Monitoring, Incentive Contracting, and Accounting Manipulation

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Abstract: This study examines how a monitoring system that constrains accounting manipulation affects shareholder value and managerial rents. Although it is generally argued that constraining manipulation via monitoring alleviates effort control problems, this study demonstrates that monitoring can make it harder, not easier, to induce managerial effort. The key intuition is that when investment outcomes are contractible, management's manipulation incentives increase in the level of productive effort. This result implies that restricting manipulation via monitoring can increase the cost of incentive contracting, which reduces shareholder value. In addition, monitoring discourages managers from engaging in costly manipulation activities and thus can increase managerial rents. The analysis also shows that monitoring can increase shareholder value and managerial rents simultaneously, suggesting that shareholders and managers do not always disagree on the optimal monitoring system.

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1 Introduction

Accounting manipulation is generally viewed as an action that benefits managers at the expense of shareholders. One aspect of this argument suggests that accounting manipulation exacerbates effort control problems (e.g. Feltham and Xie 1994, Goldman and Slezak 2006). Intuitively, accounting manipulation makes it more difficult to induce high managerial effort because managers can manipulate information to achieve desirable performance measurement reports instead of exerting high effort to improve actual performance. Constraining manipulation via monitoring therefore makes it easier to induce high managerial effort and reduces the cost of incentive contracting. In this study, I demonstrate that, under certain conditions, restricting manipulation via monitoring can make it more difficult to induce high managerial effort. The key driver behind this result is that management's manipulation incentives increase in the level of productive effort. Allowing managers to manipulate the report increases the likelihood they will obtain a bonus, but it increases more quickly when they exert high effort than when they exert low effort. Consequently, constraining manipulation via monitoring can make it less attractive for managers to exert high effort, resulting in an increase in the cost of incentive contracting.

One implication of the finding that monitoring can aggravate effort control problems is that shareholders may not always prefer a strong monitoring system, even when monitoring is costless. In a similar vein, managers may not always prefer a weak monitoring system because monitoring can increase managerial rents. The analysis also shows that a monitoring system that constrains manipulation activities can simultaneously increase both shareholder value and managerial rents, suggesting that shareholders and managers do not always have different preferences for an optimal monitoring system. As a consequence, organizational changes that shift the relative power between managers and shareholders do not necessarily trigger changes in monitoring intensity.

I consider a moral hazard model in which shareholders hire a manager to work on an investment project. Shareholders offer an incentive contract to induce unobservable managerial effort that improves project quality. At an interim stage, the manager privately observes a signal that provides information about project quality, although this signal is not perfectly accurate. The manager can manipulate this signal by incurring a personal cost, which is determined by the level of manipulation and the intensity of monitoring. Higher-intensity monitoring causes higher marginal cost of manipulation. Shareholders observe a potentially manipulated signal in the form of an interim accounting report and have the right to liquidate the project if they find it optimal to do so.

To analyze the effects of monitoring on shareholder value and managerial rents, I consider two contracting environments based on contractibility of investment outcomes. In both cases, monitoring improves the quality of interim accounting information and thus improves shareholders' ability to correctly decide whether to continue or to liquidate the project. Consequently, monitoring improves investment efficiency, which enhances shareholder value.

Although monitoring always improves investment efficiency, its impact on incentive contracts depends on the contracting environment. When investment outcomes are not contractible, the manager is rewarded a bonus when the interim accounting report is favorable. In this case, manipulation and productive effort are substitutes because the likelihood that the manager will manipulate the report decreases as the level of productive effort increases. Therefore, allowing the manager to manipulate the report reduces the manager's incentive to supply high productive effort, resulting in an increase in the cost of incentive contracting as well as an increase in managerial rents. Put differently, constraining manipulation via monitoring reduces the cost of incentive contracting and managerial rents, consistent with the conventional view that monitoring reduces agency conflicts between shareholders and managers.

When investment outcomes can be used for contracting purposes, however, the manager is rewarded a bonus only for long-term success which can be achieved only when the project is continued. As a result, the manager has an incentive to manipulate the interim report to convince shareholders to continue the project. Although managerial effort decreases the likelihood that the manager will manipulate the report, it increases the manipulation level when the manager actually does manipulate the report. This result follows because, when determining the manipulation level, the manager faces a trade-off between the benefit and the cost of manipulation. The expected benefit of manipulation increases in the likelihood of obtaining the bonus if manipulation is successful while the cost of manipulation increases in the level of manipulation. As the productive effort level increases, the likelihood that the project succeeds increases, and the manager's expected benefit from manipulation increases. Therefore, the manager optimally chooses a higher level of manipulation when he exerts high effort than when he exerts low effort. This result implies that allowing manipulation increases the probability that the manager is rewarded more quickly when he exerts high effort than when he exerts low effort, suggesting that manipulation reduces the bonus required to induce high managerial effort. Nevertheless, manipulation also increases the likelihood that the manager obtains the bonus. I show that when the agency friction is severe, the effect of manipulation in reducing the bonus level dominates its effect in increasing the probability that the manager obtains the bonus such that restricting manipulation via monitoring leads to an increase in expected compensation. In addition, a monitoring system that makes it difficult to manipulate the report benefits the manager because it discourages him from engaging in manipulation activities and saves him from incurring manipulation costs. As a consequence, constraining manipulation via monitoring increases managerial rents.

Taken as a whole, these results show that shareholders do not always attempt to strengthen a monitoring system and that managers do not always weaken it. In fact, it is possible that shareholders prefer a weak monitoring system while managers prefer a strong one, suggesting a positive association between the relative degree of managerial influence over a monitoring system and monitoring intensity. In addition, monitoring can increase both shareholder value and managerial rents simultaneously because it reduces the deadweight loss associated with expected manipulation cost and inefficient investment decisions, and this gain is shared between shareholders and managers. Consequently, shareholders and managers do not always have different preferences in terms of optimal monitoring systems. The results of this study also show that shareholder value can be maximized in the presence of high managerial rents, weak monitoring, high manipulation, or high expected compensation, whereas managerial rents can be maximized when expected compensation is low. Finally, a monitoring system that constrains accounting manipulation always decreases the manipulation level but can either increase or decrease the bonus level. As a consequence, the relationship between the level of bonus and manipulation incentive can be either positive or negative.

The moral hazard model in this study modifies the capital financing model used in Dessi (2005) in which an agent's effort affects investment outcomes and the interim information is used for a project continuation decision as well as for contracting purposes. Dessi (2005) assumes that the interim information is either publicly observable or privately observed by the agent. I modify this assumption by assuming that there is an accounting system that reduces information asymmetry between a principal and an agent. However, this information is not perfectly accurate because of exogenous noises and manipulation incentives. In addition, while Dessi (2005) focuses on deriving optimal financing contracts, the emphasis in this paper is on the effects of constraining manipulation via monitoring on shareholder value and managerial rents.

This study is related to prior literature that examines the moral hazard problem and accounting manipulation (e.g., Feltham and Xie 1994, Goldman and Slezak 2006, Crocker and Slemrod 2007, Laux 2014). Prior studies that examine this relationship focus on one contracting environment, either when investment outcomes are not contractible (Feltham and Xie 1994, Goldman and Slezak 2006, Crocker and Slemrod 2007) or when investment outcomes are contractible (Laux 2014). In this study, I examine the relationships between a monitoring system, shareholder value, and managerial rents under different contracting environments and show that contractibility of investment outcomes affects these relationships. In addition, while prior studies have shown that constraining manipulation via monitoring alleviates effort control problems, I show that it can aggravate, rather than alleviate, these problems.

This study can also be linked to prior literature that shows the benefits of accounting manipulation to shareholders. Arya et al. (1998) show that allowing managers to manipulate accounting information protects them from being dismissed early and thus may reduce the cost to induce them to accept employment contracts. Similarly, Demski (1998) shows that, under certain conditions, firms benefit from earnings management that results in income smoothing. Dutta and Gigler (2002) show that it is not always optimal to design the accounting system to prevent accounting manipulation because accounting manipulation makes it easier to elicit truthful forecasts from managers. Considering a trade-off between productive effort and manipulation effort, Demski et al. (2004) show that it may be optimal for principals to facilitate the accounting manipulation process because it reduces agents' manipulation incentives and alleviates effort control problems. Liang (2004) shows that manipulation can reduce the variability of compensation across periods and thus reduce the risk premium paid to agents. Finally, Drymiotes (2008) shows that it may be optimal to allow managers to influence their performance evaluation in order to lower managerial compensation costs. Although these papers show that manipulation can be beneficial to shareholders, the intuitions behind these results are different from the intuition in the present study which argues that the manager manipulates the report to convince shareholders to continue the project and that this manipulation incentive increases in the level of managerial effort. Consequently, manipulation can make it more attractive for the manager to exert high effort, resulting in lower costs of incentive contracting. In addition, unlike prior studies that show the benefits of accounting manipulation to shareholders, this study analyzes the impacts of monitoring on both shareholder value and managerial rents simultaneously in order to provide a better understanding of how shifts in the relative power between shareholders and managers may affect monitoring intensity.

The remainder of the paper is organized as follows. Section 2 describes the model and assumptions. Section 3 shows the effects of monitoring on optimal contracting, expected compensation, and managerial rents when investment outcomes are not contractible while Section 4 shows these effects when investment outcomes are contractible. The effect of monitoring on investment efficiency is shown in Section 5. Section 6 shows the optimal monitoring system given the relative degree of influence over a monitoring system between shareholders and managers. I discuss the empirical implications of the model in Section 7. Section 8 concludes the paper. All proofs are shown in the Appendix.

