setting, where the cost of manipulation is sufficiently high ( $\kappa = \infty$ ), so that neither type of agent engages in manipulation when the principal uses the short-term performance measure for a firing decision, i.e.,  $m^C = m^I = 0$ . However, the short-term performance measure is still subject to error.

#### 3.1 Value of Ignoring Short-Term Performance

I start with the case where the principal does not measure short-term performance and does not fire the agent. Because the principal only uses the short-term performance measure to

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<sup>6</sup>The assumption that the principal does not pay the agent a wage simplifies the analysis, and the results are qualitatively the same if a wage is determined endogenously.

make a firing decision, not measuring short-term performance is equivalent to measuring short-term performance and committing to ignore it. I first determine each type of agent's incentive to provide productive effort, and then consider the agent's choice of whether to join the firm.

Without a short-term performance measure, the principal commits to never fire the agent and both types of agent receives the benefit of being employed,  $\pi$ . In this case, the competent agent has no incentive to provide high effort, and, thus, only provides low effort. This is because he is never fired and always receives  $\pi$  regardless of effort, and high effort is costly. *Ex ante*, an agent of unknown type is willing to join the firm because he will receive  $\pi > 0$ , which is greater than his reservation wage of zero.

The following lemma summarizes the contract without a short-term performance measure, and specifies the agent's expected payoff and the principal's expected profits. All proofs are in Appendix A.

**Lemma 1** *Without a short-term performance measure, both types of agents supply low productive effort, and neither type is fired. The agent's expected payoff depending on his type is,*

$$U(A^C)^{NoF} = U(A^I)^{NoF} = \pi. \quad (10)$$

*The principal's expected profits are,*

$$U^{PNoF} = \theta q x_g. \quad (11)$$

*The principal prefers to hire an agent and never fire the agent rather than to always fire the agent if  $U^{PNoF} \geq \phi$ , or if,*

$$x_g \geq \frac{\phi}{\theta q}. \quad (12)$$

Without a short-term performance measure, the principal only benefits from good long-term firm value when she hires a competent agent. Because the competent agent only provides low effort, long-term value is good with probability  $q < 1$ . With an incompetent agent, the firm's long-term value is always bad, which yields zero benefit to the principal.

Next, I turn to the case where the principal uses the short-term performance measure to make a firing decision. It is useful to start by considering all of the principal's firing strategies with a short-term performance measure: (i) she can hire an agent and always fire the agent; (ii) she can fire the agent after observing a low short-term performance measure; (iii) she can fire the agent after observing a high short-term performance measure. I rule out the first strategy by assuming

that good long-term value, i.e.,  $x_g$ , is sufficiently high. With the third strategy, the principal's expected profits are always lower than the expected profits with no firing (which is equivalent to no short-term performance measure).<sup>7</sup> That leaves one possible firing strategy, which is a typical firing rule, i.e., fire the agent after observing low short-term performance.

When the principal uses the short-term performance measure to fire the agent after observing low performance, the cost of high effort must be low relative to the benefit of being employed to motivate the competent agent to work hard. Specifically, without manipulation, the competent agent will prefer to work hard if,

$$\lambda_g \pi - c \geq [q\lambda_g + (1 - q)(1 - \lambda_b)]\pi. \quad (13)$$

Rearranging, this is,

$$c \leq \pi(\lambda_g + \lambda_b - 1)(1 - q). \quad (14)$$

In the following analysis, I assume that  $c$  is sufficiently low so that the inequality in (14) holds. Then, with the competent agent's high productive effort, the firm's long-term value is always good, i.e.,  $\Pr(x_g | e_H; A^C) = 1$ . However, the competent agent is fired when the performance measure mistakenly reports low performance, which occurs with probability  $1 - \lambda_g$ .

Just like without a short-term performance measure, the incompetent agent supplies low productive effort, and the firm's long-term value is always bad, which yields a zero benefit to the principal. However, with the short-term performance measure and no manipulation, the incompetent agent is fired when the performance measure correctly reports low performance, which occurs with probability  $\lambda_b$ .

Finally, an agent of unknown type is willing to join the firm because his expected payoff is always greater than his reservation wage of zero, or,

$$\theta(\lambda_g \pi - c) + (1 - \theta)(1 - \lambda_b)\pi > 0. \quad (15)$$

The following lemma summarizes the setting with a short-term performance measure and firing after observing  $y_\ell$ .

**Lemma 2** *With a short-term performance measure and no manipulation, the competent agent provides high productive effort, and is fired if the performance measure mistakenly reports low*

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<sup>7</sup>See the proof of Proposition 1 in Appendix A for details.

performance. The incompetent agent provides low productive effort and is fired if the short-term performance measure correctly reports low performance. The agent's expected payoff depending on his type is,

$$U(A^C)^{FN\circ M} = \lambda_g \pi - c. \quad (16)$$

$$U(A^I)^{FN\circ M} = (1 - \lambda_b) \pi. \quad (17)$$

The principal's expected profits are,

$$U^{PFNoM} = \theta[\lambda_g x_g + (1 - \lambda_g)\phi] + (1 - \theta)\lambda_b \phi. \quad (18)$$

With no manipulation, the principal prefers to fire the agent after observing  $y_\ell$  than to always fire the agent if,

$$x_g \geq \frac{\phi[\theta\lambda_g + (1 - \theta)(1 - \lambda_b)]}{\theta\lambda_g} < \frac{\phi}{\theta q}. \quad (19)$$

With the short-term performance measure, either type of agent may be fired or retained because of the measurement error. Because the competent agent is motivated to provide high effort, the firm's long-term value is good if the principal hires a competent agent and retains the agent, which, with no manipulation, occurs with probability  $\lambda_g$ . The principal earns continuation profits,  $\phi$ , when she fires either type of agent. Note that if the principal prefers no short-term performance measure and no firing to always firing the agent, i.e., if (12) holds, then the principal also prefers the short-term performance measure and to fire the agent after  $y_\ell$  than to always fire the agent.

Before determining the principal's preference for whether to use the short-term performance measure, the following states the effect of the measurement error on the principal's expected profits with no manipulation.

**Observation 1** *With no manipulation, the principal's expected profits with the short-term performance measure and firing after observing  $y_\ell$  are increasing in the accuracy of the short-term performance measure, i.e.,  $\frac{\partial U^{PFNoM}}{\partial \lambda_g} > 0$ , and  $\frac{\partial U^{PFNoM}}{\partial \lambda_b} > 0$ .*

An increase in the accuracy of the short-term performance measure with no manipulation has two effects, both of which are beneficial to the principal. First, an increase in  $\lambda_g$  means that the competent agent's short-term performance measure is more likely to be high, and the principal is less likely to fire the competent agent. This increases the principal's expected profits, because the competent agent's high productive effort yields good long-term firm value, which is more beneficial

to the principal than the continuation profits she earns from firing the competent agent, i.e.,  $x_g > \phi$ . Second, an increase in  $\lambda_b$  means that the incompetent agent's short-term performance measure is more likely to be low, and the principal is more likely to fire the incompetent agent. This also increases the principal's expected profits because the incompetent agent's productive effort yields bad long-term firm value, which has a zero benefit to the principal, and which is less than the continuation profits from firing the incompetent agent,  $\phi$ .

I now turn to the principal's preference for not producing a short-term performance measure versus using a short-term performance measure without manipulation, by comparing the principal's expected profits in Lemma 1 to her expected profits in Lemma 2. The following proposition states the principal's preference.

**Proposition 1** *With no manipulation and with  $x_g \geq \frac{\phi}{\theta q}$ , the principal prefers no short-term performance measure and no firing if  $q > 1 - \lambda_b \frac{(\theta x_g - \phi)}{\theta x_g}$  and  $\lambda_g \in (1 - \lambda_b, \bar{\lambda}_g^{NoM}]$ . Otherwise, the principal prefers the short-term performance measure and firing after low short-term performance. The threshold,  $\bar{\lambda}_g^{NoM}$ , is given by,*

$$\bar{\lambda}_g^{NoM} = \frac{\theta(qx_g - \phi) - (1 - \theta)\lambda_b\phi}{\theta(x_g - \phi)}. \quad (20)$$

Comparing the principal's expected profits, one difference is the impact of the competent agent's productive effort. Without a short-term performance measure, the competent agent does not work hard, but with the short-term performance measure, the competent agent works hard. This implies that the likelihood of good long-term firm value is lower without the short-term performance measure, i.e.,  $q < 1$ . Then, for the principal to prefer no short-term performance, the likelihood of good long-term firm value with low effort, i.e.,  $q$ , must be sufficiently large. Specifically, if productivity with low effort is low, or  $q \leq 1 - \lambda_b \frac{(\theta x_g - \phi)}{\theta x_g}$ , then the threshold is infeasible, or  $\bar{\lambda}_g^{NoM} < 1 - \lambda_b$ , and the principal always prefers the short-term performance measure.

Even if the competent agent's productivity with low effort is sufficiently large, the principal will only prefer to ignore short-term performance when the accuracy of the high short-term performance measure about good long-term firm value is low, i.e., when  $\lambda_g$  is low. With a less accurate high short-term performance measure, the principal is more likely to fire the competent agent because the short-term performance measure mistakenly reports his performance as low.

The following observation is about the effect of the accuracy of the low performance measure about bad long-term value, i.e.,  $\lambda_b$ , on the principal's preference.

**Observation 2** *The threshold,  $\bar{\lambda}_g^{NoM}$ , is decreasing in the accuracy of the low short-term performance measure,  $\lambda_b$ .*

With a more accurate low short-term performance measure, the principal is more likely to fire the incompetent agent, which increases the principal's expected profits. The results in Proposition 1 and Observation 2 suggest that, without manipulation, the overall informativeness of the short-term performance measure,  $\lambda_g$  and  $\lambda_b$ , drives the principal's preference for whether or not to use the performance measure. The value of ignoring short-term performance arises with a less informative performance measure.

Figure 3 shows the principal's expected profits both with and without the short-term performance measure and no manipulation, as a function of the accuracy of the short-term performance measure,  $\lambda_g$  (in Panel A) and  $\lambda_b$  (in Panel B).

Insert Figure 3

### 3.2 Firing and Retention Errors

In this section, I discuss the firing and retention errors that arise both with and without the short-term performance measure, when there is no manipulation. The most efficient firing decision is to fire the agent when his productivity leads to bad long-term firm value, and the most efficient retention decision is to retain the agent when his productivity leads to good long-term firm value. Whether the principal makes a firing or a retention error depends on whether or not she uses the short-term performance measure to fire the agent when the agent's performance is low.

