

Equilibrium Earnings Management and Managerial Compensation in a Multiperiod Agency Setting

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Abstract

To investigate how the possibility of earnings manipulation affects managerial compensation contracts, we study a two period agency setting in which a firm's manager can engage in "window dressing" activities to manipulate reported accounting earnings. Earnings manipulation boosts the reported earnings in one period at the expense of the reported earnings in the other period. We show that the pay-performance sensitivities across periods must converge as the manager's personal cost of earnings manipulation declines. We also find that the optimal pay-performance sensitivity may increase and expected managerial compensation may decrease as the manager's cost of earnings management decreases. When the manager is privately informed about the payoff of an investment project to the firm, we identify plausible conditions under which prohibiting earnings management can result in a *less* efficient investment decision for the firm and *more* rents for the manager.

1 Introduction

A large literature, starting with Holmstrom (1979), has studied the design of optimal managerial compensation contracts. In the traditional framework, a principal (shareholders) hires an agent (manager) who can undertake an unobservable action to influence the observable and contractible firm profits. To motivate the effort- and risk-averse manager to exert personally costly effort, the optimal contracts link managerial compensation to realized firm earnings. The optimal pay-performance sensitivity reflects the usual tradeoff between the incentive benefit of tying managerial compensation to realized earnings and the cost of imposing risk on the risk-averse manager.

A large body of empirical research in accounting has provided evidence that managers can, and often do, take unobservable actions (e.g., discretionary accruals) to “manage” reported accounting earnings to meet various objectives.¹ For example, self-serving managers have obvious incentives to engage in earnings management if their bonuses are based on reported accounting earnings. Consequently, optimal compensation contracts must be designed so as to motivate managerial actions that enhance the firm’s intrinsic value, but deter non-productive earnings manipulation. This paper investigates how the possibility of earnings management impacts on the choice of optimal compensation contracts. For instance, does the presence of earnings management necessarily lead to lower-powered incentives for managers? How does the intertemporal pattern of optimal pay-performance sensitivities change when managers can manipulate their performance reports? How does the possibility of earnings management affect managerial compensation levels? What is the effect of earnings management on other managerial decisions such as investment choices?

To address these questions, we study a two period agency model in which a firm’s manager contributes personally costly productive effort in each period to enhance the firm’s “true” earnings, which are privately observed by the manager. The manager provides a publicly observable and contractible accounting earnings report to the owner at the end of each period. The manager can undertake personally costly actions to bias reported earnings in the first

¹See Dechow, Ge, and Schrand (2010) and Healy and Wahlen (1999) for two reviews of this literature.

period. A key feature of our analysis is the notion that though accounting manipulations can change how earnings are distributed across periods, the sum of earnings over the life of the firm remains unchanged. Specifically, we assume that any bias added to accounting earnings in the first period reverses in the second period so that the sum of reported accounting earnings is equal to the sum of economic earnings over the life of the firm. Put differently, while periodic true economic earnings are privately observed by the manager, the sum of economic earnings, and hence true firm value, is publicly observable and contractible.

In the absence of earnings management (i.e., if earnings management were prohibitively costly), the optimal pay-performance sensitivity in a given period would be tailored to the specific agency problem in that period. For example, if the manager were to become more productive over time or operational uncertainty were to diminish over time, the optimal pay-performance sensitivities would increase over time. However, when the manager can shift earnings across periods, any difference in the periodic pay-performance sensitivities provides the manager with an arbitrage opportunity to maximize his compensation. In particular, the manager would have incentives to shift accounting profits to the period with higher pay-performance sensitivity from the one with lower pay-performance sensitivity. We note that the firm could eliminate these earnings manipulation incentives by setting identical pay-performance sensitivity across the two periods. However, this would be generally suboptimal from the perspective of providing desirable productive effort incentives. Consistent with the result in Liang (2004), we show that it is generally optimal to reduce (but not eliminate) the spread between the two bonus rates.

This result has two important implications. First, the firm optimally chooses to tolerate some earnings management in equilibrium. Second, the optimal pay-performance sensitivities across periods are closer to each other when earnings manipulation is possible than when it is prohibited. We show that the difference between the pay-performance sensitivities across periods monotonically decreases as the manager's cost of earnings management declines. While our paper considers managerial incentives to shift earnings across periods, Baldenius and Michaeli (2011) derive a need to "harmonize" incentives within integrated firms when managers can shift profits across divisions through their choices of internal transfer prices.