2 Model

I consider a model with two risk-neutral players in a firm—a manager and shareholders. The firm has an investment project and the quality of the project depends on the manager's unobservable effort. Thus, shareholders must offer an incentive contract to induce the manager to choose the desired effort.

Timing: There are four dates: t_0, t_1, t_2, and t_3. At t_0, a manager and shareholders implement a monitoring system. The intensity of the monitoring system is jointly determined by both parties. At t_1, shareholders offer the manager an incentive contract, and the manager chooses an unobservable effort choice that affects project quality. At t_2, the manager privately observes a signal that provides information about project quality and can manipulate it. Shareholders observe potentially manipulated information and decide whether to continue or to liquidate the project. At t_3, an investment outcome is realized.

Investment projects and productive effort: The firm has an investment project which can be a high quality project (λ_h) or a low quality project (λ_l). The quality of the project cannot be observed by any parties but can be inferred after observing investment outcomes as a high quality project yields a high outcome of $R > 0$ while a low quality project yields a low outcome of 0. The quality of the project depends on unobservable managerial effort. If the manager exerts high effort (referred to as "a working manager"), he incurs a personal cost of $b > 0$ and the probability that project quality is high is p_h. However, if the manager chooses low effort (referred to as "a shirking manager"), the probability that project quality is high is reduced to p_l, $1 > p_h > p_l > 0$, but he does not incur any personal cost of effort. As is common in moral hazard literature, I assume that it is optimal for shareholders to induce the manager to exert high effort. This is the case, for example, when R is sufficiently large or when b is sufficiently small.[1]

Information, Manipulation Activities, and Monitoring Technology: At t_2, the manager privately observes a binary signal, $s \in \{s_h, s_l\}$, that provides information about project quality, λ. The accuracy of the signal is exogenously given and is denoted by $q \in (0.5, 1)$ such that $\Pr(s_h|\lambda_h) = \Pr(s_l|\lambda_l) = q$ and $\Pr(s_l|\lambda_h) = \Pr(s_h|\lambda_l) = (1-q)$.[2] After observing the signal, the manager can choose whether or not to engage in accounting manipulation activities, which distort the information contained in the accounting report, $\theta \in \{\theta_h, \theta_l\}$. If the manager chooses not to manipulate the information, the report is truthful in the sense that when the signal is high (s_h), the report is θ_h and when the signal is low (s_l), the report is θ_l. If, however, the manager privately chooses a manipulation level $m \in [0, 1]$ by incurring a personal cost of $0.5km^2$, the accounting report is distorted (i.e. the report is θ_l when $s = s_h$ and θ_h when $s = s_l$) with probability m and is truthful with probability $1 - m$.

The parameter k represents the monitoring intensity, $k \in [k_{\min}, k_{\max}]$, $k_{\min} > k_0 > 0$ where k_0 is defined in the Appendix.[3] The assumption that $k \geq k_{\min}$ reflects the

[1] In equilibrium, the manager always exerts high effort and, therefore, a shirking manager does not exist. Nevertheless, analyzing actions taken by a shirking manager is important because shareholders have to design an incentive contract to prevent the manager from shirking.

[2] The assumption that the signal is, on average, unbiased is not crucial for the analysis. The results in this study continue to hold as long as $\Pr(s_l|\lambda_h) \in (0, 1)$ and $\Pr(s_l|\lambda_l) > 0$. One example is a conservative signal in which $\Pr(s_l|\lambda_l) = 1$, $\Pr(s_l|\lambda_h) = c$, and $\Pr(s_h|\lambda_h) = 1 - c$ where c represents the degree of conservatism.

[3] To focus on the effects of monitoring on accounting manipulation, incentive contracting, share-

notion that firms must implement some forms of monitoring to satisfy regulatory requirements. For example, companies must prepare their financial reports under the Generally Accepted Accounting Principles and these reports must be audited by external auditors. In addition, the SEC requires companies to disclose whether their audit committees include at least one financial expert (SEC 2003). Although these requirements are in place, they represent minimum requirements that firms must satisfy, and firms have discretion in implementing a more intense monitoring system, $k > k_{\min}$. As an example, firms can design a stricter internal control system, include more independent members in their boards of directors, or include more financial experts in their audit committees. The focus of this study is on discretionary monitoring. I assume that monitoring is costless but k is jointly determined by the manager and shareholders at t_0.[4] The assumption that both the manager and shareholders can influence monitoring intensity can be motivated by the observation that shareholders do not have full control over a monitoring system, as evidenced by a substantial role of management in appointing directors (Rosenstein and Wyatt 1990). To determine the optimal monitoring system, the manager proposes his preferred monitoring intensity, k_M, while shareholders propose their preferred monitoring system, k_S. The implemented monitoring intensity is $k = \alpha k_M + (1 - \alpha) k_S$ where $\alpha \in (0, 1)$ represents the relative degree of managerial influence over a monitoring system. Once the monitor-

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holder value, and managerial rents, I define monitoring as a mechanism that constrains accounting manipulation activities. Other definitions of monitoring used in prior studies include the ability to identify the manager's ability or type (e.g. Cremer 1995, Hermalin and Weisbach 1998, Laux 2016), the ability to identify the manager's effort level (Huddart 1993), the ability to find a replacement manager (Almazan et al. 2005), and the precision of information (Drymiotes 2007).

[4] In reality, monitoring is likely costly and the cost of monitoring can be another factor that determines optimal monitoring intensity. I abstract away from costly monitoring to focus on the relationship between the relative degree of managerial influence over a monitoring system and the optimal monitoring intensity.

ing system is implemented, it remains in place until t_2, after the accounting system generates the accounting report. This assumption reflects the notion that monitoring technology cannot be changed in the short run. All variables, except project quality, the signal, the manager's effort, and the manipulation level, are publicly observable.

Project Continuation Decisions: At t_2, after the accounting system generates the accounting report, shareholders decide whether to continue or to liquidate the project. If the project is continued, the investment outcome, either R or 0, is realized at t_3. In contrast, if the project is liquidated, it yields a liquidation value of L at t_2 and no investment outcome is realized at t_3. To ensure that accounting information is relevant in deciding whether to continue or to liquidate the project, I assume that $p_h \left(R - \frac{b}{(p_h - p_l) q} \right) > L \geq \Pr(\lambda_h | s_l, p_h) R$. As will become clear later, this assumption implies that shareholders find it optimal to continue the project when $\theta = \theta_h$ and to liquidate it when $\theta = \theta_l$.[5]

Incentive Contracts: Shareholders offer a compensation contract to induce managerial effort. The pay plan takes the form $W = (w(\theta_h), w(\theta_l), w(R), w(0), w(L))$. This pay plan is based on contractible information which includes the accounting report, $\theta \in \{\theta_h, \theta_l\}$, the investment outcome (R or 0), and the liquidation value (L). In equilibrium, the project is liquidated when $\theta = \theta_l$, implying that the manager's pay when the accounting report is low is the same as his pay when the project is liquidated, $w(\theta_l) = w(L)$. Therefore, the optimal pay plan can be simplified to $W = (w(\theta_h), w(\theta_l), w(R), w(0))$. The manager is protected by limited liability such that all payments must be non-negative, $w(\cdot) \geq 0$. Given the project continuation decision described above, if $\theta = \theta_h$, the manager's pay is either $w(\theta_h) + w(R)$ (if the project yields the high outcome) or $w(\theta_h) + w(0)$ (if the project yields the low

[5]The proof of the optimal project continuation decision is provided in the Appendix.

outcome), and if $\theta = \theta_l$, the manager receives $w(\theta_l)$. The shareholders' objective is to maximize shareholder value:

$$V = \Pi - C,$$

where Π is expected return from the investment project and C is expected compensation.

3 Monitoring and Incentive Contracting: Non-Contractible Investment Outcomes

In this section, I show the effects of monitoring on incentive contracting in the benchmark setting in which investment outcomes cannot be used for contracting purposes. The assumption that long-term investment outcomes are not contractible is commonly used in prior literature in earnings management (e.g. Feltham and Xie 1994, Goldman and Slezak 2006, Crocker and Slemrod 2007) and can be motivated by various reasons. For example, investment outcomes may not be realized until far enough in the future such that it is not feasible to offer managerial compensation contracts based on these outcomes. Even when equity compensation is granted, managers may sell their shares prior to the realization of investment outcomes, making these outcomes non-contractible. When the investment outcomes are not contractible, the pay plan is based on the interim accounting report, $\theta \in \{\theta_h, \theta_l\}$. The following proposition describes the characteristics of the optimal incentive contract in this case.

Proposition 1 *When the investment outcomes are not contractible,*
(i) $w(\theta_h) = k\left(1 - \sqrt{1 - \frac{2b}{k(p_h - p_l)(2q-1)}}\right)$ *and* $w(\theta_l) = 0$, *and*
(ii) the manipulation level is $m = \frac{w(\theta_h)}{k}$.

The results in Proposition 1 show the optimal pay plan and the manipulation level when the investment outcomes are not contractible. To maximize the manager's incentive to exert high effort, the contract offers minimum payment to the manager when the interim report is low, $\theta = \theta_l$. Due to the manager's limited liability, it is therefore optimal to offer $w(\theta_l) = 0$ and $w(\theta_h) > 0$.[6] With this optimal pay plan, the manager chooses not to manipulate the report when the signal is high, $s = s_h$, but chooses to distort the information when the signal is low, $s = s_l$. Although the manipulation level is the same regardless of the manager's effort choice, the probability that the manager engages in accounting manipulation activities decreases when the effort level increases.