With an imperfect short-term performance measure, the competent agent works hard, which always leads to good long-term firm value. In this case, the principal sometimes makes a firing error, because she fires the competent agent when his short-term performance is low. The incompetent agent's production always leads to bad long-term firm value, implying that the principal sometimes makes a retention error by retaining the incompetent agent when his short-term performance is high.

Without a short-term performance measure and without firing, the competent agent does not work hard, and the firm's long-term value may be good or bad. Without firing, the principal always retains the agent. This means that the principal never makes a firing error, but sometimes makes a retention error with the competent agent, and always makes a retention error with the incompetent

agent. These firing and retention errors are costly to the principal because of foregone profits. Table 1 summarizes the expected costs of the firing and retention errors with no manipulation.

	No Short-Term Performance Measure	Short-Term Performance Measure
<i>Firing Error</i>	0	$\theta(1 - \lambda_g)(x_g - \phi)$
<i>Retention Error</i>	$[\theta(1 - q) + (1 - \theta)]\phi$	$(1 - \theta)(1 - \lambda_b)\phi$

**Table 1:** Expected Costs of the Firing and Retention Errors With No Manipulation

The firing error with the short-term performance measure is costly to the principal because of the foregone profits: when she fires the competent agent, she receives the continuation profits of  $\phi$ , but loses the benefit of good long-term firm value,  $x_g$ . The retention error is also costly to the principal because when she retains an incompetent agent she does not receive a benefit from long-term firm value, and gives up the continuation profits,  $\phi$ . The following is an observation about the effect of the informativeness of the short-term performance measure on the firing and retention costs.

**Observation 3** . *With no manipulation, an increase in the accuracy of the high short-term performance measure, i.e.,  $\lambda_g$ , reduces the cost of the firing error, and an increase in the accuracy of the low short-term performance measure, i.e.,  $\lambda_b$ , reduces the cost of the retention error.*

Comparing the cost of the errors, with no manipulation, the cost of the retention error is higher without a short-term performance measure and without firing. Without a short-term performance measure, the principal always retains the incompetent agent, while with the short-term performance measure, the principal sometimes correctly fires the incompetent agent. In addition, without a short-term performance measure, the principal retains the competent agent when his production leads to bad long-term firm value. Thus, with no manipulation, an important benefit of the short-term performance measure is correctly firing the incompetent agent. However, the cost of the short-term performance measure is mistakenly firing the competent agent when his production leads to good long-term firm value.

## 4 Short-Term Performance Manipulation

In this section, in addition to measurement error, the agent's cost of manipulation is not too high, or  $\kappa < \infty$ , and both types of agents can engage in manipulation of the short-term performance measure.



## 4.1 Value of Ignoring Short-Term Performance

I consider the principal's preference for whether or not to use the short-term performance measure for firing the agent when the agent can manipulate the performance measure. Similar to the benchmark section, I focus on the principal's strategy of firing the agent after observing low short-term performance. I also continue to assume that the benefit to the principal of good long-term firm value, i.e.,  $x_g$ , is sufficiently high, so that the principal does not always want to fire the agent.

With the short-term performance measure, I determine each type of agent's incentive to provide productive effort, and the optimal manipulation effort. Then, I consider the agent's choice of whether to join the firm. The competent agent can tailor his manipulation effort to his productive effort, and will prefer to work hard rather than not work hard if,

$$\begin{aligned} & [m_H^C + \lambda_g(1 - m_H^C)]\pi - c - \frac{\kappa}{2}(m_H^C)^2 \\ & \geq \{q[m_L^C + \lambda_g(1 - m_L^C)] + (1 - q)[m_L^C + (1 - \lambda_b)(1 - m_L^C)]\}\pi - \frac{\kappa}{2}(m_L^C)^2. \end{aligned} \quad (21)$$

Given the competent agent's manipulation, the cost of effort must be sufficiently low so that the competent agent prefers to work hard with the short-term performance measure.

The competent agent solves the following to determine the optimal amount of manipulation, depending on his productive effort:

$$m_H^C \in \arg \max [m_H^C + \lambda_g(1 - m_H^C)]\pi - c - \frac{\kappa}{2}(m_H^C)^2; \quad (22)$$

$$\begin{aligned} m_L^C \in \arg \max \{ & q[m_L^C + \lambda_g(1 - m_L^C)] \\ & + (1 - q)[m_L^C + (1 - \lambda_b)(1 - m_L^C)]\}\pi - \frac{\kappa}{2}(m_L^C)^2. \end{aligned} \quad (23)$$

The solution is,

$$m_H^{C*} = \begin{cases} \frac{(1-\lambda_g)\pi}{\kappa} & \text{if } \frac{\kappa}{\pi} > (1 - \lambda_g) \\ 1 & \text{if } \frac{\kappa}{\pi} \leq (1 - \lambda_g) \end{cases} \quad (24)$$

$$m_L^{C*} = \begin{cases} \frac{[q(1-\lambda_g) + (1-q)\lambda_b]\pi}{\kappa}, & \text{if } \frac{\kappa}{\pi} > [q(1 - \lambda_g) + (1 - q)\lambda_b] \\ 1, & \text{if } \frac{\kappa}{\pi} \leq [q(1 - \lambda_g) + (1 - q)\lambda_b] \end{cases} \quad (25)$$

If the cost of manipulation is sufficiently low relative to the agent's benefit of being employed,

i.e., if  $\frac{\kappa}{\pi} \leq (1 - \lambda_g) < [q(1 - \lambda_g) + (1 - q)\lambda_b]$ , then manipulation is perfect regardless of effort, or  $m_H^{C*} = m_L^{C*} = 1$ , and the principal cannot motivate the competent agent to work hard. This is because with perfect manipulation the competent agent is never fired, which means he always receives the benefit of being employed,  $\pi$ , he incurs the cost of manipulation of  $\frac{\kappa}{2}$  regardless of effort, and low productive effort is less costly than high effort. For a higher manipulation cost-benefit ratio, i.e.,  $\frac{\kappa}{\pi} > (1 - \lambda_g)$ , then manipulation is imperfect, or  $m_H^{C*} < 1$ , and the principal can motivate the competent agent to provide high productive effort as long as the cost of high effort,  $c$ , is sufficiently low.

The incompetent agent's productive effort always leads to bad long-term firm value, which yields zero benefit to the principal. However, because the agent wants to retain his job and earn the benefit,  $\pi$ , he has an incentive to manipulate the performance measure. Specifically, the incompetent agent solves the following to determine the optimal amount of manipulation:

$$m^I \in \arg \max [m^I + (1 - \lambda_b)(1 - m^I)]\pi - \frac{\kappa}{2}(m^I)^2. \quad (26)$$

The solution is,

$$m^{I*} = \begin{cases} \frac{\lambda_b \pi}{\kappa} & \text{if } \frac{\kappa}{\pi} > \lambda_b \\ 1 & \text{if } \frac{\kappa}{\pi} \leq \lambda_b \end{cases}$$

The incompetent agent's optimal interior level of manipulation is always higher than the competent agent's optimal interior level of manipulation. If the manipulation cost-benefit ratio is sufficiently low, i.e., if  $\frac{\kappa}{\pi} \leq \lambda_b$ , and  $m^{I*} = 1$ , then there is no contract that involves firing the agent after observing a low short-term performance measure. This is because the incompetent agent's short-term performance is always high, and low short-term performance indicates that the agent is competent, and the principal would not fire the competent agent.

Finally, *ex ante*, an agent of unknown type will join the firm if his expected payoff is greater than the reservation wage of zero. When the agent's manipulation cost-benefit ratio is low, i.e.,  $\frac{\kappa}{\pi} \leq \lambda_b$ , the principal never fires the agent, and each type of agent always receives  $\pi > 0$ , which is more than the agent's reservation wage. When the agent's manipulation cost-benefit ratio is not low, i.e.,  $\frac{\kappa}{\pi} > \lambda_b$ , the competent agent will work hard, and each type of agent's manipulation effort

is interior. Then an agent of unknown type will join the firm if,

$$\begin{aligned} & \theta\{[m_H^C + \lambda_g(1 - m_H^C)]\pi - c - \frac{\kappa}{2}m_H^2\} \\ & + (1 - \theta)\{[m^I + (1 - \lambda_b)(1 - m^I)]\pi - \frac{\kappa}{2}m_I^2\} \geq 0. \end{aligned} \quad (27)$$

Because the cost of high effort,  $c$ , must be sufficiently low to motivate the competent agent to work hard, i.e., the inequality in (21) holds, and because the incompetent agent's expected payoff is positive, then the inequality in (27) always holds.

The following lemma summarizes the contract with a short-term performance measure with manipulation and firing after observing  $y_\ell$ , and specifies the agent's expected payoff depending on his type, and the principal's expected profits.