A number of empirical studies provide evidence of a positive association between the use of incentive compensation and manipulation of accounting reports². However, there is scant theory work on investigating how the potential for earnings manipulation affects the equilibrium level of pay-performance sensitivity. Goldman and Slezak (2006) investigate this question in a single period agency setting. Their analysis demonstrates that the optimal pay-performance sensitivity is lower than what it would be in the absence of the possibility of earnings manipulation. Since there is no unwinding of earnings management in their single period model, the manager's incentive to bias reported earnings is driven by the *level* of pay-performance sensitivity. In contrast, in our model, any accounting bias added in the first period reverses in the second period, and hence the manager's incentive to manipulate earnings is driven by the *difference* between the periodic pay-performance sensitivities. Our analysis shows that the optimal pay-performance sensitivity, as measured by the average bonus coefficient across the two periods, can be *higher* in the presence of earnings manipulation possibility. More specifically, we find that in our two period model with unwinding of earnings management, the average pay-performance can either increase or decrease, depending on the characteristics of the agency problems in the two periods. Our analysis provides specific conditions for either of these two possibilities to emerge in equilibrium.

We also investigate how the equilibrium level of managerial compensation changes as earnings manipulation is made more difficult, for instance by tightening accounting standards. While one might think prohibiting earnings management would prevent managers from inflating their bonuses, we identify plausible circumstances under which the equilibrium level of managerial compensation *increases* in cost of earnings management. Though the manager shifts income across periods to maximize his bonus, he does not benefit in equilibrium. The reason is that the firm lowers the fixed component of the manager's compensation rationally anticipating the equilibrium earnings manipulation strategy. In equilibrium, therefore, the manager's compensation is solely determined by the cost of inducing effort (disutility of productive and manipulation efforts and risk premium). When earnings ma-

²See, for instance, Bergstresser and Philippon (2005), Burns and Kedia (2005), Efendi et al. (2005), Gaver et al. (1995), Healy (1985), Holthausen et al. (1995), Johnson et al. (2005), and Ke (2003).

nipulation becomes more difficult, the optimal incentive contract induces more productive effort from the manager, which in turn requires a higher level of managerial compensation.

Finally, we examine an extended setting in which the manager has private information about the profitability of an investment project. We investigate how earnings management affects the optimal managerial compensation and investment decision in the presence of ex ante information asymmetry about expected firm profitability. In the absence of earnings management, Dutta and Reichelstein (2002) show that the firm owner optimally underinvests and provides low powered incentives to economize on the manager's informational rents. In our model with earnings management, we find plausible circumstances under which the investment decision becomes more efficient as the manager's personal cost of earnings management decreases. Thus, our model predicts that prohibiting earnings management can actually lead to less efficient investment decision. More generally, we demonstrate that whether the investment efficiency increases or decreases in the manager's cost of earnings management depends on the intertemporal profile of the investment payoffs.

In our model, earnings management imposes a deadweight cost to the firm for two reasons. First, in equilibrium, the firm has to compensate the manager for his personal cost of earnings manipulation. Second, earnings management distorts the investment decision and provision of effort incentives. The wedge between the firm's profit and the efficient social surplus arises due to (i) informational rents accrued to the manager, and (ii) the inefficiencies resulting from information asymmetry and earnings management. As the manager's cost of earnings management increases, the deadweight loss decreases, but the manager's rents might also increase. Thus, a conclusion of our model is that the manager's rents might *increase* as earnings management becomes more difficult.

Taken together, our analysis generates several predictions that are contrary to predictions from single period models of earnings manipulation as well as to many commonly-held beliefs about the potential effects of earnings management. For instance, we show that the possibility of earnings manipulation when combined with its eventual reversal (i) leads to more uniform pay-performance sensitivities across periods, (ii) may result in *higher*, rather than lower, pay-performance sensitivities, (iii) may *improve* investment efficiency, and (iv) may

reduce managerial rents and compensation. More generally, our paper demonstrates that incorporating the basic accounting notion, namely that any manipulation must eventually unwind, in models of earnings management can have significant bearing on their predictions.

Fisher and Verrecchia (2000) study earnings management in a capital market equilibrium, and characterize the effects of accounting manipulation on price informativeness of reported earnings. Ewert and Wagenhoffer (2005) extend their analysis to a setting in which the manager can engage in accounting as well as real earnings management, and examine whether tighter accounting standards necessarily lead to less earnings management.³ However, unlike our paper which characterizes the equilibrium relationship between earnings management and incentive contracts, these two papers assume that the manager’s incentives are exogenously specified.