As monitoring becomes more intense (k increases), it is more costly to manipulate the accounting report. In response, the manager reduces his manipulation incentive, $\frac{dm}{dk} < 0$. This reduction in m makes shirking an unattractive option for the manager because it becomes much harder to obtain the bonus by shirking when manipulation opportunity is limited. Constraining manipulation via monitoring therefore increases the attractiveness of exerting high effort for the manager and reduces the optimal bonus level required to induce managerial effort, $w(\theta_h)$. The following proposition summarizes this result.

Proposition 2 *When the investment outcomes are not contractible, as k increases, the bonus level required to induce the manager to exert high effort and the manipulation level decrease, $\frac{dw(\theta_h)}{dk} < 0$ and $\frac{dm}{dk} < 0$.*

[6] Throughout this paper, I refer to the manager's pay when the accounting report is high or when the project succeeds as a bonus. An alternative interpretation of this form of contract is a stock option plan in which the option is in the money only when the report is high or when the project yields a high outcome.

Given the optimal contract and the manipulation level shown in Proposition 1, expected compensation, C_{no}, can be written as

$$C_{no} = \left(\Pr\left(s_h|p_h\right) + \Pr\left(s_l|p_h\right) m\right) w\left(\theta_h\right), \tag{1}$$

where "*no*" stands for non-contractible outcomes. An increase in k has two effects on expected compensation—a decrease in the bonus level, $\frac{dw(\theta_h)}{dk} < 0$, and a decrease in the likelihood that the manager obtains the bonus due to a lower manipulation level, $\frac{dm}{dk} < 0$. Both effects work in the same direction such that an increase in k leads to a decrease in expected compensation, $\frac{dC_{no}}{dk} < 0$.

Similar to (1), the manager's expected rent (U_{no}) is

$$U_{no} = \Pr\left(s_h|p_h\right) w\left(\theta_h\right) + \Pr\left(s_l|p_h\right)\left(mw\left(\theta_h\right) - 0.5km^2\right) - b. \tag{2}$$

Substituting m and $w\left(\theta_h\right)$ from Proposition 1 into (2) and rearranging the terms, yields

$$U_{no} = w\left(\theta_h\right) - \frac{\Pr\left(s_l|p_l\right) b}{\left(p_h - p_l\right)\left(2q - 1\right)}. \tag{3}$$

Equation (3) shows that the manager's expected rent depends on the bonus level, $w\left(\theta_h\right)$. Since $w\left(\theta_h\right)$ decreases in k, the manager's expected rent also decreases in k. These results can be summarized in the following proposition.

Proposition 3 *When the investment outcomes are not contractible, as k increases,*
(i) expected compensation decreases, $\frac{dC_{no}}{dk} < 0$, and
(ii) managerial rents decrease, $\frac{dU_{no}}{dk} < 0$.

The results in Proposition 3 are consistent with the conventional view that monitoring reduces expected compensation and managerial rents.

4 Monitoring and Incentive Contracting: Contractible Investment Outcomes

I now return to the main assumption outlined in Section 2 that investment outcomes can be used for contracting purposes. When investment outcomes are contractible, the incentive contract consists of $w(\theta_h)$, $w(\theta_l)$, $w(R)$, and $w(0)$. Given that shareholders continue (liquidate) the project when $\theta = \theta_h$ ($\theta = \theta_l$), if $s = s_l$ and the manager does not manipulate the report, his compensation is $w(\theta_l)$. On the other hand, if $s = s_l$ and the manager successfully manipulates the report, he receives not only the payment when the report is high, $w(\theta_h)$, but also the payment based on the investment outcome, either $w(R)$ or $w(0)$. Therefore, expected compensation of the manager who observes s_l and successfully manipulates the report is

$$w(\theta_h) + \Pr(\lambda_h | s_l, p)\, w(R) + \Pr(\lambda_l | s_l, p)\, w(0).$$

Let's presume for now, and I will show later, that the following condition holds:

$$w(\theta_h) + \Pr(\lambda_h | s_l, p)\, w(R) + \Pr(\lambda_l | s_l, p)\, w(0) > w(\theta_l) \text{ for } p \in \{p_h, p_l\}. \tag{4}$$

Condition (4) states that if the manager observes s_l, his expected compensation when he successfully manipulates the report is greater than his payment when he does not manipulate the report, regardless of the effort level. This condition implies that if the manager observes s_h, he will not manipulate the accounting report but if he observes s_l, he will choose the manipulation level, m, that maximizes the following function.

$$U_{co}(s_l) = m\left(w(\theta_h) + \Pr(\lambda_h | s_l, p)\, w(R) + \Pr(\lambda_l | s_l, p)\, w(0)\right) + (1 - m)\, w(\theta_l) - 0.5km^2.$$

The notation "*co*" refers to contractible outcomes.

Using the first-order condition, the manipulation level is

$$m = \frac{w(\theta_h) + \Pr(\lambda_h | s_l, p) w(R) + \Pr(\lambda_l | s_l, p) w(0) - w(\theta_l)}{k}. \tag{5}$$

I show that when $k \geq k_{\min}$, the optimal contract sets $w(R) > 0$ and $w(\theta_h) = w(\theta_l) = w(0) = 0$. The intuition is as follows. To maximize the manager's incentive to choose high effort and to minimize expected compensation, it is optimal to reward the manager only when the outcome is the most informative about managerial effort. Since the investment outcome is directly linked to the manager's effort, it is optimal to reward the manager only when the investment outcome is high, $w(R) > 0$. Setting $w(\theta_h) > 0$ is not optimal because it incentivizes the manager to choose low effort and manipulate the report to obtain the bonus rather than to exert high effort in the first place. Similarly, offering $w(0) > 0$ incentivizes the manager to choose low effort because it is more likely that the project yields the low outcome when he exerts low effort than high effort.

Now consider the manager's pay when $\theta = \theta_l$. By offering $w(\theta_l) > 0$, the manager's incentive to exert high effort is weakened because the manager is more likely to have a low interim report when he chooses low effort than when he chooses high effort. Therefore, setting $w(\theta_l) > 0$ increases the bonus level required to induce high effort, $w(R)$, and increases expected compensation. Nevertheless, as will be shown later in Section 5, offering $w(\theta_l) > 0$ can be useful because it reduces manipulation incentive and thus improves the efficiency of the project continuation decision. However, when $k \geq k_{\min}$, the cost from an increase in the expected compensation outweighs the benefit from the improvement in the project continuation decision efficiency, suggesting that it is not optimal to reward the manager when $\theta = \theta_l$, $w(\theta_l) = 0$.[7]

Substituting $w(\theta_h) = w(\theta_l) = w(0) = 0$ from the optimal contract into (5), we obtain the following manipulation level.

$$m = \frac{\Pr(\lambda_h | s_l, p)\, w(R)}{k}. \tag{6}$$

The following proposition summarizes the optimal contract and the manipulation level when the investment outcomes are contractible.

Proposition 4 *When the investment outcomes are contractible,*
(i) $w(R) = k\left(\frac{-(p_h-p_l)q+\sqrt{(p_h-p_l)^2q^2+\frac{2b(1-q)(p_h\Pr(\lambda_h|s_l,p_h)-p_l\Pr(\lambda_h|s_l,p_l))}{k}}}{(1-q)(p_h\Pr(\lambda_h|s_l,p_h)-p_l\Pr(\lambda_h|s_l,p_l))}\right)$, $w(\theta_h) = w(\theta_l) = w(0) = 0$, *and*
(ii) the manipulation level is $m = \frac{\Pr(\lambda_h|s_l,p)w(R)}{k}$.

Proposition 4 presents an interesting result regarding management's manipulation incentive. Unlike the result in Proposition 1, the manipulation level shown in Proposition 4 not only depends on the bonus, $w(R)$, and the monitoring intensity, k, but also depends on the probability that project quality is high when $s = s_l$, $\Pr(\lambda_h|s_l, p)$. When the investment outcomes are contractible, the manager who observes s_l will obtain the bonus if and only if he successfully manipulates the report *and* possesses a high quality project. Due to the unobservability of the true project quality, the manager updates his belief about the probability that the project will yield the high

[7] To my knowledge, no prior empirical studies document the role of ex ante severance agreements (similar to $w(\theta_l)$ in this model) in reducing manipulation incentives. This lack of empirical evidence is consistent with the argument in Arya et al. (1998) that severance pay is a costly mechanism and is not likely used to reduce manipulation activities. Prior empirical literature shows that firms use ex ante severance agreements to motivate risk taking (Rau and Xu 2013, Rusticus 2006) but corporate governance has no effect on the probability of having a severance agreement (Rusticus 2006).

outcome based on the signal and his effort level. Specifically, when $s = s_l$, the probability that the investment outcome is high is greater when the manager chooses high effort than when he chooses low effort. The implication of this result is that, after observing s_l, a working manager will choose a higher manipulation level than a shirking manager, $m_h > m_l$ where $m_h = \frac{\Pr(\lambda_h|s_l,p_h)w(R)}{k}$ and $m_l = \frac{\Pr(\lambda_h|s_l,p_l)w(R)}{k}$. In other words, when the investment outcomes are contractible, the productive effort and the manipulation incentive are complements, rather than substitutes. As a monitoring system becomes more intense, the manipulation level decreases, and it decreases more quickly for a working manager than for a shirking manager, $\frac{dm_h}{dk} < \frac{dm_l}{dk} < 0$. Note that the manager always works in equilibrium and thus the equilibrium manipulation level is m_h. The following lemma summarizes the results with respect to the manipulation level.