**Lemma 3** *With a short-term performance measure and manipulation, if the agent's manipulation cost-benefit ratio is low, or  $\frac{\kappa}{\pi} \leq \lambda_b$ , then both types of agents provide low productive effort, and neither type of agent is fired. If the agent's manipulation cost-benefit ratio is high, or  $\frac{\kappa}{\pi} > \lambda_b$ , then the competent agent provides high productive effort, and is fired if his manipulation is unsuccessful and if the performance measure mistakenly reports low performance. The incompetent agent provides low productive effort and is fired if his manipulation is unsuccessful and the short-term performance measure correctly reports low performance. The agent's expected payoff depending on his type is,*

$$U(A^C)^F = U(A^I)^F = \pi, \text{ if } \frac{\kappa}{\pi} \leq \lambda_b; \quad (28)$$

$$U(A^C)^F = [m_H^{C*} + \lambda_g(1 - m_H^{C*})]\pi - c - \frac{\kappa}{2}(m_H^{C*})^2 \text{ if } \frac{\kappa}{\pi} > \lambda_b. \quad (29)$$

$$U(A^I)^F = [m^{I*} + (1 - \lambda_b)(1 - m^{I*})]\pi - \frac{\kappa}{2}(m^{I*})^2 \text{ if } \frac{\kappa}{\pi} > \lambda_b. \quad (30)$$

The principal's expected profits are,

$$U^{PF} = \begin{cases} \theta q x_g, \text{ if } \frac{\kappa}{\pi} \leq \lambda_b; \\ \theta\{[m_H^{C*} + \lambda_g(1 - m_H^{C*})]x_g + (1 - \lambda_g)(1 - m_H^{C*})\phi\} \\ \quad + (1 - \theta)\lambda_b(1 - m^{I*})\phi, \text{ if } \frac{\kappa}{\pi} > \lambda_b. \end{cases}$$

With manipulation, the principal prefers to fire the agent after observing  $y_\ell$  than to always fire the agent if,

$$x_g \geq \phi \left[ 1 + \frac{(1 - \theta)[(1 - \lambda_b) + \lambda_b m^{I*}]}{\theta[\lambda_g + (1 - \lambda_g)m_H^{C*}]} \right].$$

When the agent's manipulation cost-benefit ratio is low, i.e.,  $\frac{\kappa}{\pi} \leq \lambda_b$ , the principal never fires the agent, and the competent agent provides low effort, implying that long-term firm value is good with probability  $q$ . With the incompetent agent, the firm's long-term value is always bad, which yields zero benefit to the principal. When the agent's manipulation cost-benefit ratio is not low, i.e.,  $\frac{\kappa}{\pi} > \lambda_b$ , the competent agent provides high effort, and long-term firm value is always good. However, the principal fires the competent agent when his manipulation is unsuccessful and the performance measure mistakenly reports low performance, which occurs with probability  $(1 - \lambda_g)(1 - m_H^{C*})$ . The principal also fires the incompetent agent when his manipulation is unsuccessful and the performance measure correctly reports low performance, which occurs with probability  $\lambda_b(1 - m_I^*)$ .

Before determining the principal's preference to ignore short-term performance, I first assess the effect of the measurement error on the principal's expected profits with manipulation.

**Proposition 2** *With manipulation, and with the short-term performance measure and firing after  $y_\ell$ , the principal's expected profits can be decreasing, increasing, or independent of the informativeness of the performance measure, depending on the agent's manipulation cost-benefit ratio. Specifically,*

- i. If  $\frac{\kappa}{\pi} \leq \lambda_b$ , then  $\frac{\partial U^{PF}}{\partial \lambda_g} = \frac{\partial U^{PF}}{\partial \lambda_b} = 0$ .
- ii. If  $\lambda_b < \frac{\kappa}{\pi} < 2(1 - \lambda_g)$ , then  $\frac{\partial U^{PF}}{\partial \lambda_g} < 0$ , and if  $\frac{\kappa}{\pi} \geq 2(1 - \lambda_g)$ , then  $\frac{\partial U^{PF}}{\partial \lambda_g} \geq 0$ .
- iii. If  $\lambda_b < \frac{\kappa}{\pi} < 2\lambda_b$ , then  $\frac{\partial U^{PF}}{\partial \lambda_b} < 0$ , and if  $\frac{\kappa}{\pi} \geq 2\lambda_b$ , then  $\frac{\partial U^{PF}}{\partial \lambda_b} \geq 0$ .

Compared to the benchmark case without manipulation, the effect of the informativeness of the short-term performance measure on the principal's expected profits differs significantly, and depends on the agent's manipulation cost-benefit ratio. When this cost-benefit ratio is very low, i.e.,  $\frac{\kappa}{\pi} \leq \lambda_b$ , then the principal never fires the agent, both types of agents provide low effort, and neither type of agent manipulates the performance measure. In this case, because the principal never fires the agent, the performance measurement error has no effect on the principal's expected profits.

When the agent's manipulation cost-benefit ratio is not low, i.e.,  $\frac{\kappa}{\pi} > \lambda_b$ , then the competent agent provides high effort, and each agent's manipulation is imperfect, implying that the performance measurement error has an effect on the principal's expected profits. The effect of an increase in the accuracy of the performance measure on the principal's expected profits depends on

whether the accuracy of the high or low short-term performance measure increases, and the agent's manipulation cost-benefit ratio.

An increase in the accuracy of the high short-term performance measure,  $\lambda_g$ , has two opposing effects. When the competent agent's manipulation is unsuccessful, an increase in  $\lambda_g$  means that the principal is less likely to fire the competent agent, which increases the principal's expected profits. However, an increase in  $\lambda_g$  also causes the competent agent's optimal manipulation effort,  $m_H^{C*}$ , to decrease. This latter effect means that the principal is more likely to fire the competent agent because the agent's manipulation is less likely to be successful, which decreases the principal's expected profits. Which effect dominates depends on the level of the accuracy of the high short-term performance measure,  $\lambda_g$ , relative the agent's manipulation cost-benefit ratio,  $\frac{\kappa}{\pi}$ . When this cost-benefit ratio is low, or when the high short-term performance measure is less accurate, i.e., when  $\frac{\kappa}{\pi} < 2(1 - \lambda_g)$ , then the effect on the agent's manipulation dominates, and the principal's expected profits are decreasing in  $\lambda_g$ . Otherwise, the former effect dominates, and the principal's expected profits are increasing in  $\lambda_g$ . Together, this means that for a given manipulation cost-benefit ratio,  $\frac{\kappa}{\pi}$ , the principal's expected profits are U-shaped in the accuracy of the high short-term performance measure,  $\lambda_g$ .

An increase in the accuracy of the low short-term performance measure,  $\lambda_b$ , also has two opposing effects. When the incompetent agent's manipulation is unsuccessful, an increase in  $\lambda_b$  means that the principal is more likely to fire the agent, which increases the principal's expected profits. However, an increase in  $\lambda_b$  also causes the incompetent agent's manipulation effort,  $m^I*$ , to increase, which means the incompetent agent's manipulation is more likely to be successful, which decreases the principal's expected profits. Similar to the case with the competent agent, which effect dominates depends on the level of the accuracy of the low short-term performance measure,  $\lambda_b$ , relative the agent's manipulation cost-benefit ratio,  $\frac{\kappa}{\pi}$ . If this cost-benefit ratio is low, or the low short-term performance measure is more accurate, i.e.,  $\frac{\kappa}{\pi} < 2\lambda_b$ , then the effect on the agent's manipulation dominates, and the principal's expected profits are decreasing in  $\lambda_b$ . Otherwise, the former effect dominates, and the principal's expected profits are increasing in  $\lambda_b$ . Together, this means that for a given manipulation cost-benefit ratio,  $\frac{\kappa}{\pi}$ , the principal's expected profits are hump-shaped in the accuracy of the low short-term performance measure,  $\lambda_b$ .

I now turn to the principal's preference for using a short-term performance measure and firing the agent when his performance is low, or not producing a short-term performance measure, by comparing the principal's expected profits in Lemma 1 to her expected profits in Lemma 3. The fol-

lowing proposition establishes the principal's preference with measurement error and manipulation, where the thresholds,  $\underline{\lambda}_g$ ,  $\bar{\lambda}_g$ ,  $\underline{q}$ , and  $\bar{q}$  are defined in Appendix A.

**Proposition 3** *With manipulation and with  $x_g \geq \frac{\phi}{\theta q}$ , the principal prefers no short-term performance measure if  $\lambda_b < \frac{\kappa}{\pi} \leq 2\lambda_b$ ,  $\underline{q} < q < \bar{q}$ , and  $\lambda_g \in [\underline{\lambda}_g, \bar{\lambda}_g]$ , or if  $\frac{\kappa}{\pi} > \lambda_b$ ,  $q > \bar{q}$  and  $\lambda_g \in (1 - \lambda_b, \bar{\lambda}_g]$ . If  $\frac{\kappa}{\pi} \leq \lambda_b$ , then the principal is indifferent between using the short-term performance measure to fire the agent after low performance and no short-term performance measure. Otherwise, the principal prefers the short-term performance measure and firing after low performance.*

Compared to the benchmark case without manipulation, one similarity in the principal's preference for no short-term performance measure is that the competent agent's productivity with low effort, i.e.,  $q$ , must be sufficiently large, or  $q > \underline{q}$  for the principal to prefer no short-term performance measure. However, the principal is indifferent if the agent's manipulation cost-benefit ratio is very low, because the principal never fires the agent, and neither type of agent provides high productive effort. When the cost-benefit ratio is not low, the agent's manipulation has a significant impact on the principal's preference, via the effect of the informativeness of the short-term performance measure.

From Proposition 2, for a given manipulation cost-benefit ratio that is not low, i.e.,  $\frac{\kappa}{\pi} > \lambda_b$ , the principal's expected profits with the short-term performance are decreasing in  $\lambda_g$  when  $\lambda_g$  is small, and increasing in  $\lambda_g$  when  $\lambda_g$  is large, i.e., U-shaped in  $\lambda_g$ . When the high short-term performance measure is not very accurate, the competent agent's manipulation is more likely to be successful, which is beneficial to the principal, because she is less likely to fire the competent agent. In contrast, when the high performance measure is more accurate, the principal is less likely to fire the agent when his manipulation is unsuccessful, which is beneficial to the principal. The non-monotonic effect of the accuracy of the high short-term performance measure on the principal's expected profits implies that the principal will prefer no short-term performance measure for intermediate levels of the accuracy of the high short-term performance, i.e., for  $\lambda_g \in [\underline{\lambda}_g, \bar{\lambda}_g]$ . Note that this result also holds when there is no bias, i.e., when  $\lambda_g = \lambda_b$ .<sup>8</sup>

The smaller threshold is only feasible (i.e.,  $\underline{\lambda}_g > 1 - \lambda_b$ ) when the competent agent's productivity with low effort is not too large, i.e.,  $q < \bar{q}$ , and if the agent's manipulation cost-benefit ratio is not too large, i.e.,  $\frac{\kappa}{\pi} \leq 2\lambda_b$ . In the former case, if the competent agent's productivity with low

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<sup>8</sup>See Appendix B for an analysis without performance measurement bias.

effort is large,  $q \geq \bar{q}$ , then, similar to the benchmark case, the principal's expected profits without a short-term performance measure are higher than with the short-term performance measure as long as  $\lambda_g < \bar{\lambda}_g$ . Even if the competent agent's productivity with low effort is not too large, if the accuracy of the low short-term performance measure is sufficiently small, i.e.,  $\lambda_b < \frac{\kappa}{2\pi}$ , then, similar the benchmark case, the principal prefers no short-term measure when  $\lambda_g < \bar{\lambda}_g$ .