Earnings management has also been studied in the optimal contracting contexts. Arya et al. (1998), Demski (1998), and Dye (1988) model “reported” earnings as a costless message sent by management to communicate their private information to shareholders. Earnings management is said to occur when the manager misrepresents his private information, which can be optimal only if the revelation principle fails to hold. In contrast to the above models, Dutta and Gigler (2002) and Feltham and Xie (1994) model earnings management as a form of window dressing action that changes reported earnings, but have no effect on underlying true earnings. While our analysis and these two studies share this modeling feature, our paper is quite different from these studies in terms of its research focus and other modeling choices. These two papers consider single period settings which do not allow for eventual unwinding of earnings management. While Liang (2004) also examine a two period agency model in which any manipulation of the first period accounting profit reverses in the second period, he does not characterize how the potential for information manipulation effects equilibrium pay-performance sensitivities and other managerial decisions such as investment choices.

The rest of the paper is organized as follows. Section 2 describes the model. Section 3 characterizes the optimal (linear) contracts and the level of earnings management induced

³See Ewert and Wagenhoffer (2012) for a review of the related literature on earnings management in capital market settings.

in equilibrium. Section 4 characterizes the equilibrium investment decision and the induced level of earnings management when the manager also possesses private information about an investment project in addition to his ability to shift income across periods. Section 5 concludes the paper.

2 The Model

We study a two-period agency relationship between a risk-neutral principal (firm) and a risk-averse agent (manager). In each period, the manager contributes unobservable productive effort a_t to enhance the expected value of the firm’s “true ” earnings, y_t . Specifically, true economic earnings are given by:

$$y_t = \lambda_t \cdot a_t + \epsilon_t,$$

where a_t denotes the manager’s choice of productive effort, λ_t is the marginal product of managerial effort, and ϵ_t is a noise term. We assume that the noise terms ϵ_1 and ϵ_2 are independent of each other, and ϵ_t is normally distributed with mean zero and variance σ_t^2 .

Note that we allow for the marginal impact of the manager’s productive effort to differ across the two periods. For example, the manager’s skills in operating the firm may improve ($\lambda_1 < \lambda_2$) over time due to “learning-by-doing”, or, conversely, managerial skills might become less relevant ($\lambda_1 > \lambda_2$) over time due to technological changes. Similarly, we allow for the possibility that the firm’s gross earnings in the two periods are subject to different levels of risk; i.e., $\sigma_1 \neq \sigma_2$.

At the end of period t , the manager privately observes the realized value of true earnings y_t . The manager is required to issue a public accounting report on the firm’s periodic earnings. We assume that the manager has some discretion over the accounting for the earnings report and can use that discretion to “bias” the reported earnings. In particular, after observing the true earnings in the first period y_1 , the manager can add a “bias” b to the reported earnings e_1 ; i.e.,

$$e_1 = y_1 + b.$$

The principal observes the accounting report e_1 , but not the manager's choice of earnings manipulation b . The manager can choose earnings bias b to be either positive or negative. We interpret b as the amount or extent of earnings management. When b is positive (negative), the manager inflates (deflates) the first period earnings relative to the underlying true state.

A fraction $\delta \in [0, 1]$ of the bias added in the first period reverses in the second period. Therefore, the reported earnings in the second period are given by:

$$e_2 = y_2 - \delta \cdot b.$$

The remaining amount of earnings management, $(1 - \delta) \cdot b$, is assumed to reverse subsequent to the end of the manager's planning horizon at date 2. When $\delta = 1$, earning management fully reverses in the second period, and hence the manager's choice of b affects only the intertemporal distribution of accounting earnings across the two periods, but not the sum of earnings over the two periods.

We assume that the two parties can commit to a two-period contract at the beginning of period 1.⁴ To ease notation, we ignore discounting and assume that the manager consumes all his income at the end of period 2. The manager has negative exponential utility with risk aversion coefficient ρ . As a function of his compensation (s_1, s_2) and action choices (a_1, a_2, b) , the manager's utility takes the form:

$$U = -\exp \left[-\rho \cdot \left(\sum_{t=1}^2 \left(s_t - \frac{1}{2} \cdot a_t^2 \right) - \frac{1}{2} \cdot w \cdot b^2 \right) \right],$$

where $\frac{1}{2} \cdot a_t^2$ is the manager's personal cost of productive effort a_t and $\frac{1}{2} \cdot w \cdot b^2$ is the manager's disutility of earnings manipulation with $w \geq 0$.