Lemma 1 *When the investment outcomes are contractible, the manipulation level increases in the effort level, $m_h > m_l$. As k increases, the manipulation level decreases, and it decreases more quickly for m_h than m_l, $\frac{dm_h}{dk} < \frac{dm_l}{dk} < 0$.*

It is now useful to discuss the relationship between manipulation, the project continuation decision, and the optimal incentive contract. Recall that when $\theta = \theta_l$, the project is liquidated and the manager receives nothing, $w(\theta_l) = 0$. If it is not possible to manipulate the report, the project is always liquidated when $s = s_l$. Thus, the manager that possesses a high quality project and observes s_l is unintentionally penalized by the inaccuracy of the signal because he would receive the bonus, $w(R)$, if the project were continued. This penalty discourages the manager from choosing high effort because the manager is more likely to have a high quality project when he exerts high effort than when he chooses low effort. Accounting manipulation ensures the continuity of the project and reduces the likelihood of this penalty. Consequently, accounting manipulation makes it more attractive for the manager to supply high productive effort.

In addition, as shown in Lemma 1, the incentive to override the accounting system to control the project continuation decision is stronger for a working manager than for a shirking manager, $m_h > m_l$. As a monitoring system becomes more intense, the manipulation level decreases at a faster rate for m_h than for m_l. This result implies that monitoring reduces the manager's ability to control the project continuation decision, and this effect is stronger when he exerts high effort than when he exerts low effort. Consequently, constraining manipulation via monitoring reduces the attractiveness of working, resulting in an increase in the bonus level required to induce managerial effort. The following proposition summarizes this result.

Proposition 5 *When the investment outcomes are contractible, as k increases, the bonus level required to induce the manager to exert high effort increases,* $\frac{dw(R)}{dk} > 0$.

Proposition 5 presents a counter-intuitive result. Generally, the manager's ability to manipulate the accounting report reduces the informativeness of contractible information with respect to managerial effort because it is difficult to determine whether a favorable performance report is a result of managerial effort or a result of manipulation activities, as shown in Proposition 2. However, I show that, when the investment outcomes can be used for contracting purposes, the manager's opportunity to manipulate the report increases the informativeness of contractible information with respect to managerial effort, resulting in a decrease in the optimal bonus level.

Although constraining accounting manipulation via monitoring increases the level of bonus required to induce managerial effort, its effect on expected compensation is less clear. Similar to (1), expected compensation when the investment outcomes are contractible can be expressed as

$$C_{co} = \left(p_h q + p_h \left(1-q\right) m_h\right) w\left(R\right). \tag{7}$$

An increase in k has two opposing effects on expected compensation. On the one hand, as monitoring becomes more intense, the manipulation level decreases, resulting in a decrease in the probability that the manager receives the bonus (the negative effect). On the other hand, as shown in Proposition 5, an increase in k increases the bonus level (the positive effect). Therefore, the net effect of k on expected compensation is ambiguous.

To better understand the two forces that affect the relationship between monitoring and expected compensation, consider another benchmark case in which manipulation imposes no cost to the manager but the maximum manipulation level is restricted by monitoring, $m = m_0\left(k\right)$ where $\frac{dm_0(k)}{dk} < 0$. In this case, the manipulation incentive is independent of the effort choice as the manager always chooses the manipulation level $m_0\left(k\right)$. With this manipulation incentive, the optimal bonus level is $w\left(R\right) = \frac{b}{(p_h - p_l)(q+(1-q)m_0(k))}$. In addition, expected compensation is

$$C_{m_0(k)} = \left(p_h q + p_h \left(1-q\right) m_0\left(k\right)\right) w\left(R\right) = \frac{p_h b}{\left(p_h - p_l\right)},$$

which does not depend on the monitoring level, $\frac{dC_{m_0(k)}}{dk} = 0$. This implies that, when there is no relationship between manipulation incentive and effort choice, the effects of monitoring in increasing the bonus level and in decreasing the likelihood that the manager obtains the bonus cancel each other out such that monitoring does not affect expected compensation. Similarly, the manager's expected rent is unaffected by a change in monitoring intensity because (i) monitoring does not affect expected compensation and (ii) manipulation is costless. The following lemma summarizes the results in this benchmark case.

Lemma 2 *When the investment outcomes are contractible, manipulation is costless, and the maximum manipulation level is* $m_0(k)$*, expected compensation is* $C_{m_0(k)} = \frac{p_h b}{(p_h - p_l)}$ *and managerial rents are* $U_{m_0(k)} = \frac{p_l b}{(p_h - p_l)}$*. Both expected compensation and managerial rents are independent of the monitoring level,* $\frac{dC_{m_0(k)}}{dk} = 0$ *and* $\frac{dU_{m_0(k)}}{dk} = 0$*.*

Note that the case when $m_0(k) = 1$ is similar to the case in which shareholders make a credible commitment to never liquidate the project where as the case when $m_0(k) = 0$ occurs if manipulation is strictly prohibited. Since expected compensation is the same in these two scenarios, the results in Lemma 2 show that shareholders' ability to commit to always continue the project does not affect expected compensation.

The results in Lemma 2 no longer hold when manipulation incentive depends on the effort level. Specifically, the analysis shows that, holding p_h and q constant, expected compensation decreases in monitoring intensity when p_l is sufficiently low. However, when p_l is sufficiently high, implementing a strong monitoring system increases expected compensation. The intuition is as follows. When p_l is sufficiently high (but still optimal to induce the manager to choose high effort), the agency friction is severe because the manager has a strong incentive to choose low effort. Therefore, the bonus level required to induce high managerial effort, $w(R)$, as well as the difference between m_h and m_l are large, suggesting that manipulation is beneficial to shareholders in reducing expected compensation. This implies that a monitoring system that constrains accounting manipulation increases expected compensation.

In contrast, when p_l is sufficiently low, inducing the manager to exert high effort is relatively easy, resulting in a low level of $w(R)$. Consequently, as k increases, the bonus level marginally increases while the manipulation level significantly decreases, resulting in a decrease in expected compensation.

Using (6) and (7), the manager's expected rent is

$$U_{co} = C_{co} - (1 - \Pr(s_h|p_h)) \left(0.5km_h^2\right) - b. \tag{8}$$

The manager's expected rent is a function of expected compensation, C_{co}, and expected manipulation cost, $0.5km_h^2$. Consider first the effect of monitoring on expected manipulation cost. As k increases, the *marginal* cost of manipulation increases. This, however, does not imply that *expected* manipulation cost will also increase. Holding other things constant, monitoring increases expected manipulation cost. But other things cannot be held constant. Specifically, the manager responds to an increase in k by reducing the manipulation level, resulting in a decrease in expected manipulation cost. To understand the intuition, consider an extreme case when manipulation is prohibitively costly, $k \to \infty$. In this case, the manager will choose not to manipulate the report, $m_h = 0$, suggesting that the manager does not incur any manipulation costs. As k decreases, the manipulation level increases, and so does the expected cost of manipulation incurred by the manager.

Although monitoring always decreases expected manipulation cost, its impact on expected compensation depends on p_l, as described above. When p_l is high, monitoring increases the manager's expected rent because it increases expected compensation and decreases expected manipulation cost. When p_l is low, however, monitoring reduces expected compensation but also reduces expected manipulation cost. Since the manipulation level significantly decreases when k increases and p_l is low, the latter effect always dominates the former such that the manager's expected rent increases in k. Therefore, when the investment outcomes are contractible, the manager's expected rent always increases in the monitoring level. This result is in contrast to the conventional argument that monitoring limits managerial rents. The following proposition summarizes the relationships between monitoring, expected compensation, and managerial rents when the investment outcomes can be used for contracting purposes.

Proposition 6 *When the investment outcomes are contractible, as k increases,*
(i) managerial rents increase, $\frac{dU_{co}}{dk} > 0$, and
(ii) holding p_h and q constant, if $p_l < p_l^*$, expected compensation decreases in k, $\frac{dC_{co}}{dk} \leq 0$, and if $p_l \geq p_l^*$, expected compensation increases in k, $\frac{dC_{co}}{dk} \geq 0$.

The threshold p_l^* is shown in the Appendix.

The results in Proposition 6 show that when the investment outcomes are contractible, monitoring always increases managerial rents but can increase or decrease expected compensation. It is important to note that the results that monitoring affects expected compensation and managerial rents crucially rely on two inputs—the project continuation decision and the interaction between manipulation incentive and productive effort ($m_h > m_l$). Without the project continuation decision, the project is always continued and the manager has no incentive to manipulate the accounting report. Therefore, monitoring will have no impact on expected compensation and managerial rents. Similarly, when manipulation incentive does not depend on the manager's effort choice, there is no association between (i) monitoring and expected compensation or (ii) monitoring and managerial rents, as shown in Lemma 2.