Next, I analyze the effect of an increase in the accuracy of the low short-term performance measure,  $\lambda_b$ , on the principal's preference for whether or not to use the short-term performance measure, as stated in the following corollary.

**Corollary 1** *An increase in  $\lambda_b$  causes the smaller threshold,  $\underline{\lambda}_g$ , to decrease, and causes the larger threshold,  $\bar{\lambda}_g$ , to increase if  $\frac{\kappa}{\pi} \leq 2\lambda_b$ , and to decrease if  $\frac{\kappa}{\pi} > 2\lambda_b$ .*

When both thresholds for  $\lambda_g$  in Proposition 3 are feasible, then an increase in the accuracy of the low short-term performance measure implies that the principal is more likely to prefer no short-term performance measure, i.e., the smaller threshold,  $\underline{\lambda}_g$ , decreases, and the larger threshold,  $\bar{\lambda}_g$ , increases. This is because the agent's manipulation cost-benefit is low relative to the accuracy of the low short-term performance measure, and from Proposition 2, in this case, the principal's expected profits are decreasing in  $\lambda_b$ . However, when only the larger threshold for  $\lambda_g$  in Proposition 3 is feasible, then an increase in the accuracy of the low short-term performance measure implies that the principal is more likely to prefer the short-term performance measure, i.e., the larger threshold,  $\bar{\lambda}_g$ , decreases, which is similar to the benchmark case without manipulation. This is because the agent's manipulation cost-benefit is high relative to the accuracy of the low short-term performance measure, and from Proposition 2, in this case, the principal's expected profits are increasing in  $\lambda_b$ .

Figure 4 shows the principal's preference for short-term performance measurement as a function of the accuracy of the performance measure,  $\lambda_g$  (Panel A), and  $\lambda_b$  (Panel B). Panel A of Figure 4 demonstrates the effect of an increase in the accuracy of the high short-term performance measure ( $\lambda_g$ ) on the principal's expected profits, which, from Proposition 2, is U-shaped. It also illustrates the results from Proposition 3, when the agent's manipulation cost-benefit ratio is not too large relative to the accuracy of the low performance measure, and the competent agent's productivity from low effort is not too high. That is, the principal prefers to use the short-term performance measure when the high short-term performance measure is either very inaccurate or very accurate.

Panel B of Figure 4 demonstrates the effect of an increase in the accuracy of the low short-term performance measure ( $\lambda_b$ ), which, from Proposition 2, is hump-shaped. The figure also demon-

strates that, for a given level of accuracy of the high short-term performance measure,  $\lambda_g$ , the principal prefers to use the short-term performance measure for an intermediate level of the accuracy of the low short-term performance measure.

Insert Figure 4

## 4.2 Firing and Retention Errors

The costs of the firing and retention errors play an important role in the principal's preference for whether or not to produce and use a short-term performance measure. With no short-term performance measure and no firing, the principal never incurs a cost for firing the competent agent. In contrast, with a short-term performance measure, the principal fires the competent agent, depending on the extent of the measurement error in the high short-term performance measure, i.e.,  $\lambda_g$ , and the agent's manipulation effort,  $m_H^{C*}$ . In this case, the cost to the principal is the foregone profits when long-term value is good less the continuation profits.

With the incompetent agent and no short-term performance measure, the principal always incurs a retention cost due to lost continuation profits. In contrast, with a short-term performance measure, the principal only fires the incompetent agent when his manipulation is unsuccessful and the performance measure is correct. Thus, the principal incurs a retention cost that depends on the agent's manipulation,  $m^{I*}$ , as well as the measurement error of the low short-term performance measure,  $\lambda_b$ . Table 2 summarizes the expected costs of the firing and retention errors with manipulation.

	No Short-Term Performance Measure	Short-Term Performance Measure
<i>Firing Error</i>	0	$\theta(1 - \lambda_g)(1 - m_H^{C*})(x_g - \phi)$
<i>Retention Error</i>	$[\theta(1 - q) + (1 - \theta)]\phi$	$(1 - \theta)(1 - \lambda_b + \lambda_b m^{I*})\phi$

**Table 2:** Expected Costs of the Firing and Retention Errors With Manipulation

The following corollary considers the effect of the informativeness of the short-term performance measure on the principal's firing and retention costs.

**Corollary 2** *With manipulation, an increase in the accuracy of the high short-term performance measure,  $\lambda_g$ , decreases the cost of the firing error if  $\frac{\kappa}{\pi} > 2(1 - \lambda_g)$ , and otherwise increases the cost of the firing error. An increase in the accuracy of the low short-term performance measure,  $\lambda_b$ , decreases the cost of the retention error if  $\frac{\kappa}{\pi} > 2\lambda_b$ , and otherwise increases the cost of the retention error.*



The effect of the informativeness of the short-term performance measure on the retention and firing costs follows from the effect of the performance measure's informativeness on the principal's expected profits, as in Proposition 2. When the agent's manipulation cost-benefit ratio is high, or the accuracy of the low short-term performance measure is low, i.e., if  $\frac{\kappa}{\pi} > 2\lambda_b$ , then an increase in the accuracy of low short-term performance measure ( $\lambda_b$ ) increases the principal's expected profits because the agent's manipulation is more likely to be unsuccessful, and the principal is less likely to retain the incompetent agent. Similarly, when the agent's manipulation cost-benefit ratio is high, or the accuracy of the high short-term performance measure is high, i.e., if  $\frac{\kappa}{\pi} > 2(1 - \lambda_g)$ , then an increase in the accuracy of high short-term performance measure ( $\lambda_g$ ) increases the principal's expected profits because the principal is less likely to fire the competent agent.

I turn next to the effect of the agent's cost of manipulation on the firing and retention errors. Given the performance measurement error, the principal can take steps to increase the cost of the agent's manipulation,  $\kappa$ , e.g., by installing a stricter internal control system. With a higher cost of manipulation, both types of agents' optimal manipulation effort decreases. However, whether or not this is beneficial to the principal depends on the impact on her firing and retention decisions, as stated in the following proposition.

**Proposition 4** *An increase in the agent's cost of manipulation,  $\kappa$ , causes the total expected cost of the firing and retention errors to increase if  $\lambda_g \in (1 - \lambda_b, 1 - \lambda_b \sqrt{\frac{(1-\theta)\phi\pi}{\theta(x_g-\phi)\pi}})$ ; otherwise, an increase in  $\kappa$  causes the total expected cost of the firing and retention errors to decrease.*

Because the competent agent's manipulation is beneficial to the principal, and the incompetent agent's manipulation is costly to the principal, less manipulation can lead to more or less efficient firing and retention. An increase in the cost of manipulation increases the cost of the firing error, but has the opposite effect on the cost of the retention error. For a given level of the informativeness of the performance measure, when the competent agent's manipulation effort decreases, the principal is more likely to mistakenly fire the competent agent, which is costly. However, when the incompetent agent's manipulation effort decreases, the principal is less likely to mistakenly retain the incompetent agent.

Whether an increase in the cost of manipulation causes the total cost of the errors to increase or to decrease depends on the informativeness of the performance measure. When the informativeness of the performance measure is low, i.e., either  $\lambda_g$  or  $\lambda_b$  is low, then the increase in the cost of the firing error dominates the decrease in the cost of the retention error. This is because with

an inaccurate high performance measure, the competent agent’s manipulation is more beneficial to the principal due to less inefficient firing. When the low performance measure is inaccurate, then the incompetent agent’s manipulation is less likely to be successful, and the decrease in the incompetent agent’s manipulation has a small effect.

Figure 5 illustrates the effect of the agent’s cost of manipulation,  $\kappa$ , on the total cost of the errors, both with and without a short-term performance measure, when  $\lambda_g$  is low (Panel A) and when  $\lambda_g$  is high. Given the accuracy of the low short-term performance measure,  $\lambda_b$ , Figure 5 clearly depicts the results in Corollary 4: when  $\lambda_g$  is low (high), the cost of the total errors is increasing (decreasing) in  $\kappa$ .

Furthermore, Figure 5 also depicts how the cost of the total errors with a short-term performance measure compare to the cost of the total error without a short-term performance, which consists only of the retention error. In Panel A, when the informativeness of the short-term performance measure is low, the cost of the total errors with a short-term performance is only lower than without a short-term performance measure, when the cost of manipulation is relatively low. In contrast, in Panel B, when the informativeness of the short-term performance measure is high, the cost of the total errors with a short-term performance is only lower than without a short-term performance measure, when the cost of manipulation is relatively high.

Insert Figure 5

## 5 Conclusion

This paper studies how measurement error and an agent’s manipulation effort affect the value of ignoring short-term performance, when it could be used for a firing decision. Performance measure manipulation can either be beneficial or costly to the principal, depending on the agent’s competence. This means that the effect of the informativeness of the short-term performance measure on the principal’s expected profits is non-monotonic. When the short-term performance measure is less accurate about the competent agent’s performance, the competent agent’s manipulation is beneficial because it keeps the principal from making a firing error due to measurement error, but when the short-term performance measure is more accurate, the competent agent’s manipulation is not important. Thus, it is valuable to ignore short-term performance when it is neither accurate nor inaccurate about the competent agent’s performance. An incompetent agent’s manipulation is costly to the principal, and while a more accurate short-term performance measure helps to avoid

costly retention errors, it also increases the incompetent agent's manipulation. This means that it may be more valuable to ignore short-term performance when it is more informative about the incompetent agent's performance.

The results also suggest that increasing the cost of the agent's manipulation, e.g., by installing a stricter internal control system, may have a negative impact, depending on the informativeness of the performance measure. With a less informative performance measure, increasing the agent's manipulation cost increases the total cost of the firing and retention errors. In this case, the benefit of the competent agent's manipulation is significant, and it is more beneficial to reduce the manipulation cost and tolerate the incompetent agent's manipulation.

The results have important implications for practice, and understanding how short-term performance evaluation can be detrimental to a firm's long-term value. Depending on the extent of measurement error, and the cost of manipulation to the manager, the firm owner may wish to avoid measuring short-term performance, even if it means retaining an incompetent manager.