⁴Our results would remain unchanged if the manager were unable to make long-term commitment. When the manager cannot commit to stay with the firm for two periods, a feasible contract must also satisfy the manager's interim participation constraint. It can be easily verified that this additional constraint merely affects the timing of compensation, and have no effect on the two parties's payoffs.

The disutility of earnings management reflects the manager’s time and efforts, psychic and reputation costs, and litigation risk. The parameter w captures the marginal cost of earnings management and represents exogenous factors such as accounting and legal regulatory environments, internal governance structures, and firm characteristics such as size and complexity of the business. For instance, earnings management will be relatively easy (i.e., w will be relatively low) if either the regulatory mechanisms are lax, or the internal corporate governance is weak, or the firm operates in a complex business environment.

For tractability, we restrict our attention to compensation contracts that are linear functions of reported earnings. The manager’s compensation in period t takes the form:

$$s_t(e_t) = \alpha_t + \beta_t \cdot e_t,$$

where α_t denotes the fixed salary and β_t denotes the pay-performance sensitivity. Given our LEN framework, the manager’s expected utility becomes $EU = -\exp\{-\rho \cdot CE\}$, where

$$CE \equiv \sum_{t=1}^2 \left[\alpha_t + \beta_t \cdot \lambda_t \cdot a_t - \frac{1}{2} \cdot a_t^2 - \frac{1}{2} \cdot \rho \cdot \beta_t^2 \cdot \sigma_t^2 \right] + (\beta_1 - \delta \cdot \beta_2) \cdot b - \frac{1}{2} \cdot w \cdot b^2, \quad (1)$$

represents the certainty equivalent of the risky contract $\{s_t = \alpha_t + \beta_t \cdot e_t\}_{t=1}^2$.

3 Optimal Contract and Equilibrium Earnings Management

We now study the design of optimal (linear) compensation contracts and earnings management induced in equilibrium. Before examining our main setting, it is instructive to consider the following two benchmark cases:

No Earnings Management

The first benchmark we investigate is a setting in which earnings management can be directly prohibited; or equivalently, a setting in which earnings management is prohibitively costly (i.e., $w = \infty$). As usual, we solve for the equilibrium of the model by backward

induction. First we derive the optimal level of effort chosen by the manager as a function of the contract offered by the principal. Then, given the effect of the contract parameters on managerial effort, we determine the optimal contract that maximizes the principal's expected payoff.

For a given contract $\{s_t = \alpha_t + \beta_t \cdot e_t\}_{t=1}^2$, the manager's certainty equivalent is given by (1) with the earnings manipulation variable b set equal to zero. Therefore, the manager's choices of periodic productive efforts will satisfy the following first-order conditions:

$$a_t = \lambda_t \cdot \beta_t.$$

As usual, the induced level of effort a_t depends on the pay-performance sensitivity β_t of the compensation contract. We note that a unit increase in the pay-performance sensitivity induces λ_t more units of productive effort from the manager.

Given the above managerial response to a given contract, the principal's problem of choosing an optimal contract can be written as:

$$\mathbf{P}^0 : \max_{\{\alpha_t, \beta_t\}} \sum_{t=1}^2 [\lambda_t \cdot a_t - \alpha_t - \beta_t \cdot \lambda_t \cdot a_t]$$

subject to

$$(i) \quad a_t = \lambda_t \cdot \beta_t$$

$$(ii) \quad CE \geq 0$$

The objective function of the above program reflects the principal's expected payoff net of compensation payment to the manager. Constraint (i) and (ii) are the manager's incentive compatibility and participation constraints, respectively. Without loss of generality, we normalize the manager's outside option to zero; that is, we assume that the manager can earn a work- and risk-free wage of zero in outside employment.

The participation constraint in (ii) will bind at the optimum, and hence the principal's optimization program in \mathbf{P}^0 simplifies to the following unconstrained maximization problem:

$$\max_{\beta_1, \beta_2} \sum_{t=1}^2 \left[\lambda_t^2 \cdot \beta_t - \frac{1}{2} \cdot \lambda_t^2 \cdot \beta_t^2 - \frac{1}{2} \cdot \rho \cdot \beta_t^2 \cdot \sigma_t^2 \right].$$

We note that the above objective function is separable in β_1 and β_2 . Thus, the principal will choose the bonus coefficient in a given period to maximize the expected surplus π_t from that period, where

$$\pi_t(\beta_t) \equiv \left[\lambda_t^2 \cdot \beta_t - \frac{1}{2} \cdot \beta_t^2 \cdot (\lambda_t^2 + \rho \cdot \sigma_t^2) \right]. \quad (2)$$