5 Monitoring and Investment Efficiency

Monitoring not only influences incentive contracting but also affects investment efficiency. Since $L \geq \Pr(\lambda_h|s_l, p_h) R$, by assumption, it is first-best optimal to liquidate the project when $s = s_l$. In addition, the assumption that $p_h \left(R - \frac{b}{(p_h - p_l)q}\right) > L$ implies that it is first-best optimal to continue the project when $s = s_h$. Given that shareholders find it optimal to continue the project when $\theta = \theta_h$ and to liquidate it when $\theta = \theta_l$, if the manager does not manipulate the report, the first-best project continuation decision is achieved as the project is always continued when $s = s_h$ and is always liquidated when $s = s_l$. Accounting manipulation distorts the information contained in the accounting report and thus distorts investment efficiency. As shown in Section 3 and Section 4, the manager has an incentive to engage in manipulation activities when $s = s_l$ but does not manipulate the report when $s = s_h$. Consequently, investment inefficiency arises when $s = s_l$ and the manager successfully manipulates the accounting report. Using this argument, the project's expected return, Π, can be expressed as follows:

$$\Pi = p_h q R + \Pr(s_l|p_h) L - \Pr(s_l|p_h) m (L - \Pr(\lambda_h|s_l, p_h) R). \tag{9}$$

The first part of (9), $p_h q R + \Pr(s_l|p_h) L$, is the project's expected return when the project is continued if and only if $s = s_h$ (the first-best expected return). The second part of (9), $\Pr(s_l|p_h) m (L - \Pr(\lambda_h|s_l, p_h) R)$, is the expected cost of investment inefficiency, where $\Pr(s_l|p_h)$ is the probability that $s = s_l$, m is the manipulation level, and $(L - \Pr(\lambda_h|s_l, p_h) R)$ is the opportunity cost of continuing a project that should have been liquidated.

As monitoring becomes more intense, the manipulation level decreases, and the probability that shareholders make the inefficient project continuation decision reduces. The impact of monitoring on the overall reduction in expected cost of investment inefficiency depends on the opportunity cost of inefficient project continuation decisions, $(L - \Pr(\lambda_h | s_l, p_h) R)$. Specifically, the opportunity cost of making inefficient project continuation decisions increases in L. Consider an extreme case when L is very low, $L = \lim_{\varepsilon \to 0^+} (\Pr(\lambda_h | s_l, p_h) R + \varepsilon)$. In this case, the opportunity cost of continuing a project that should have been liquidated is very low and therefore constraining manipulation via monitoring improves the project's expected return only by a small margin. As L increases, the opportunity cost of making the incorrect project continuation decision increases. Consequently, a monitoring system that constrains manipulation activities has a larger impact on the overall investment efficiency when L is high than when L is low. The following proposition summarizes the results in this section.

Proposition 7 *As k increases, investment efficiency and the project's expected return increase, $\frac{d\Pi}{dk} > 0$. This effect is stronger when the opportunity cost of making inefficient project continuation decisions increases, $\frac{d^2\Pi}{dLdk} > 0$.*

6 Optimal Monitoring System

Having analyzed the effects of monitoring on optimal incentive contracts and investment efficiency, in this section, I derive the optimal monitoring system and show the effect of the relative power in influencing a monitoring system between managers and shareholders on optimal monitoring intensity.

When the investment outcomes are not contractible, monitoring increases shareholder value because it reduces expected compensation (Proposition 3) as well as increases investment efficiency (Proposition 7). Therefore, shareholders, who wish to maximize shareholder value, prefer an intense monitoring system, $k_S = k_{\max}$. In contrast, the manager, who wishes to maximize his rents, prefers a weak monitoring system, $k_M = k_{\min}$, because monitoring decreases his expected rent (Proposition 3). Since the manager and shareholders prefer a different monitoring system, the implemented monitoring intensity is

$$k_{no}^* = \alpha k_{\min} + (1 - \alpha)\, k_{\max}.$$

As the degree of managerial influence over a monitoring system, α, increases, the level of monitoring declines. This result is consistent with the conventional view that managerial power in influencing a monitoring system is negatively associated with monitoring intensity. The following proposition summarizes this result.

Proposition 8 *When the investment outcomes are not contractible, the implemented monitoring system is* $k_{no}^* = \alpha k_{\min} + (1 - \alpha)\, k_{\max}$. *This monitoring intensity decreases in the degree of managerial influence over a monitoring system,* $\frac{dk_{no}^*}{d\alpha} < 0$.

When shareholders can use the investment outcomes for contracting purposes, however, these results no longer hold. The results in Proposition 6 show that the manager's expected rent increases in monitoring intensity. Consequently, the manager always prefers an intense monitoring system, $k_M = k_{\max}$. Shareholders may agree or disagree with the manager regarding the monitoring technology. When p_l is sufficiently low, an increase in k not only reduces expected compensation (Proposition 6) but also increases investment efficiency (Proposition 7), resulting in an increase in shareholder value. Therefore, when p_l is sufficiently low, shareholders also prefer an intense monitoring system, $k_S = k_{\max}$. Since both the manager and shareholders prefer intense monitoring, $k_{\max}$ is implemented and the relative power between the manager and shareholders have no impact on the optimal monitoring system.

When p_l is sufficiently high, monitoring increases both investment efficiency and expected compensation. The net effect of monitoring on shareholder value depends on the strength of these two forces. When L is high, the former effect dominates the latter such that monitoring increases shareholder value. Thus, when both p_l and L are high, shareholders prefer intense monitoring, $k_S = k_{\max}$, which is consistent with the manager's preference. As a result, the implemented monitoring is $k_{\max}$. Note that in this case, shareholders prefer intense monitoring although monitoring increases expected compensation. Thus, a positive association between monitoring and expected compensation does not necessarily imply that shareholders prefer a weak monitoring system.

Finally, when p_l is sufficiently high and L is low, the effect of monitoring in increasing expected compensation dominates its effect in improving investment efficiency such that monitoring reduces shareholder value. Therefore, shareholders prefer weak monitoring while the manager prefers intense monitoring. The implemented monitoring is $k^*_{co} = \alpha k_{\max} + (1-\alpha)\, k_{\min}$, implying that managerial power in influencing a monitoring system is positively associated with monitoring intensity, $\frac{dk^*_{co}}{d\alpha} = k_{\max} - k_{\min} > 0$. These results are in sharp contrast to the conventional argument that monitoring benefits shareholders and imposes costs on managers. Instead, these results show that when both managers and shareholders can influence a monitoring system, managers will attempt to implement a strong system while shareholders will try to weaken it. These results can be summarized as follows.

Proposition 9 *When the investment outcomes are contractible,*

(i) if $p_l < p^*_l$, the implemented monitoring technology is $k^*_{co} = k_{\max}$,

(ii) if $p_l \geq p_l^*$ *and* $L \geq L^*$*, the implemented monitoring technology is* $k_{co}^* = k_{\max}$*, and*

(iii) if $p_l \geq p_l^*$ *and* $L < L^*$*, the implemented monitoring technology is* $k_{co}^* = \alpha k_{\max} + (1-\alpha) k_{\min}$*, and this monitoring intensity increases in the degree of managerial influence over a monitoring system,* $\frac{dk_{co}^*}{d\alpha} > 0$*.*

The threshold L^* is defined in the Appendix.

The results in part (i) and (ii) of Proposition 9 show that monitoring can increase shareholder value and managerial rents simultaneously. The intuition behind this result is that monitoring reduces the deadweight loss associated with expected manipulation cost incurred by the manager as well as the cost of inefficient investment decisions. Therefore, when the gain from the reduction in this deadweight loss is shared between shareholders and managers, both shareholders and managers are better off with increased monitoring. However, in part (iii) of Proposition 9, monitoring improves managerial welfare at the expense of shareholders because the effect of monitoring in increasing the cost of incentive contracting outweighs its effect in reducing the cost of inefficient investment decisions.

To sum up, the results in this section show that as the manager has more power to influence the monitoring system, the monitoring level can increase, decrease, or remain unchanged. In addition, shareholders may find it optimal to implement a monitoring system that results in a high level of expected compensation, a high level of managerial rents, or a high level of accounting manipulation. In a similar vein, the manager may prefer a strong monitoring system even when monitoring is negatively associated with expected compensation because monitoring reduces the expected cost of manipulation.

7 Empirical Implications

In this paper, I define monitoring as a mechanism that increases the marginal cost of manipulation and thus constrains manipulation activities. Although the model focuses on financial reporting processes in which managers manipulate information in financial statements, it is important to note that the implication of the results in this study can be extended to other settings. For example, one can think of a managerial accounting setting in which a regional manager works on a project and is required to submit interim performance reports to the headquarter while the headquarter can terminate the project. That being said, testing empirical predictions using managerial accounting data can be challenging due to data availability. Therefore, the emphasis on this empirical implication section is on financial accounting.

I discuss the empirical implication of the analysis by focusing on two monitoring mechanisms—internal controls and boards of directors. These two mechanisms are appropriate proxies for monitoring in this setting because prior empirical studies have shown that both internal controls and boards of directors reduce manipulation activities. For example, Doyle et al. (2007) document a positive association between internal control weaknesses and estimated accruals that are not realized as cash flows. In addition, Ashbaugh-Skaife et al. (2008) show that firms with internal control deficiencies have lower quality accruals than firms with no internal control deficiencies. Similarly, prior studies show that board independence, audit committee independence, and audit committee financial expertise are negatively associated with abnormal accruals (Klein 2002, Peasnell et al. 2005, Xie et al. 2003) and restatements (Abbott et al. 2004, Agrawal and Chadha 2005, Carcello et al. 2011).

The analysis in Section 5 shows the relationship between monitoring and investment efficiency. Specifically, the result in Proposition 7 suggests that monitoring intensity is positively associated with investment efficiency. Prior empirical studies document evidence consistent with this result. Cheng et al. (2013) show that firms with material weaknesses in internal controls have less efficient investment and that this effect is mitigated when firms remediate control weaknesses. Similarly, Feng et al. (2015) show that material weaknesses in internal control over financial reporting are negatively associated with return on assets.