## Appendix A

**Proof of Lemma 1:** Without a short-term performance measure and without firing, given the agent's benefit of being retained,  $\pi$ , the competent agent will not work hard because,

$$\pi - c < \pi. \quad (31)$$

The incompetent agent also supplies low effort. Then, the agent's expected payoff depending on his type is,

$$U(A^C)^{NoF} = U(A^I)^{NoF} = \pi. \quad (32)$$

With a reservation wage of zero, an agent of unknown type will join the firm for any  $\pi \geq 0$ . The principal's expected profits are,

$$U^{PNoF} = \theta q x_g. \quad (33)$$

The principal prefers to hire an agent and never fire the agent rather than to always fire the agent if  $U^{PNoF} \geq \phi$ , or if,

$$x_g \geq \frac{\phi}{\theta q}. \quad (34)$$

■

**Proof of Lemma 2:** With a short-term performance measure, firing after  $y_\ell$  is observed, and no manipulation, the competent agent will prefer to supply high effort if,

$$\begin{aligned} \lambda_g \pi - c &\geq [q \lambda_g + (1 - q)(1 - \lambda_b)] \pi, \text{ or,} \\ c &\leq (1 - q)(\lambda_g + \lambda_b - 1) \pi. \end{aligned} \quad (35)$$

In the analysis that follows, I assume that the competent agent's cost of high effort is not that large so that the inequality in (35) always holds. The incompetent agent only supplies low effort and his long-term performance is always bad. With no manipulation, the incompetent agent is retained with probability  $\Pr(y_h | e_L, A^I) = (1 - \lambda_b)$ . Then, each agent's expected payoff given his type is,

$$U(A^C)^{FNoM} = \lambda_g \pi - c. \quad (36)$$

$$U(A^I)^{FNoM} = (1 - \lambda_b) \pi. \quad (37)$$

An agent of unknown type is willing to join the firm if,

$$\theta(\lambda_g\pi - c) + (1 - \theta)(1 - \lambda_b)\pi \geq 0. \quad (38)$$

Because the inequality in (35) must hold, then the agent's expected payoff in (38) is always strictly positive.

The principal retains the competent agent when  $y_h$  is observed, which occurs with probability  $\theta\lambda_g$ . In this case, the agent's long-term performance will be good, and the principal earns  $x_g$ . She also retains the incompetent agent when  $y_h$  is observed, which occurs with probability  $(1 - \theta)(1 - \lambda_b)$ , but his long-term performance will be bad, which means the principal receives  $x_b = 0$ . When the principal fires either agent, she earns continuation profits,  $\phi$ . Putting this altogether, the principal's expected profits are,

$$U^{PFNoM} = \theta[\lambda_g x_g + (1 - \lambda_g)\phi] + (1 - \theta)\lambda_b\phi. \quad (39)$$

The principal prefers to fire the agent after observing  $y_\ell$  rather than to always fire the agent if  $U^{PFNoM} \geq \phi$ , or if

$$x_g \geq \frac{\phi[\theta\lambda_g + (1 - \theta)(1 - \lambda_b)]}{\theta\lambda_g}. \quad (40)$$

However,  $\frac{\phi[\theta\lambda_g + (1 - \theta)(1 - \lambda_b)]}{\lambda_g} < \frac{\phi}{\theta q}$  for all  $\lambda_g$  and  $\lambda_b$ . ■

**Proof of Proposition 1:** From above, with  $x_g \geq \frac{\phi}{\theta q}$ , the principal prefers no short-term performance measure with no firing to always firing the agent. Next, I show that the principal prefers no short-term performance measure with  $x_g \geq \frac{\phi}{\theta q}$  rather than to use the short-term performance measure and fire the agent after observing  $y_h$ . With firing the agent after observing  $y_h$ , the competent agent will not work hard because, with  $\lambda_b > 1 - \lambda_g$ , his expected payoff with high effort is always less than with low effort, or,

$$(1 - \lambda_g)\pi - c < [q(1 - \lambda_g) + (1 - q)\lambda_b]\pi. \quad (41)$$

The incompetent agent also supplies low effort. Then, an agent of unknown type is willing to join the firm if,

$$\theta[q(1 - \lambda_g) + (1 - q)\lambda_b]\pi + (1 - \theta)\lambda\pi \geq 0. \quad (42)$$

This inequality holds for any  $\pi \geq 0$ . The principal's expected profits are,

$$U^{PH} = \theta\{q(1 - \lambda_g)x_g + [q\lambda_g + (1 - q)(1 - \lambda_b)]\phi\} + (1 - \theta)(1 - \lambda_b)\phi. \quad (43)$$

The principal's expected profits are higher with no short-term performance measure, i.e.,

$U^{NoF} > U^{PH}$  if,

$$x_g > \frac{\phi}{\theta q} \frac{\{\theta[q\lambda_g + (1 - q)(1 - \lambda_b)] + (1 - \theta)(1 - \lambda_b)\}}{\lambda_g}. \quad (44)$$

Because  $\theta[q\lambda_g + (1 - q)(1 - \lambda_b)] + (1 - \theta)(1 - \lambda_b) < \lambda_g$  and with  $x_g \geq \frac{\phi}{\theta q}$ , this is true.

Then, with no manipulation, the principal prefers no short-term performance measure with no firing to the short-term performance measure and firing after observing  $y_\ell$  if  $U^{PNoF} \geq U^{PFNoM}$ , or if,

$$\theta qx_g \geq \theta[\lambda_g x_g + (1 - \lambda_g)\phi] + (1 - \theta)\lambda_b \phi. \quad (45)$$

Rearranging, this is

$$\lambda_g \leq \bar{\lambda}_g^{NoM} \equiv \frac{\theta(qx_g - \phi) - (1 - \theta)\lambda_b \phi}{\theta(x_g - \phi)}. \quad (46)$$

Note that by observation,  $\bar{\lambda}_g^{NoM} < 1$ , and  $\theta(qx_g - \phi) - (1 - \theta)\lambda_b \phi > 0$  because  $x_g \geq \frac{\phi}{\theta q}$ . The threshold is feasible if  $\bar{\lambda}_g^{NoM} > 1 - \lambda_b$ , or if,

$$q > 1 - \lambda_b \frac{(\theta x_g - \phi)}{\theta x_g}. \quad (47)$$

This condition on  $q$  is stronger than  $x_g \geq \frac{\phi}{\theta q}$ , which, rearranging, is  $q \geq \frac{\phi}{\theta x_g}$ . Then, the principal prefers the short-term performance measure and firing after observing  $y_\ell$  if  $q \leq (1 - \lambda_b) + \frac{\phi \lambda_b}{\theta x_g}$ , or if  $q > (1 - \lambda_b) + \frac{\phi \lambda_b}{\theta x_g}$  and  $\lambda_g > \bar{\lambda}_g^{NoM}$ . ■

**Proof of Lemma 3:** With manipulation, the competent agent's incentive constraint is,

$$\begin{aligned} [\lambda_g + (1 - \lambda_g)m_H^C]\pi - c - \frac{\kappa}{2}(m_H^C)^2 \geq \\ \{q[\lambda_g + (1 - \lambda_g)m_L^C] + (1 - q)[(1 - \lambda_b) + \lambda_b m_L^C]\}\pi - \frac{\kappa}{2}(m_L^C)^2. \end{aligned} \quad (48)$$

The competent agent solves the following to determine the optimal amount of manipulation

depending on his productive effort:

$$m_H^C \in \arg \max[\lambda_g + (1 - \lambda_g)m_H^C]\pi - c - \frac{\kappa}{2}(m_H^C)^2. \quad (49)$$

$$m_L^C \in \arg \max\{q[\lambda_g + (1 - \lambda_g)m_L^C] + (1 - q)[(1 - \lambda_b) + \lambda_g m_L^C]\}\pi - \frac{\kappa}{2}(m_L^C)^2. \quad (50)$$

The first order condition for each possible manipulation effort is,

$$m_H^{C*} = \begin{cases} \frac{(1-\lambda_g)\pi}{\kappa} & \text{if } \frac{\kappa}{\pi} > (1 - \lambda_g) \\ 1 & \text{if } \frac{\kappa}{\pi} \leq (1 - \lambda_g) \end{cases} \quad (51)$$

$$m_L^{C*} = \begin{cases} \frac{[q(1-\lambda_g)+(1-q)\lambda_b]\pi}{\kappa} & \text{if } \frac{\kappa}{\pi} > q(1 - \lambda_g) + (1 - q)\lambda_b \\ 1 & \text{if } \frac{\kappa}{\pi} \leq q(1 - \lambda_g) + (1 - q)\lambda_b \end{cases} \quad (52)$$

If  $m_H^{C*} = \frac{(1-\lambda_g)\pi}{\kappa} < 1$ , I assume that the competent agent's cost of high effort,  $c$ , is sufficiently small so that he prefers to supply high effort, i.e.,  $c$ , is sufficiently small so that the inequality in (48) holds.

The incompetent agent does not work hard, and solves the following to determine the optimal amount of manipulation,

$$m_I \in \arg \max[(1 - \lambda_b) + \lambda_b m_I]\pi - \frac{\kappa}{2}m_I^2. \quad (53)$$

The first order condition is,

$$m_I^* = \begin{cases} \frac{\lambda_b \pi}{\kappa} & \text{if } \frac{\kappa}{\pi} > \lambda_b \\ 1 & \text{if } \frac{\kappa}{\pi} \leq \lambda_b \end{cases} \quad (54)$$

If  $\frac{\kappa}{\pi} \leq (1 - \lambda_g) < \lambda_b$ , then  $m_H^{C*} = m_{LH}^{C*} = m_I^* = 1$ . In this case, the competent agent's short-term performance is always high, and he is never fired. Therefore, the competent agent has no incentive to work hard because if he works hard, he receives  $\pi - c - \frac{\kappa}{2}$ , and if he does not work hard, he receives  $\pi - \frac{\kappa}{2}$ . The incompetent agent is also never fired because his short-term performance is always high. Then, each type of agent receives  $\pi - \frac{\kappa}{2}$ . For an agent of unknown type to be willing to join the firm, then the agent's benefit of being employed must be sufficiently high, i.e.,  $\pi \geq \frac{\kappa}{2}$ , or  $\frac{\kappa}{\pi} \leq 2$ . However with the cost of manipulation so low, i.e.,  $\frac{\kappa}{\pi} < (1 - \lambda_g)$ , this is always true. When both types of agents supply low productive effort, and their manipulation effort is perfect, the principal never fires either agent, and her expected profits are the same as with no short-term performance measure, i.e., as in (33).