We thus obtain the familiar expression for the optimal bonus coefficients:

$$\beta_t^0 = \frac{\lambda_t^2}{\lambda_t^2 + \rho \cdot \sigma_t^2}. \quad (3)$$

The optimal pay-performance sensitivity in (3) reflects the usual tradeoff between risk and incentives. A unit increase in the pay-performance sensitivity β_t induces λ_t more units of productive effort from the manager and hence increases the firm's expected value by λ_t^2 . However, a unit increase in the pay-performance sensitivity also increases the required compensation to the manager by $(\lambda_t^2 + \rho\sigma_t^2) \cdot \beta_t$ due to increases in effort cost and risk exposure. The optimal pay-performance sensitivity equates the marginal cost of profit sharing with its marginal benefit.

For future reference, we note that

$$\frac{d^2 \pi_t}{d\beta_t^2} = \Delta_t,$$

where

$$\Delta_t \equiv \lambda_t^2 + \rho \cdot \sigma_t^2.$$

Thus, the parameter Δ_t represents the “curvature” of the periodic surplus with respect to the pay-performance sensitivity.

No Reversal of Earnings Management

Next we consider a benchmark setting in which the manager's choice of earnings management does not reverse during his planning horizon (i.e., $\delta = 0$). To model this, we assume that the manager works for the firm for only the first period. The reported earnings in the first period are given by:

$$e = \lambda \cdot a + \varepsilon + b,$$

where, for brevity, we have suppressed the subscripts from the variables. As before, we consider linear compensation contracts of the form $s = \alpha + \beta \cdot e$. We also assume that ε is a normally distributed noise term with mean zero and variance σ^2 and the manager's risk preferences are described by $U = -\exp[-\rho(s - \frac{1}{2} \cdot (a^2 + w \cdot b^2))]$. Given this LEN framework, the manager's preferences can be equivalently represented by the following certainty equivalent expression:

$$CE = \alpha + \beta \cdot (\lambda \cdot a + b) - \frac{1}{2} \cdot (a^2 + w \cdot b^2 + \rho \cdot \beta^2 \cdot \sigma^2).$$

It thus follows that, for a given contract $s = \alpha + \beta \cdot e$, the manager will optimally choose:

$$a = \lambda \cdot \beta \tag{4}$$

$$b = w^{-1} \cdot \beta \tag{5}$$

In order to induce the manager to exert productive effort, the principal must offer a contract that is sensitive to accounting earnings. In addition to inducing effort, however, such an incentive contract also leads to earnings manipulation. Thus, earnings-based compensation induces both productive effort as in (4) and non-productive earnings management as in (5).

In our model, the principal can perfectly predict the manager's choice of earnings management b in equilibrium. The principal rationally anticipates the incremental expected bonus of $\beta \cdot b$ that the manager earns from earnings manipulation, and lowers the manager's fixed salary accordingly. Therefore, though the manager manipulates earnings to increase his expected bonus, he does not earn any rents in equilibrium (i.e., $CE = 0$).

Given the induced choices in (4) and (5) and the fact that the participation constraint binds in equilibrium (i.e., $CE = 0$), the principal's optimization problem simplifies to:

$$\max_{\beta} \left[\lambda^2 \cdot \beta - \frac{1}{2} \cdot \beta^2 \cdot (\lambda^2 + \rho \cdot \sigma^2 + w^{-1}) \right].$$

Since the principal's objective function is strictly concave in β , the optimal pay-performance sensitivity in the presence of earnings management is given by the following first-order condition:

$$\beta^* = \frac{\lambda^2}{\lambda^2 + \rho \cdot \sigma^2 + w^{-1}}. \tag{6}$$

A comparison of equations (3) and (6) reveals that when the manager is not concerned about the eventual reversal of earnings management, the possibility of earnings management unambiguously results in lower pay-performance sensitivity (i.e., $\beta^* < \beta^0$). This result is consistent with the finding of Goldman and Slezak (2006). To understand why, we note that though the manager cannot directly benefit from earnings manipulation, it is nonetheless costly to the principal because he ultimately pays for the manager's equilibrium cost of earnings management $\frac{1}{2} \cdot w \cdot b^2$. The optimal pay-performance sensitivity balances the incremental value of productive effort against the incremental cost of earnings manipulation. However, the analysis below demonstrates that this prediction of lower pay-performance sensitivity crucially hinges on the extreme assumption that none of earnings management reverses during the manager's planning horizon.