The results in this study also show the relationships between monitoring and expected compensation. When the investment outcomes are not contractible or when they are contractible and the agency friction is not severe (p_l is low), monitoring reduces expected compensation. However, when the investment outcomes are contractible and the agency friction is severe (p_l is high), monitoring increases expected compensation. The result that monitoring can be positively or negatively associated with expected compensation is consistent with mixed findings documented in prior empirical studies. For example, Chhaochharia and Grinstein (2009) show a negative association between monitoring and expected compensation by documenting a decrease in CEO compensation following the implementation of rules requiring independent boards. However, Hoitash et al. (2012) show that CFO compensation decreases in internal control material weaknesses, suggesting a positive association between monitoring and compensation. In addition, Core et al. (1999) show the positive relation between CEO compensation and a percentage of the board composed of outside directors.

A similar argument can be made with respect to the relationships between monitoring and firm value. The results in Proposition 3, Proposition 6, and Proposition 7 predict that monitoring decreases firm value when the investment outcomes are contractible, the agency friction is severe, and the cost of inefficient project continuation decisions is low. For all other firms, monitoring increases firm value. This ambiguous effect of monitoring on firm value is also consistent with mixed empirical evidence shown in prior studies. For example, Bhagat and Black (2002) find no association between the degree of board independence and firm value. In contrast, relying on the argument that small boards are better at monitoring than large boards, Yermack (1996) shows a negative association between board size and firm value. DeFond et al. (2005) examine market reactions after firms appoint financial experts to their audit committees and show that the appointment of accounting financial experts assigned to audit committees has a positive impact on market reactions.

Finally, the results in this study have implications for the relation between manipulation levels and pay-performance sensitivity (PPS). Specifically, both the PPS (measured here with the bonus level, $w(\theta_h)$ or $w(R)$) and the manipulation level are determined by monitoring intensity, k. Furthermore, these two variables affect each other as the PPS affects the manipulation incentive which, in turn, affects the optimal PPS. When the investment outcomes are not contractible, I show that monitoring decreases both the PPS and manipulation incentive (Proposition 1), suggesting a positive relation between these two variables. In contrast, when the investment outcomes are contractible, monitoring increases the PPS but decreases manipulation incentive (Proposition 5), suggesting a negative relation between the PPS and the manipulation level. Therefore, the analysis in this study shows that the relation between manipulation levels and PPS can be positive or negative, as summarized in the following Corollary.

Corollary 1 *When the investment outcomes are not contractible (are contractible), the relation between manipulation levels and pay-performance sensitivity is positive (negative).*

8 Conclusion

This study shows an unintended consequence of constraining manipulation via monitoring on shareholder value and managerial rents. Contrary to the notion that shareholders are better off and managers are worse off with increased monitoring, this study shows that constraining manipulation via monitoring can reduce shareholder value and increase managerial rents because monitoring can make it harder to induce managerial effort. This result follows because managers have incentives to manipulate accounting information to convince shareholders to continue the project, and these manipulation incentives are stronger when managers exert high productive effort than when they choose low productive effort. Allowing manipulation therefore makes it more attractive for managers to supply high productive effort because the likelihood of obtaining a bonus significantly increases. This result suggests that restricting manipulation via monitoring can increase the cost of incentive contracting. In addition, the analysis shows that an increase in monitoring intensity can be Pareto-optimal, as both shareholders and managers benefit from increased monitoring.

The results of this study suggest many implications that contrast with conventional wisdom. For example, shareholders may prefer a weak monitoring system that leads to a high level of accounting manipulation. Additionally, shareholders may optimally implement a monitoring system that results in a high level of expected compensation and managerial rents. In the same vein, managers may be better off in a monitoring environment where expected compensation is low. Finally, as managerial power over a monitoring system increases, optimal monitoring intensity can remain unaffected or increase rather than decrease.

This study can be extended in several ways. As an example, in this study, the accuracy of information is exogenously given and is publicly observed. Future studies can endogenize this variable or consider cases in which this information is privately observed by the manager or shareholders. Another extension would be to examine multiple roles of monitoring in an organization. In order to focus on the effect of monitoring on accounting information, this study examines one role of monitoring—to constrain accounting manipulation activities. Future research could analyze other roles of monitoring, including learning about project quality or managerial effort, and examine the interaction across various roles.

Appendix

Proof that shareholders find it optimal to continue (to liquidate) the project when $\theta = \theta_h$ ($\theta = \theta_l$).

When the investment outcomes are not contractible:

The optimal contract sets $w(\theta_h) > 0$ and $w(\theta_l) = 0$.

Suppose $\theta = \theta_l$. Expected shareholder value if the project is continued is $\Pr(\lambda_h | s_l, p_h) R - w(\theta_l) = \Pr(\lambda_h | s_l, p_h) R$. If the project is liquidated, expected shareholder value is $L - w(\theta_l) = L$. Therefore, it is optimal to liquidate the project because $L \geq \Pr(\lambda_h | s_l, p_h) R$, by assumption.

Suppose $\theta = \theta_h$. Expected shareholder value if the project is continued is

$$\begin{aligned}
& \left(\frac{p_h q + p_h (1-q) m}{p_h q + (1-p_h)(1-q) + (p_h (1-q) + (1-p_h) q) m} \right) R - w(\theta_h) \\
\geq & \left(\frac{p_h q + p_h (1-q)}{p_h q + (1-p_h)(1-q) + (p_h (1-q) + (1-p_h) q)} \right) R - w(\theta_h) \\
= & \; p_h R - w(\theta_h).
\end{aligned}$$

If the project is liquidated, expected shareholder value is $L - w(\theta_h)$. Therefore, it is optimal to continue the project because the assumption $p_h \left(R - \frac{b}{(p_h - p_l) q} \right) > L$ implies $p_h R > L$.

When the investment outcomes are contractible:

The optimal contract sets $w(R) > 0$ and $w(\theta_h) = w(\theta_l) = w(0) = 0$.

Suppose $\theta = \theta_l$. Expected shareholder value if the project is continued is $\Pr(\lambda_h | s_l, p_h)(R - w(R))$. If the project is liquidated, expected shareholder value is $L - w(\theta_l) = L$. Therefore, it is optimal to liquidate the project because the assumption $L \geq \Pr(\lambda_h | s_l, p_h) R$ implies $L > \Pr(\lambda_h | s_l, p_h)(R - w(R))$.

Suppose $\theta = \theta_h$. Expected shareholder value if the project is continued is

$$\begin{aligned}
& \left(\frac{p_h q + p_h (1-q) m_h}{p_h q + (1-p_h)(1-q) + (p_h (1-q) + (1-p_h) q) m_h}\right)(R - w(R)) \\
\geq & \left(\frac{p_h q + p_h (1-q)}{p_h q + (1-p_h)(1-q) + (p_h (1-q) + (1-p_h) q)}\right)(R - w(R)) \\
= & \; p_h (R - w(R)) \\
> & \; p_h \left(R - \lim_{k \to k_{\max}} w(R)\right) \\
> & \; p_h \left(R - \lim_{k \to \infty} w(R)\right),
\end{aligned}$$

because $\frac{dw(R)}{dk} > 0$ (Proposition 5) and $k_{\max} < \infty$.

Using $w(R) = \frac{b + \Pr(s_l|p_l)\left(0.5km_l^2\right) - \Pr(s_l|p_h)\left(0.5km_h^2\right)}{(p_h - p_l)q}$ in (18), it follows that $\lim_{k\to\infty} w(R) = \frac{b}{(p_h - p_l)q}$. If the project is liquidated, expected shareholder value is $L - w(\theta_l) = L$. Therefore, it is optimal to continue the project because $p_h\left(R - \frac{b}{(p_h - p_l)q}\right) > L$, by assumption.■

Proof of Proposition 1

Suppose $w(\theta_h) > w(\theta_l)$. If the manager observes s_h, he does not manipulate the report and obtains $w(\theta_h)$. If he observes s_l, he chooses the manipulation level, m, that maximizes the following utility function.

$$U_{no}(s_l) = mw(\theta_h) + (1-m) w(\theta_l) - 0.5km^2. \tag{10}$$

Taking the first-order condition of (10), yields

$$m = \frac{w(\theta_h) - w(\theta_l)}{k}. \tag{11}$$

Using (10) and (11), the incentive compatibility constraint is

$$\left(\Pr\left(s_h|p_h\right) - \Pr\left(s_h|p_l\right)\right)\left(w\left(\theta_h\right) - w\left(\theta_l\right) - 0.5km^2\right) \geq b. \tag{12}$$

Substituting (11) into (12) and solving the inequality, we obtain

$$w\left(\theta_h\right) - w\left(\theta_l\right) \geq k\left(1 - \sqrt{1 - \frac{2b}{k\left(p_h - p_l\right)\left(2q-1\right)}}\right).$$

Thus, the optimal contract is as follows.

$$\begin{aligned} w\left(\theta_h\right) &= k\left(1 - \sqrt{1 - \frac{2b}{k\left(p_h - p_l\right)\left(2q-1\right)}}\right) \\ w\left(\theta_l\right) &= 0. \end{aligned} \tag{13}$$

Using (11) and (13), the manipulation level is

$$m = \left(1 - \sqrt{1 - \frac{2b}{k\left(p_h - p_l\right)\left(2q-1\right)}}\right). \blacksquare \tag{14}$$

Proof of Proposition 2

Using (12) and (11), $w\left(\theta_h\right)$ can be expressed as follows.

$$w\left(\theta_h\right) = \frac{\frac{b}{\left(p_h - p_l\right)\left(2q-1\right)} - 0.5km^2}{\left(1-m\right)}. \tag{15}$$

Taking the first order condition of $w\left(\theta_h\right)$ in (15) with respect to k, yields

$$\begin{aligned} \frac{dw\left(\theta_h\right)}{dk} &= -\frac{0.5m^2}{1-m} + \frac{dm}{dk} \cdot \left(\frac{-\left(1-m\right)km + w\left(\theta_h\right)\left(1-m\right)}{\left(1-m\right)^2}\right) \\ &= -\frac{0.5m^2}{1-m} < 0. \end{aligned}$$