If  $(1 - \lambda_g) < \frac{\kappa}{\pi} \leq \lambda_b$ , then  $m_H^{C*} = \frac{(1-\lambda_g)\pi}{\kappa} < 1$ ,  $m_I^*$  is as above in (52), and  $m_I^* = 1$ . From above, with  $m_H^{C*} < 1$ , and firing after observing  $y_\ell$ , the competent agent prefers to work hard. However, with  $m_I^* = 1$ , the incompetent agent is never fired because his short-term performance is always high. This means that if  $y_\ell$  is observed, the principal knows that the agent is competent and will not fire him. Thus, with  $m_I^* = 1$ , there is no feasible contract that entails firing, implying that neither agent will work hard, and the principal's expected profits are the same as with no short-term performance measure, i.e., as in (33).

If  $\frac{\kappa}{\pi} > \lambda_b$ , then  $m_H^{C*} = \frac{(1-\lambda_g)\pi}{\kappa} < 1$  and  $m_I^* = \frac{\lambda_b\pi}{\kappa} < 1$ . An agent of an unknown type is willing to join the firm if,

$$\begin{aligned} \theta\{\lambda_g + (1 - \lambda_g)m_H^{C*}\pi - c - \frac{\kappa}{2}(m_H^{C*})^2\} \\ + (1 - \theta)\{(1 - \lambda_b) + \lambda_b m_I^*\pi - \frac{\kappa}{2}(m_I^*)^2\} \geq 0 \end{aligned} \quad (55)$$

This inequality is always strictly positive because the competent agent's incentive constraint in (inequality in (48) holds, and with  $m_I^* = \frac{\lambda_b\pi}{\kappa}$ , the incompetent agent's expected payoff is  $[(1 - \lambda_b) + \lambda_b m_I^*]\pi - \frac{\kappa}{2}m_I^{*2} > 0$ . The principal's expected payoff is,

$$\begin{aligned} U^{PF} &= \theta\{\lambda_g + (1 - \lambda_g)m_H^{C*}\}x_g + (1 - \lambda_g)(1 - m_H^{C*})\phi\} \\ &+ (1 - \theta)\lambda_b(1 - m_I^*)\phi. \end{aligned} \quad (56)$$

The principal prefers to fire the agent after observing  $y_\ell$  rather than to always fire the agent if  $U^{PF} \geq \phi$ , or,

$$x_g \geq \phi \left[ 1 + \frac{(1 - \theta)[(1 - \lambda_b) + \lambda_b m_I^*]}{\theta[\lambda_g + (1 - \lambda_g)m_H^{C*}]} \right] \quad (57)$$

■

**Proof of Proposition 2:** There are two parts to this proof.

1. Assume that  $\frac{\kappa}{\pi} \leq \lambda_b$ , then  $m_I^* = 1$ , and regardless of  $m_H^{C*}$ , the principal's expected profits are  $U^{PF} = \theta q x_g$ , and  $\frac{\partial U^{PF}}{\partial \lambda_g} = \frac{\partial U^{PF}}{\partial \lambda_b} = 0$ .
2. Assume that  $\frac{\kappa}{\pi} > \lambda_b$ , then  $m_H^{C*} = \frac{(1-\lambda_g)\pi}{\kappa} < 1$  and  $m_I^* = \frac{\lambda_b\pi}{\kappa} < 1$ . The principal's expected profits are increasing in  $\lambda_g$  if,

$$\frac{\partial U^{PF}}{\partial \lambda_g} = \theta(x_g - \phi)(1 - 2m_H^{C*}) > 0. \quad (58)$$



Because  $x_g - \phi > 0$ , then this can only hold if  $m_H^{C*} < \frac{1}{2}$ , or if  $\frac{\kappa}{\pi} > 2(1 - \lambda_g)$ . Note that this is only feasible if  $2(1 - \lambda_g) \geq \lambda_b$ . Otherwise,  $\frac{\partial U^{PF}}{\partial \lambda_g} \leq 0$ .

The principal's expected profits are increasing in  $\lambda_b$  if,

$$\frac{\partial U^{PF}}{\partial \lambda_b} = (1 - \theta)\phi(1 - 2m_I^*) > 0. \quad (59)$$

This can only hold if  $m_I^* < \frac{1}{2}$ , or if  $\frac{\kappa}{\pi} > 2\lambda_b$ . Otherwise,  $\frac{\partial U^{PF}}{\partial \lambda_b} \leq 0$ . ■

**Proof of Proposition 3:** In the following, I compare the principal's expected profits without a short-term performance measure and with the short-term performance measure and firing after observing  $y_\ell$ , assuming  $x_g \geq \frac{\phi}{\theta q}$ . Using the short-term performance measure to fire the agent after observing  $y_h$  is never optimal because neither type of agent will manipulate the performance measure. Then, as shown above, the principal always prefers no short-term performance measure. In addition, with  $x_g \geq \frac{\phi}{\theta q}$ , it is never optimal to always fire the agent. There are two parts to this proof.

1. Assume that  $\frac{\kappa}{\pi} \leq \lambda_b$ , which means  $m_I^* = 1$ . The principal's expected profits with no short-term performance measure are the same as with the short-term performance measure and firing after observing  $y_\ell$ , i.e.,  $U^{PNof} = U^{PF} = \theta q x_g$ .
2. Assume that  $\frac{\kappa}{\pi} > \lambda_b$ . Then,  $m_H^{C*} = \frac{(1 - \lambda_g)\pi}{\kappa} < 1$  and  $m_I^* = \frac{\lambda_b \pi}{\kappa} < 1$ . The principal prefers no short-term performance measure to using the short-term performance measure and firing after observing  $y_\ell$ , if  $U^{PNof} \geq U^{PF}$ , or if

$$\theta q x_g \geq \theta \{[\lambda_g + (1 - \lambda_g)m_H^{C*}]x_g + (1 - \lambda_g)(1 - m_H^{C*})\phi\} + (1 - \theta)\lambda_b(1 - m_I^*)\phi. \quad (60)$$

Substituting for  $m_H^{C*} = \frac{(1 - \lambda_g)\pi}{\kappa}$  and  $m_I^* = \frac{\lambda_b \pi}{\kappa}$ , and rearranging, this is

$g(\lambda_g) \equiv \lambda_g^2 A + \lambda_g B + C \leq 0$ , where,

$$\begin{aligned} A &= \theta \frac{\pi}{\kappa} (x_g - \phi); \\ B &= -\theta \left( \frac{2\pi}{\kappa} - 1 \right) (x_g - \phi); \\ C &= \theta \left[ \frac{\pi}{\kappa} (x_g - \phi) - (q x_g - \phi) \right] + (1 - \theta) \lambda_b \left( 1 - \frac{\lambda_b \pi}{\kappa} \right) \phi. \end{aligned}$$

The coefficient on  $\lambda_g^2$  is always positive, i.e.,  $A > 0$ . However, with  $\frac{\kappa}{\pi} > \lambda_b$ , then  $\frac{\pi}{\kappa}$  can be small, and the signs of  $B$  and  $C$  depend on  $\frac{\pi}{\kappa}$ .

Assume first that  $\frac{\pi}{\kappa} > \frac{1}{2}$ , which means that  $B < 0$ . Also, assume that  $C > 0$ . Then, the discriminant of  $g(\lambda_g)$  is strictly positive if,

$$q > \underline{q} \equiv 1 - \frac{[\theta(x_g - \phi) - (1 - \theta)\frac{4\pi}{\kappa}\lambda_b(1 - \frac{\lambda_b\pi}{\kappa})\phi]}{\theta\frac{4\pi}{\kappa}x_g}. \quad (61)$$

Note that with  $\frac{\pi}{\kappa} > \frac{1}{2}$ ,  $\underline{q} < 1$ . With  $q > \underline{q}$  and  $\frac{\pi}{\kappa} > \frac{1}{2}$ , there are two positive roots of  $g(\lambda_g)$ , denoted  $\underline{\lambda}_g$  and  $\bar{\lambda}_g$ , where  $\underline{\lambda}_g < \bar{\lambda}_g$ . Checking the feasibility of  $\bar{\lambda}_g$ ,  $\bar{\lambda}_g < 1$  if  $\sqrt{B^2 - 4AC} < 2A + B$ .

The right-hand side of this inequality is positive, and rearranging yields

$\theta[(x_g - \phi) - (qx_g - \phi)] + (1 - \theta)\lambda_b(1 - \frac{\lambda_b\pi}{\kappa})\phi > 0$ , which is true. Furthermore,  $\bar{\lambda}_g > 1 - \lambda_b$  if  $\sqrt{B^2 - 4AC} > 2A(1 - \lambda_b) + B$ , which is true if  $\frac{\pi}{\kappa} > \frac{1}{2\lambda_b}$ . If  $\frac{\pi}{\kappa} < \frac{1}{2\lambda_b}$ , then, this inequality holds if,

$$q > \bar{q} \equiv 1 - \frac{(\theta x_g - \phi)\lambda_b(1 - \frac{\lambda_b\pi}{\kappa})}{\theta x_g}. \quad (62)$$

Note that  $\bar{q} > \underline{q}$ . Next,  $\underline{\lambda}_g > 1 - \lambda_b$  if  $\sqrt{B^2 - 4AC} < -B - 2A(1 - \lambda_b)$ . The right hand side of this inequality is positive if  $\frac{\pi}{\kappa} > \frac{1}{2\lambda_b}$ . Then, rearranging yields  $q < \bar{q}$ . With  $\frac{\pi}{\kappa} > \frac{1}{2\lambda_b}$  and  $\underline{q} < q < \bar{q}$ , then  $1 - \lambda_b < \underline{\lambda}_g < \bar{\lambda}_g < 1$ . Finally,  $C > 0$  if,

$$q < \hat{q} \equiv \frac{\theta[\frac{\pi}{\kappa}(x_g - \phi) + \phi] + (1 - \theta)\lambda_b(1 - \frac{\lambda_b\pi}{\kappa})\phi}{\theta x_g}. \quad (63)$$

With  $\frac{\pi}{\kappa} > \frac{1}{2\lambda_b}$ , then  $\hat{q} > \bar{q}$ . Summarizing, if  $\frac{1}{2\lambda_b} < \frac{\pi}{\kappa} < \frac{1}{\lambda_b}$  and  $\underline{q} < q < \bar{q}$ , then the principal prefers no short-term performance measurement if  $\lambda_g \in [\underline{\lambda}_g, \bar{\lambda}_g]$ , and otherwise prefers the short-term performance measure. If  $\frac{1}{2} < \frac{\pi}{\kappa} < \frac{1}{\lambda_b}$  and if  $q > \bar{q}$ , then the principal prefers no short-term performance measurement if  $\lambda_g \in (1 - \lambda_b, \bar{\lambda}_g]$ , and otherwise prefers the short-term performance measure.