Earnings Management and Reversal

We now investigate our main setting in which earnings management is feasible (i.e., $w < \infty$) and reverses, at least partially, during the manager's planning horizon (i.e., $\delta > 0$). For expositional convenience, we will focus on a case in which earnings management fully reverses in the subsequent period; i.e., $\delta = 1$. The qualitative nature of our results remains unchanged when we allow for a partial reversal of earnings management.⁵

As before, we solve for the subgame perfect equilibrium of the model by backward induction. First we derive the optimal levels of productive effort and earnings manipulation chosen by the manager as a function of the contract $\{s_t = \alpha_t + \beta_t\}_{t=1}^2$ offered by the principal. Given the manager's response functions, we determine the optimal contract that maximizes the principal's expected payoff. The equilibrium levels of effort and earnings manipulation are then given by the optimal response functions evaluated at this contract.

In order to isolate the impact of earnings management, we have formulated our model such that the two periods are technologically independent in the absence of earnings manipulation. As shown earlier, therefore, the principal's problems of choosing optimal bonus

⁵A potentially interesting extension for future research would be to consider a setting in which the extent of reversal in a given period is *ex ante* uncertain.

contracts are intertemporally separable when earnings manipulation is prohibited. When the manager can engage in earnings management, however, the incentive problems in the two periods interact. In particular, the manager would like to “borrow” earnings from the second period whenever the contract parameters are such that $\beta_1 > \beta_2$, and “save” earnings for the second period whenever $\beta_1 < \beta_2$. The certainty equivalent expression in (1) shows that, for a given contract $\{s_t = \alpha_t + \beta_t\}_{t=1}^2$, the manager’s optimal choice of earnings manipulation is given by the following first-order condition:

$$b = \frac{\beta_1 - \beta_2}{w}.$$

With reversal of earnings management, we note that the manager’s earnings manipulation incentives depend on the *difference* between the two bonus coefficients (rather than on the *levels* of bonus coefficients). Consequently, depending on the sign of $\beta_1 - \beta_2$, the manager may have incentives to either inflate ($b > 0$) or deflate ($b < 0$) the first period accounting report. From the above equation, we can also see that the magnitude of earnings manipulation varies cross-sectionally with several firm characteristics as well as with policy parameters. For example, the optimal amount of earnings manipulation is determined in equilibrium by such things as firm-specific risk σ_t^2 , managerial productivity λ_t^2 , and the marginal cost of earnings management w .

For a given contract, the manager’s optimal choices of productive effort are similarly given by the following first-order conditions:

$$a_t = \lambda_t \cdot \beta_t.$$

Therefore, when earnings management is possible ($w < \infty$), the principal chooses the

contract parameters to solve the following optimization program:

$$\mathbf{P}^* : \max_{\{\alpha_t, \beta_t\}} \sum_{t=1}^2 [\lambda_t \cdot a_t - \alpha_t - \beta_t \cdot \lambda_t \cdot a_t]$$

subject to

$$\begin{aligned} (i) \quad & a_t = \lambda_t \cdot \beta_t \\ (ii) \quad & b = \frac{\beta_1 - \beta_2}{w} \\ (iii) \quad & CE \geq 0 \end{aligned}$$

Constraint (i) and (ii) reflect the first-order conditions of the manager's incentive compatibility constraints with respect to a_t and b , respectively. It can be easily verified that these conditions are necessary as well as sufficient, since the manager's expected utility, as represented by $CE(a_1, a_2, b)$, is a concave function of a_1, a_2 , and b .

Substituting (i) and (ii), the certainty equivalent expression in (1) simplifies to:

$$CE = \sum_{t=1}^2 \left[\alpha_t + \frac{1}{2} \cdot \lambda_t^2 \cdot \beta_t^2 - \frac{1}{2} \cdot \rho \cdot \beta_t^2 \cdot \sigma_t^2 \right] + \frac{1}{2} \cdot w^{-1} \cdot (\beta_1 - \beta_2)^2.$$

Again, though the principal cannot directly observe the manager's choice of earnings manipulation, he can perfectly predict it in equilibrium. Therefore, the principal will choose the manager's fixed salaries such that the participation constraint binds (i.e., $CE = 0$) in equilibrium. Consequently, the optimization program in \mathbf{P}^* simplifies to the following unconstrained maximization problem:

$$\max_{\{\beta_1, \beta_2\}} \sum_{t=1}^2 \pi_t(\beta_t) - \frac{1}{2} \cdot w^{-1} \cdot (\beta_1 - \beta_2)^2, \quad (7)$$

where $\pi_t(\cdot)$ is as defined in (2).