In addition, using (11), we obtain

$$\frac{dm}{dk} = \frac{\frac{dw(\theta_h)}{dk} - m}{k} < 0$$

because $\frac{dw(\theta_h)}{dk} < 0$, as just established.■

Proof of Proposition 3

Using (1), we obtain

$$\begin{aligned}
\frac{dC_{no}}{dk} &= \left(\Pr\left(s_h|p_h\right) + \Pr\left(s_l|p_h\right) m\right) \frac{dw\left(\theta_h\right)}{dk} + \Pr\left(s_l|p_h\right) w\left(\theta_h\right) \frac{dm}{dk} \\
&< 0 \text{ because } \frac{dw\left(\theta_h\right)}{dk} < 0 \text{ and } \frac{dm}{dk} < 0.
\end{aligned}$$

In addition, using (2), we obtain

$$\begin{aligned}
\frac{dU_{no}}{dk} &= \Pr\left(s_h|p_h\right) \frac{dw\left(\theta_h\right)}{dk} + \frac{\Pr\left(s_l|p_h\right)}{2} \left(2km\frac{dm}{dk} + m^2\right) \\
&= \left(\Pr\left(s_h|p_h\right) + \Pr\left(s_l|p_h\right) m\right) \frac{dw\left(\theta_h\right)}{dk} - \frac{\Pr\left(s_l|p_h\right) m^2}{2} \\
&< 0 \text{ because } \frac{dw\left(\theta_h\right)}{dk} < 0.■
\end{aligned}$$

Proof of Proposition 4

The Lagrangian of the shareholders' optimization problem is as follows:

$$\begin{aligned}
\max G &= p_h qR + \Pr(s_l|p_h)\left(m_h \Pr(\lambda_h|s_l,p_h) R + (1-m_h) L\right) - p_h q\left(w(\theta_h) + w(R)\right) \\
&\quad - (1-p_h)(1-q)\left(w(\theta_h)+w(0)\right) - \Pr(s_l|p_h)\left(w(\theta_l) + km_h^2\right) \\
&\quad +\mu_1\left(q\left(w(\theta_h)+w(R)\right) - (1-q)\left(w(\theta_h)+w(0)\right) - \frac{b}{(p_h-p_l)}\right) \\
&\quad +\mu_1\frac{\Pr(s_l|p_h)\left(w(\theta_l)+0.5km_h^2\right)}{(p_h-p_l)} - \mu_1\frac{\Pr(s_l|p_h)\left(w(\theta_l)+0.5km_l^2\right)}{(p_h-p_l)} \\
&\quad +\mu_2\left(\left(w(\theta_h) + \Pr(\lambda_h|s_l,p_h) w(R) + \Pr(\lambda_l|s_l,p_h) w(0)\right) - w(\theta_l) - m_h k\right) \\
&\quad +\mu_3\left(\left(w(\theta_h) + \Pr(\lambda_h|s_l,p_l) w(R) + \Pr(\lambda_l|s_l,p_l) w(0)\right) - w(\theta_l) - m_l k\right)
\end{aligned}$$

where μ_1 is the Lagrangian multiplier associated with the effort incentive constraint, μ_2 is the multiplier associated with the manipulation constraint when the manager exerts high effort, and μ_3 is the multiplier associated with the manipulation constraint when the manager exerts low effort.

The necessary conditions for a solution include: $\frac{\partial G}{\partial w(i)} w(i) = 0$ for $i \in \{\theta_h, \theta_l, R, 0\}$, and $\frac{\partial G}{\partial m_j} m_j = 0$ for $j \in \{h, l\}$.

Assume that in the optimal solution, $w(R) > 0$ and $w(\theta_l) = 0$. This implies that $m_h > 0$ and $m_l > 0$. Therefore, the optimal solution is determined by $\frac{\partial G}{\partial w(R)} = \frac{\partial G}{\partial m_h} = \frac{\partial G}{\partial m_l} = 0$. Let μ_1^*, μ_2^*, and μ_3^* be the solution to $\frac{\partial G}{\partial w(R)} = \frac{\partial G}{\partial m_h} = \frac{\partial G}{\partial m_l} = 0$, we obtain

$$\begin{aligned}
\mu_1^* &= \frac{k(p_h-p_l)\left(p_h q + 2p_h(1-q) m_h\right) - (p_h-p_l) p_h (1-q)\left(\Pr(\lambda_h|s_l,p_h) R - L\right)}{kY} \\
\mu_2^* &= \frac{\Pr(s_l|p_h)\left(\Pr(\lambda_h|s_l,p_h) R - L\right)}{k} - 2\Pr(s_l|p_h) m_h + \mu_1^*\frac{\Pr(s_l|p_h) m_h}{(p_h-p_l)} \\
\mu_3 &= -\mu_1^*\frac{\Pr(s_l|p_l) m_l}{(p_h-p_l)},
\end{aligned}$$

where $Y \equiv q(p_h - p_l) + p_h(1-q)m_h - p_l(1-q)m_l$. Using μ_1^*, μ_2^*, μ_3^*, (6), and $w(\theta_l) = 0$, it can be shown that $\frac{\partial G}{\partial w(0)} = \frac{\partial G}{\partial w(\theta_h)} < 0$, implying that $w(0) = 0$ and $w(\theta_h) = 0$.

In addition, it can be shown that $\frac{d}{dk}\left(\frac{\partial G}{\partial w(\theta_l)}\right) < 0$ and $\lim_{k\to\infty} \frac{\partial G}{\partial w(\theta_l)} = -q < 0$, suggesting that there exists k_0 such that when $k \geq k_0$, the optimal contract sets $w(\theta_l) = 0$.

Given that $w(R) > 0$ and $w(\theta_h) = w(\theta_l) = w(0) = 0$, the incentive compatibility constraint can be written as follows.

$$p_h q w(R) + \Pr(s_l|p_h)\left(0.5k(m_h)^2\right) - b \geq p_l q w(R) + \Pr(s_l|p_l)\left(0.5k(m_l)^2\right). \tag{16}$$

Substituting (6) into (16) and solving the inequality, we obtain

$$w(R) \geq k\left(\frac{-(p_h - p_l)q + \sqrt{(p_h - p_l)^2 q^2 + \frac{2b(1-q)(p_h \Pr(\lambda_h|s_l,p_h) - p_l \Pr(\lambda_h|s_l,p_l))}{k}}}{(1-q)(p_h \Pr(\lambda_h|s_l,p_h) - p_l \Pr(\lambda_h|s_l,p_l))}\right).$$

Therefore, the optimal bonus level is

$$w(R) = k\left(\frac{-(p_h - p_l)q + \sqrt{(p_h - p_l)^2 q^2 + \frac{2b(1-q)(p_h \Pr(\lambda_h|s_l,p_h) - p_l \Pr(\lambda_h|s_l,p_l))}{k}}}{(1-q)(p_h \Pr(\lambda_h|s_l,p_h) - p_l \Pr(\lambda_h|s_l,p_l))}\right),$$

and the manipulation level is

$$m_h = \frac{\Pr(\lambda_h|s_l,p_h)\, w(R)}{k}. \blacksquare \tag{17}$$

Proof of Lemma 1

Using (6), the manipulation level is

$$m = \frac{\Pr\left(\lambda_h | s_l, p\right) w\left(R\right)}{k}.$$

Since $\Pr\left(\lambda_h | s_l, p_h\right) > \Pr\left(\lambda_h | s_l, p_l\right)$, it follows that $m_h > m_l$.

Using (16), $w\left(R\right)$ can be expressed as follows.

$$w\left(R\right) = \frac{b + \Pr\left(s_l | p_l\right)\left(0.5k\left(m_l\right)^2\right) - \Pr\left(s_l | p_h\right)\left(0.5k\left(m_h\right)^2\right)}{\left(p_h - p_l\right) q}. \tag{18}$$

Using (18), we obtain

$$\frac{dw\left(R\right)}{dk} = \frac{\Pr\left(s_l | p_l\right)\left(\frac{1}{2}\left(2km_l\frac{dm_l}{dk} + m_l^2\right)\right) - \Pr\left(s_l | p_h\right)\left(\frac{1}{2}\left(2km_h\frac{dm_h}{dk} + m_h^2\right)\right)}{\left(p_h - p_l\right) q}. \tag{19}$$

Substituting $\frac{dm_l}{dk} = \frac{\Pr(\lambda_h | s_l, p_l)\frac{dw(R)}{dk} - m_l}{k}$ and $\frac{dm_h}{dk} = \frac{\Pr(\lambda_h | s_l, p_h)\frac{dw(R)}{dk} - m_h}{k}$ into (19) and solving for $\frac{dw(R)}{dk}$, yields

$$\frac{dw\left(R\right)}{dk} = \frac{\Pr\left(s_l | p_h\right)\frac{m_h^2}{2} - \Pr\left(s_l | p_l\right)\frac{m_l^2}{2}}{\left(p_h - p_l\right) q + p_h\left(1 - q\right) m_h - p_l\left(1 - q\right) m_l}. \tag{20}$$

Using (6), we obtain

$$\frac{dm_h}{dk} = \frac{\Pr\left(\lambda_h | s_l, p_h\right)\frac{dw(R)}{dk} - m_h}{k}. \tag{21}$$