Next assume that  $\frac{\pi}{\kappa} < \frac{1}{2}$ , which means that  $B > 0$ . Assume that  $C < 0$ , because otherwise  $g(\lambda_g) > 0$  and the principal always prefers the short-term performance measure. With  $C < 0$ , there is only one positive root,  $\bar{\lambda}_g$ , which, from above, is feasible if  $q > \bar{q}$  (because  $\frac{\pi}{\kappa} < \frac{1}{2\lambda_b}$ ). Then, from above,  $C < 0$  if  $q > \hat{q}$ . With  $\frac{\pi}{\kappa} < \frac{1}{2}$ , then  $\hat{q} < \bar{q}$ . Summarizing, with  $\frac{\pi}{\kappa} < \frac{1}{2}$ , the principal prefers no short-term performance measure if  $q > \bar{q}$  and  $\lambda_g \in (1 - \lambda_b, \bar{\lambda}_g]$ , and otherwise prefers the short-term performance measure. ■

**Proof of Corollary 1:** If  $\lambda_b < \frac{\kappa}{\pi} \leq 2\lambda_b$  and  $\underline{q} < q < \bar{q}$ , then there are two feasible thresholds,  $\underline{\lambda}_g$  and  $\bar{\lambda}_g$ . With  $A$ ,  $B$ , and  $C$  as defined above, an increase in  $\lambda_b$  causes the smaller threshold,  $\underline{\lambda}_g$ , to

decrease if,

$$\frac{\partial \lambda_g}{\partial \lambda_b} = \frac{(1-\theta)(1-\frac{2\lambda_b\pi}{\kappa})\phi}{\sqrt{B^2-4AC}} \leq 0, \quad (64)$$

which is true with  $\frac{\kappa}{\pi} \leq 2\lambda_b$ . An increase in  $\lambda_b$  causes the larger threshold,  $\bar{\lambda}_g$ , to increase if,

$$\frac{\partial \bar{\lambda}_g}{\partial \lambda_b} = -\frac{(1-\theta)(1-\frac{2\lambda_b\pi}{\kappa})\phi}{\sqrt{B^2-4AC}} \geq 0, \quad (65)$$

which is true with  $\frac{\kappa}{\pi} \leq 2\lambda_b$ .

If  $\lambda_b < \frac{\kappa}{\pi}$  and  $q > \bar{q}$ , then there is one feasible threshold,  $\bar{\lambda}_g$ . As shown above  $\frac{\partial \bar{\lambda}_g}{\partial \lambda_b} \geq 0$  if  $\frac{\kappa}{\pi} \leq 2\lambda_b$ , and  $\frac{\partial \bar{\lambda}_g}{\partial \lambda_b} < 0$  if  $\frac{\kappa}{\pi} > 2\lambda_b$ . ■

**Proof of Corollary 2:** From Table 2, the expected cost of the retention error with the short-term performance measure is  $(1-\theta)(1-\lambda_b+\lambda_b m^{I*})\phi$ . Substituting for  $m^{I*} = \frac{\lambda_b\pi}{\kappa}$ , an increase in  $\lambda_b$  causes the expected cost of the retention error to decrease if  $(1-\theta)(\frac{2\lambda_b\pi}{\kappa}-1)\phi < 0$ , or if  $\frac{\kappa}{\pi} > 2\lambda_b$ ; otherwise, the expected cost of the retention error increases. Also, from Table 2, the expected cost of the firing error with the short-term performance measure is  $\theta(1-\lambda_g)(1-m_H^{C*})(x_g-\phi)$ . Substituting for  $m_H^{C*} = \frac{(1-\lambda_g)\pi}{\kappa}$ , an increase in  $\lambda_g$  causes the expected cost of the firing error to decrease if  $\theta(x_g-\phi)[\frac{2(1-\lambda_g)\pi}{\kappa}-1] < 0$ , or if  $\frac{\kappa}{\pi} > 2(1-\lambda_g)$ ; otherwise, the expected cost of the firing error increases. ■

**Proof of Proposition 4:** From Table 2, the total expected cost of the firing and retention errors with the short-term performance measure is,

$$TE = \theta(1-\lambda_g)(1-m_H^{C*})(x_g-\phi) + (1-\theta)(1-\lambda_b+\lambda_b m^{I*})\phi. \quad (66)$$

An increase in  $\kappa$  causes the cost of total errors to increase if,

$$\frac{\partial TE}{\partial \kappa} = -\frac{\partial m_H^{C*}}{\partial \kappa}\theta(1-\lambda_g)(x_g-\phi) + \frac{\partial m^{I*}}{\partial \kappa}(1-\theta)\lambda_b\phi > 0. \quad (67)$$

Substituting for  $\frac{\partial m_H^{C*}}{\partial \kappa} = -\frac{(1-\lambda_g)\pi}{\kappa^2}$  and  $\frac{\partial m^{I*}}{\partial \kappa} = -\frac{\lambda_b\pi}{\kappa^2}$ , then this inequality is,

$$\frac{\partial TE}{\partial \kappa} = \frac{(1-\lambda_g)^2\theta(x_g-\phi)\pi}{\kappa^2} - \frac{\lambda_b^2(1-\theta)\phi\pi}{\kappa^2} > 0. \quad (68)$$

Rearranging,  $\frac{\partial TE}{\partial \kappa} > 0$  if,

$$\lambda_g < 1 - \lambda_b \sqrt{\frac{(1-\theta)\phi\pi}{\theta(x_g-\phi)\pi}}.$$

Note that  $1 - \lambda_b \sqrt{\frac{(1-\theta)\phi\pi}{\theta(x_g-\phi)\pi}} > 1 - \lambda_b$ , which is the assumed lower bound for  $\lambda_g$ . If  $\lambda_g \geq 1 - \lambda_b \sqrt{\frac{(1-\theta)\phi\pi}{\theta(x_g-\phi)\pi}}$ , then an increase in  $\kappa$  causes the cost of total errors to decrease. ■

## Appendix B

In this Appendix, I analyze the case with no performance measurement bias, i.e.,  $\lambda_g = \lambda_b = \lambda$ , and then use a numerical example to show that the results are similar to the case with bias. To ensure that the short-term performance is informative without bias, i.e.,  $\Pr(y_h|x_g) > \Pr(y_\ell|x_g)$ , and  $\Pr(y_\ell|x_b) > \Pr(y_h|x_g)$ , I assume  $2\lambda - 1 > 0$ , or  $\lambda > \frac{1}{2}$ .

Substituting for  $\lambda_g = \lambda_b = \lambda$ , with no manipulation, the principal's expected profits with the short-term performance measure are,

$$U^{PFNoM} = \theta[\lambda x_g + (1 - \lambda)\phi] + (1 - \theta)\lambda\phi. \quad (69)$$

As with the case with bias, the principal's expected profits are increasing in the accuracy of the performance measure, or,

$$\frac{\partial U^{PFNoM}}{\partial \lambda} = \theta(x_g - \phi) + (1 - \theta)\phi > 0.$$

Turning to the setting with manipulation, the competent agent's optimal manipulation effort is as follows, depending on his productive effort:

$$m_H^{C*} = \begin{cases} \frac{(1-\lambda)\pi}{\kappa} & \text{if } \frac{\kappa}{\pi} > (1 - \lambda) \\ 1 & \text{if } \frac{\kappa}{\pi} \leq (1 - \lambda) \end{cases} \quad (70)$$

$$m_L^{C*} = \begin{cases} \frac{[q(1-\lambda)+(1-q)\lambda]\pi}{\kappa} & \text{if } \frac{\kappa}{\pi} > q(1 - \lambda) + (1 - q)\lambda \\ 1 & \text{if } \frac{\kappa}{\pi} \leq q(1 - \lambda) + (1 - q)\lambda \end{cases} \quad (71)$$

The incompetent agent's optimal manipulation effort is,

$$m_I^* = \begin{cases} \frac{\lambda\pi}{\kappa} & \text{if } \frac{\kappa}{\pi} > \lambda \\ 1 & \text{if } \frac{\kappa}{\pi} \leq \lambda \end{cases} \quad (72)$$

In the following, I assume that  $\frac{\kappa}{\pi} > \lambda$ , which means that the incompetent agent's manipulation is not perfect. Then, the principal's expected profits with manipulation and with the short-term performance measure are,

$$\begin{aligned} U^{PF} &= \theta\{[\lambda + (1 - \lambda)m_H^{C*}]x_g + (1 - \lambda)(1 - m_H^{C*})\phi\} \\ &\quad + (1 - \theta)\lambda(1 - m_I^*)\phi. \end{aligned} \quad (73)$$

The principal's expected profits are increasing in the accuracy of the performance measure if,

$$\frac{\partial U^{PF}}{\partial \lambda} = \theta(x_g - \phi)\left[1 - \frac{2(1 - \lambda)\pi}{\kappa}\right] + (1 - \theta)\phi\left[1 - \frac{2\lambda\pi}{\kappa}\right] > 0.$$

Rearranging, this is,

$$\frac{\kappa}{\pi} > \hat{\kappa} \equiv \frac{2[\theta(x_g - \phi)(1 - \lambda) + (1 - \theta)\phi\lambda]}{\theta(x_g - \phi) + (1 - \theta)\phi}.$$

Note that  $\hat{\kappa} > \lambda$  only if  $\lambda$  is not too large, or if  $\lambda < \frac{2\theta(x_g - \phi)}{3\theta(x_g - \phi) - (1 - \theta)\phi} < 1$ . This implies that without bias, similar to the case with bias, the principal's expected profits can be increasing or decreasing in the accuracy of the performance measure, with  $\frac{\kappa}{\pi} > \lambda$ . When  $\frac{\kappa}{\pi} \leq \lambda$ , the incompetent agent's manipulation effort is perfect, the principal never fires the agent, and the principal's expected profits are independent of the accuracy of the performance measure.

Finally, I use a numerical example to demonstrate that the principal's preference for no short-term performance measure without bias is similar to the setting with bias. Figure 6 illustrates the principal's expected profits with no bias, as a function of the accuracy of the performance measure, both without manipulation (Panel A) and with manipulation (Panel B).