Let $\{\beta_t^*\}_{t=1}^2$ denote the optimal bonus coefficients. Then the equilibrium level of earnings management is given by:

$$b^* = w^{-1} \cdot (\beta_1^* - \beta_2^*).$$

Even though the manager cannot derive any private benefits, earnings management nevertheless imposes a cost on the principal because the principal has to compensate the manager for his personal cost of earnings management as reflected by the last term in (7). The principal can entirely eliminate the cost of earnings manipulation by choosing identical pay-performance sensitivity for the two periods. However, this would be generally suboptimal from risk-sharing perspective. In choosing the optimal pay-performance sensitivities, the principal balances the goals of deterring costly earnings management activities and tailoring productive effort incentives to each period's agency problem.

As noted earlier, in our model with reversal of earnings management, earnings manipulation incentives depend on the difference between the periodic incentive coefficients. Consequently, the principal finds it optimal to lower the spread between the two bonus coefficients. It can be verified that:

$$[\beta_1^* - \beta_2^*] = m \cdot [\beta_1^0 - \beta_2^0], \quad (8)$$

where $m < 1$ and is given by

$$m = \frac{w \cdot \Delta_1 \cdot \Delta_2}{\Delta_1 + \Delta_2 + w \cdot \Delta_1 \cdot \Delta_2}.$$

The following proposition shows that the pay-performance sensitivities in the two periods become more divergent as earnings manipulation becomes more difficult (i.e., as w increases).

Proposition 1 *The spread between periodic bonus coefficients increases in the cost of earnings management w . Specifically,*

$$\frac{\partial |\beta_1^* - \beta_2^*|}{\partial w} \geq 0,$$

and the equality holds if and only if $\beta_1^0 = \beta_2^0$.

The intuition behind the above proposition is straightforward. The manager's incentive to shift earnings across periods increases in the difference between the two bonus coefficients. If the moral hazard problems are identical in the two periods, the principal will optimally choose the same pay-performance sensitivity in both periods, and hence the manager will

have no incentives to manipulate earnings. In this case, the principal achieves the same expected payoff as he would if earnings management were prohibitively costly to the manager (i.e., $w = \infty$).

When the moral hazard problems differ across the two periods, the principal would ideally like to tailor the manager's effort incentives in each period to the specifics of the agency problem in that period. To economize on the cost of non-productive manipulation activities, however, the principal chooses to set the two bonus coefficients closer to each other in order to curtail the manager's manipulation incentives. Consequently, relative to the optimal contract in P^0 , the optimal bonus coefficients in P^* diverge to a lesser degree. This need to lower the spread between the pay-performance sensitivities decreases as earnings manipulation becomes more costly; i.e., as w increases. When earnings management becomes prohibitively costly ($w = \infty$), the optimal contract and the principal's payoff approaches those under P^0 .

At the other extreme, if the manager can costlessly shift earnings across periods (i.e., $w = 0$), he can exploit even the small difference between the bonus coefficients to earn an arbitrarily large amount of bonus. Therefore, the principal must set identical bonus coefficients; i.e., $\beta_1^* = \beta_2^*$. Put differently, when earnings manipulation is costless, the manager's contract can only be based on the *aggregate* earnings over the two periods .

Corollary 1 When $w = 0$, $\beta_1^* = \beta_2^* = \frac{\lambda_1^2 + \lambda_2^2}{\Delta_1 + \Delta_2}$.

Next we examine how the average pay-performance sensitivity changes with the marginal cost of earnings management. It is often argued that high-powered incentives introduced by bonuses and stock grants are at fault for earnings manipulation. Hence, it is interesting to investigate how the optimal pay-performance sensitivity changes as earnings manipulation becomes more or less difficult. As noted earlier, in a single period model without reversal of earnings management, Goldman and Slezak (2006) show that the possibility of earnings manipulation unambiguously leads to lower-powered incentives. In contrast, the result below shows that the potential of earnings manipulation does not necessarily lead to lower pay-performance sensitivity.

Proposition 2 (i) When $\Delta_1 = \Delta_2$, the average pay-performance sensitivity is independent of the cost of earnings management w ; i.e., $\frac{\partial(\beta_1^* + \beta_2^*)}{\partial w} = 0$.