Substituting $\frac{dw(R)}{dk}$ from (20) into (21), yields

$$\begin{aligned} \frac{dm_h}{dk} &= \frac{1}{k}\left(\frac{-p_h(1-q)\frac{m_h^2}{2}+p_l(1-q)\frac{m_l m_h}{2}-(p_h-p_l)qm_h}{(p_h-p_l)q+p_h(1-q)m_h-p_l(1-q)m_l}\right) \\ &= \frac{1}{k}\left(\frac{-\frac{(1-q)m_h}{2}(p_h m_h-p_l m_l)-(p_h-p_l)qm_h}{(p_h-p_l)q+p_h(1-q)m_h-p_l(1-q)m_l}\right)<0. \end{aligned} \tag{22}$$

Similarly, using (6), we obtain

$$\frac{dm_l}{dk}=\frac{\Pr(\lambda_h|s_l,p_l)\frac{dw(R)}{dk}-m_l}{k}. \tag{23}$$

Substituting $\frac{dw(R)}{dk}$ from (20) into (23), yields

$$\begin{aligned} \frac{dm_l}{dk} &= \frac{1}{k}\left(\frac{-p_h(1-q)\frac{m_h m_l}{2}+p_l(1-q)\frac{m_l^2}{2}-(p_h-p_l)qm_h}{(p_h-p_l)q+p_h(1-q)m_h-p_l(1-q)m_l}\right) \\ &= \frac{1}{k}\left(\frac{-\frac{(1-q)m_l}{2}(p_h m_h-p_l m_l)-(p_h-p_l)qm_l}{(p_h-p_l)q+p_h(1-q)m_h-p_l(1-q)m_l}\right)<0. \end{aligned} \tag{24}$$

In addition, using (22) and (24), it follows that $\frac{dm_h}{dk}<\frac{dm_l}{dk}$ because $m_h>m_l$.■

Proof of Proposition 5

Substituting $m_h=\frac{\Pr(\lambda_h|s_l,p_h)w(R)}{k}$ and $m_l=\frac{\Pr(\lambda_h|s_l,p_l)w(R)}{k}$ into (20), yields

$$\frac{dw(R)}{dk}=\frac{(p_h m_h-p_l m_l)(1-q)w(R)}{2k((p_h-p_l)q+p_h(1-q)m_h-p_l(1-q)m_l)},$$

which is positive because $m_h>m_l$ (Lemma 1).■

Proof of Lemma 2

Suppose $w(R)>0$ and $w(\theta_h)=w(\theta_l)=w(0)=0$. The incentive compatibility constraint is

$$\left(p_h q + p_h \left(1-q\right) m_0\left(k\right)\right) w\left(R\right) - b \geq \left(p_l q + p_l \left(1-q\right) m_0\left(k\right)\right) w\left(R\right). \tag{25}$$

Solving (25), we obtain

$$w\left(R\right) = \frac{b}{\left(p_h - p_l\right)\left(q + \left(1-q\right) m_0\left(k\right)\right)}.$$

Expected compensation is

$$C_{m_0(k)} = \left(p_h q + p_h \left(1-q\right) m_0\left(k\right)\right) w\left(R\right) = \frac{p_h b}{\left(p_h - p_l\right)},$$

and the manager's expected rent is

$$U_{m_0(k)} = C_{m_0(k)} - b = \frac{p_l b}{\left(p_h - p_l\right)}.$$

In addition, $\frac{dC_{m_0(k)}}{dk} = 0$ and $\frac{dU_{m_0(k)}}{dk} = 0.$■

Proof of Proposition 6

Using (7), we obtain

$$\begin{aligned} \frac{dC_{co}}{dk} &= \left(p_h q + p_h \left(1-q\right) m_h\right) \frac{dw\left(R\right)}{dk} + p_h \left(1-q\right) w\left(R\right) \frac{dm_h}{dk} \\ &= \left(p_h q + 2p_h \left(1-q\right) m_h\right) \frac{dw\left(R\right)}{dk} - \Pr\left(s_l | p_h\right) m_h^2. \end{aligned} \tag{26}$$

Substituting $\frac{dw(R)}{dk}$ from (20) into (26) and rearranging the terms, yields

$$\begin{aligned}\frac{dC_{co}}{dk} &= \frac{\Pr(s_l|p_h)\, m_h q \left(\frac{p_l(m_h-m_l)}{2} - \frac{(p_h-p_l)m_h}{2}\right)}{(p_h-p_l)\, q + p_h(1-q)\, m_h - p_l(1-q)\, m_l} \\ &= \frac{\Pr(s_l|p_h)\, m_h q \left(\frac{(p_h-p_l)(1-q)(2p_h p_l q + p_l q - p_h p_l - p_h q) w(R)}{2k \Pr(s_l|p_h) \Pr(s_l|p_l)}\right)}{(p_h-p_l)\, q + p_h(1-q)\, m_h - p_l(1-q)\, m_l}.\end{aligned}$$

Define $p_l^* \equiv \frac{p_h q}{p_h(2q-1)+q}$. When $p_l \geq p_l^*$, $(2p_h p_l q + p_l q - p_h p_l - p_h q) \geq 0$, and $\frac{dC_{co}}{dk} \geq 0$. In contrast, when $p_l < p_l^*$, $(2p_h p_l q + p_l q - p_h p_l - p_h q) < 0$, and $\frac{dC_{co}}{dk} < 0$.

Using (8), we obtain

$$\begin{aligned}\frac{dU_{co}}{dk} &= p_h q \frac{dw(R)}{dk} + \Pr(s_l|p_h)\left(m_h \Pr(\lambda_h|s_l, p_h)\frac{dw(R)}{dk} - \frac{m_h^2}{2}\right) \\ &= (p_h q + p_h(1-q)\, m_h)\frac{dw(R)}{dk} - \Pr(s_l|p_h)\frac{m_h^2}{2}.\end{aligned} \tag{27}$$

Substituting $\frac{dw(R)}{dk}$ from (20) into (27) and rearranging the terms, yields

$$\frac{dU_{co}}{dk} = \frac{p_h p_l q(1-q)\, w(R)(m_h - m_l)}{2k\left((p_h-p_l)\, q + p_h(1-q)\, m_h - p_l(1-q)\, m_l\right)} > 0. \blacksquare$$

Proof of Proposition 7

Using (9), we obtain

$$\begin{aligned}\frac{d\Pi}{dk} &= \frac{\partial \Pi}{\partial m}\cdot\frac{dm}{dk} \\ &= -\Pr(s_l|p_h)\left(L - \Pr(\lambda_h|s_l, p_h)\, R\right)\cdot\frac{dm}{dk},\end{aligned}$$

which is positive because $(L - \Pr(\lambda_h|s_l, p_h)\, R) > 0$, by assumption, and $\frac{dm}{dk} < 0$

(Proposition 2 and Lemma 1). In addition,

$$\frac{d^2\Pi}{dLdk} = -\Pr(s_l|p_h)\frac{dm}{dk} > 0,$$

because $\frac{dm}{dk} < 0$.■

Proof of Proposition 8

It follows from the results in Proposition 3 that $k_M = k_{\min}$. In addition, shareholder value (V) can be expressed as follows.

$$V = \Pi - C_{no}.$$

Since $\frac{d\Pi}{dk} > 0$ (Proposition 7) and $\frac{dC_{no}}{dk} < 0$ (Proposition 3), it follows that $\frac{dV}{dk} > 0$ and $k_S = k_{\max}$. Thus, $k^*_{no} = \alpha k_{\min} + (1-\alpha) k_{\max}$. In addition, $\frac{dk^*_{no}}{d\alpha} = k_{\min} - k_{\max} < 0$.■

Proof of Proposition 9

L^* is defined as follows.

$$L^* = \Pr(\lambda_h|s_l, p_h) R - \frac{\frac{dC}{dk}}{\Pr(s_l|p_h)\frac{dm_h}{dk}}.$$

Note that when $p_l > p^*_l$, we obtain $L^* > \Pr(\lambda_h|s_l, p_h) R$ because $\frac{dC}{dk} > 0$ and $\frac{dm_h}{dk} < 0$.

It follows from the results in Proposition 6 that $k_M = k_{\max}$. In addition, shareholder value (V) is

$$V = \Pi - C_{co},$$

where $\frac{d\Pi}{dk} > 0$ (Proposition 7).

Part (i): When $p < p^*_l$, $\frac{dC_{co}}{dk} \leq 0$ (Proposition 6). Thus, it follows that $\frac{dV}{dk} > 0$ and

$k_S = k_{\max}$. Since $k_M = k_S$, the optimal monitoring is $k^*_{co} = k_{\max}$.

Part (ii): When $p \geq p^*_l$ and $L \geq L^*$, it follows that

$$\frac{dV}{dk} = \Pr\left(s_l|p_h\right)\left(\left(\lambda_h|s_l, p_h\right)R - L\right) \cdot \frac{dm_h}{dk} - \frac{dC_{co}}{dk} \geq 0.$$

Thus, $k_s = k_{\max}$ and the optimal monitoring is $k^*_{co} = k_{\max}$.

Part (iii): When $p \geq p^*_l$ and $L < L^*$, it follows that

$$\frac{dV}{dk} = \Pr\left(s_l|p_h\right)\left(\left(\lambda_h|s_l, p_h\right)R - L\right) \cdot \frac{dm_h}{dk} - \frac{dC_{co}}{dk} < 0.$$

Thus, $k_s = k_{\min}$ and the optimal monitoring is $k^*_{co} = \alpha k_{\max} + (1 - \alpha)\, k_{\min}$, which increases in α because $\frac{dk^*_{co}}{d\alpha} = k_{\max} - k_{\min} > 0$.■

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