Insert Figure 6

Specifically, Panel A of Figure 6 shows that without manipulation, the principal prefers no short-term performance measure, when it is less informative, i.e., when  $\lambda$  is sufficiently small, which is similar to the result in Proposition 1, as illustrated in Figure 3. Panel B of Figure 6 demonstrates that with manipulation, the principal prefers no short-term performance measure for an intermediate level of the accuracy of the performance measure. This is similar to Proposition 3, as illustrated in Figure 4.

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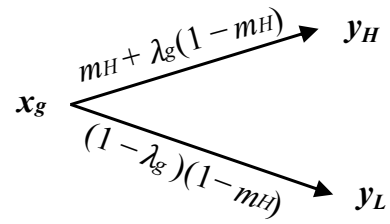
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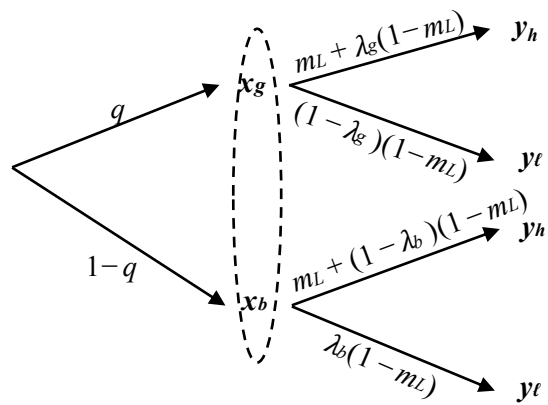


Unobservable Long-term Performance      Short-term Performance



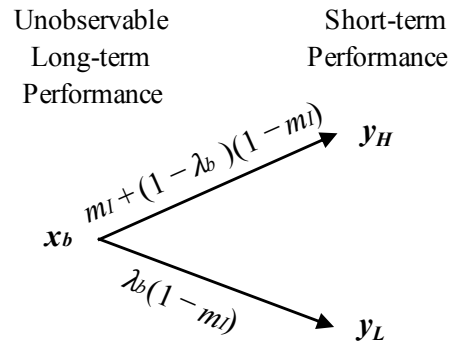
Panel A: Competent agent chooses high effort,  $e_H$

Unobservable Long-term Performance      Short-term Performance

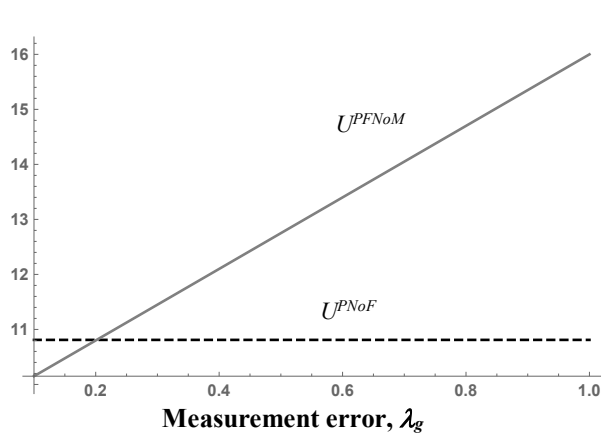


Panel B: Competent agent chooses low effort,  $e_L$

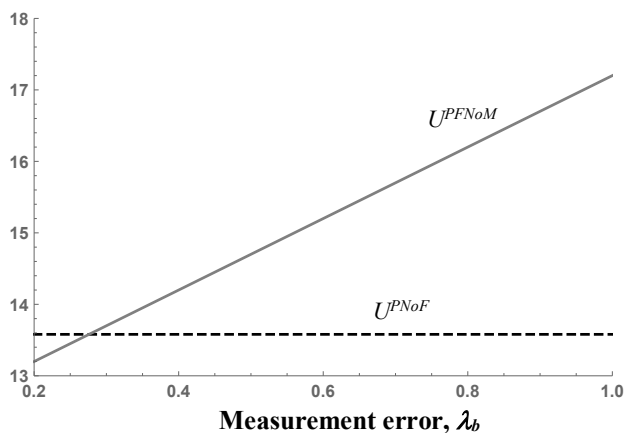
**Figure 1** Relationship between short-term performance measure,  $y$ , and long-term firm value,  $x$ , depending on the competent agent's effort,  $e$ .



**Figure 2** Relationship between short-term performance measure,  $y$ , and long-term firm value,  $x$ , given incompetent agent's effort.

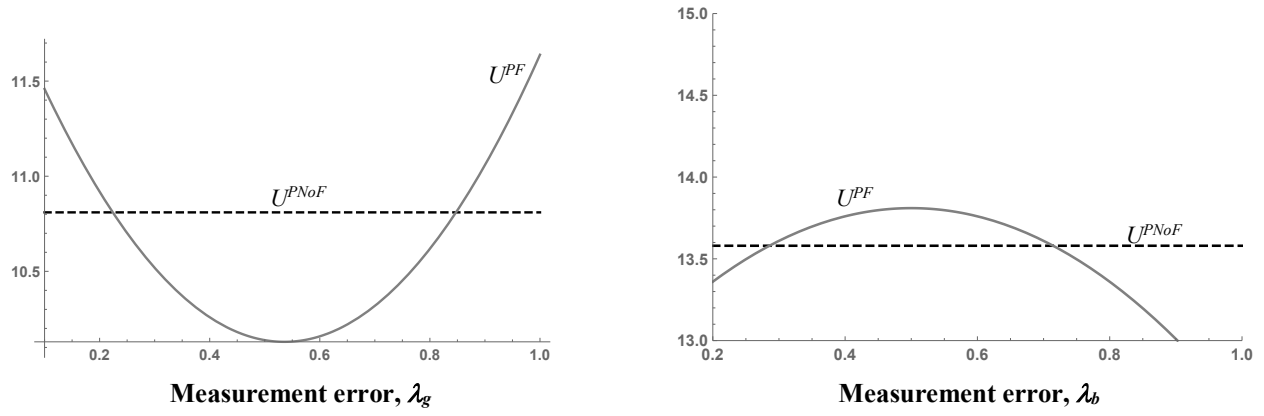


Panel A: Effect of  $\lambda_g$ , given  $\lambda_b$

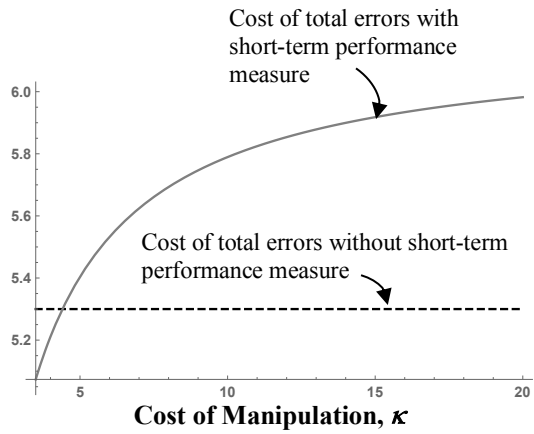


Panel B: Effect of  $\lambda_b$ , given  $\lambda_g$

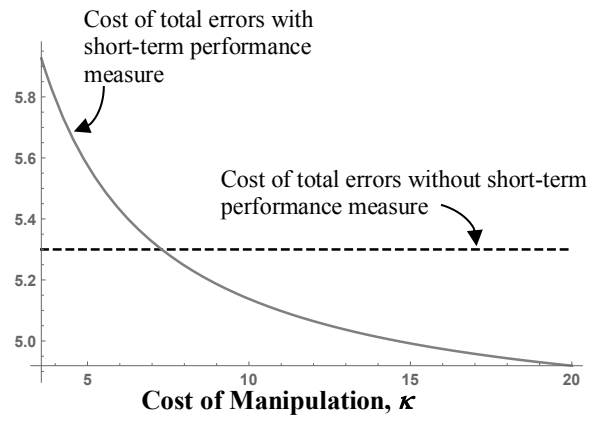
**Figure 3** Effect of measurement error,  $\lambda_g$  and  $\lambda_b$ , on the principal's expected profits, with and without the short-term performance measure, and without manipulation.



**Figure 4** Effect of measurement error,  $\lambda_g$  and  $\lambda_b$ , on the principal's expected profits, with and without the short-term performance measure, and with manipulation.

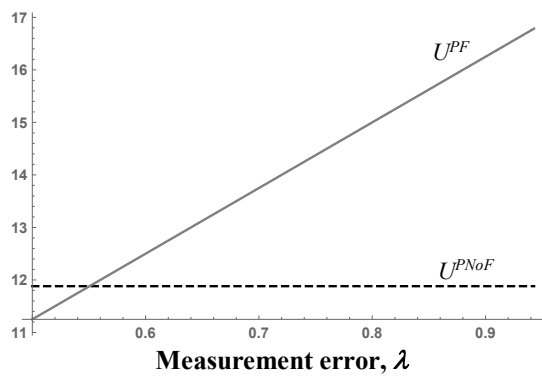


Panel A: Low  $\lambda_g$

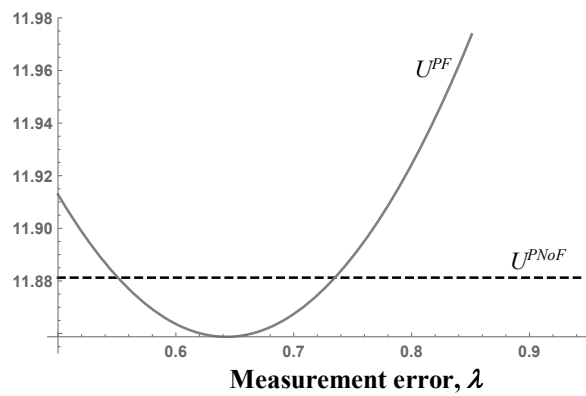


Panel B: High  $\lambda_g$

**Figure 5** Effect of the agent's cost of manipulation on the total cost of the errors with and without a short-term performance measure.



Panel A: No Manipulation



Panel B: With Manipulation

**Figure 6:** Numerical example of the effect of measurement error without bias,  $\lambda$ , on the principal's expected profits, with and without the short-term performance measure. The parameters are:  $\theta = 0.5$ ,  $\kappa = 6.6$ ,  $\pi = 7$ ,  $x_g = 25$ ,  $\phi = 10$ , and  $q = .9505$ .