(ii) When $\Delta_i > \Delta_j$, the average pay-performance sensitivity decreases (increases) in the cost of earnings management w if β_i^0 is more (less) than β_j^0 . That is,

$$\text{sgn} \left[\frac{\partial(\beta_1^* + \beta_2^*)}{\partial w} \right] = \text{sgn} [\beta_j^0 - \beta_i^0].$$

An immediate implication of Proposition 2 is that equilibrium pay-performance sensitivities can be *higher* when managers can manipulate earnings (e.g., $w = 0$) than when they cannot (i.e., $w = \infty$). This is in sharp contrast to the findings of Goldman and Slezak (2006) who show that the possibility of earnings management necessarily dampens incentives. The reason for this difference is that Goldman and Slezak (2006) model a single period setting in which the manager is not concerned about eventual reversal of earnings manipulation. The manager thus has incentives to always inflate current earnings, and these incentives increase in the pay-performance sensitivity of the compensation scheme. To curtail wasteful manipulation activities, the principal finds it optimal to lower the pay-performance sensitivity of the compensation contract.

In our model with reversal of earnings management, however, the manager's manipulation incentives are determined by the *difference* between, rather than the *levels* of, periodic bonus coefficients. To mitigate earnings manipulation, the principal sets a spread between the two bonus coefficients that is lower than what would be optimal if earnings management could be directly prohibited; that is, $|\beta_1^* - \beta_2^*| < |\beta_1^0 - \beta_2^0|$. Proposition 2 shows that, depending on the parameters of the model, such a lowering of the spread between the bonus coefficients can amount to either higher or lower average pay-performance sensitivity.

To provide some intuition, we note that the expected surplus from the manager's productive effort π_t , as defined in (2), decreases as the two bonus coefficients converge to each other from their optimal values in the absence of earnings management (i.e., β_t^0). Since Δ_t is the curvature of the periodic surplus with respect to β_t , it measures the sensitivity of the loss in expected firm profit associated with deviation of β_t from β_t^0 . Consider first the knife-edge

case in which $\Delta_1 = \Delta_2$. In this case, a unit deviation of β_1 from β_1^0 is as costly as a unit deviation of β_2 from β_2^0 . As earnings management becomes easier, in order to reduce the spread between the bonus coefficients, the principal optimally deviates each bonus coefficient from its “unconstrained” optimal value of β_t^0 by the same (absolute) amount. Therefore, when $\Delta_1 = \Delta_2$, the average pay-performance sensitivity $\beta_1^* + \beta_2^*$ remains constant as the marginal cost of earnings manipulation w varies.

When $\Delta_1 > \Delta_2$, it is more costly to distort the bonus coefficient in the first period than in the second period. Because of this asymmetry, as w decreases and earnings manipulation becomes easier, the principal prefers to reduce the difference between the two bonus coefficients by adjusting β_2 more than the amount by which he adjusts β_1 . This implies that when $\beta_2^0 > \beta_1^0$, the principal optimally chooses to reduce β_2 more than the amount by which he increases β_1 . Consequently, the average bonus coefficient gravitates towards β_1^0 and $\beta_1^* + \beta_2^*$ decreases in the ease of earnings management. Conversely, when $\beta_1^0 > \beta_2^0$, the principal will reduce the spread between the two bonus coefficients by decreasing β_1 and increasing β_2 . Since it is less costly to change β_2 , it is optimal to increase β_2 by a higher amount than the decrease in β_1 . Hence, when $\beta_1^0 > \beta_2^0$, the average pay-performance sensitivity *increases* as the earning manipulation becomes easier; i.e., as w decreases.

Proposition 3 (i) *The expected firm profit increases in w .*

(ii) *The equilibrium cost of earnings management, $\frac{1}{2} \cdot w \cdot b^{*2}$, first increases and then decreases in w .*

(iii) *The expected managerial compensation, $E(s_1 + s_2)$, increases in w .*

The intuition for the first part is obvious. In our model, earnings manipulation is a costly window-dressing activity without any benefits. Though the manager earns no rents from manipulating earnings in equilibrium, earnings management is still costly to the firm because (i) the firm has to compensate the manager for his personal cost of earnings management, $\frac{1}{2} \cdot w \cdot b^{*2}$, and (ii) earnings management leads to distorted effort incentives i.e., $\beta_t^* \neq \beta_t^0$. It

therefore follows that the firm becomes better off as earnings manipulation becomes more difficult.

The second part of Proposition 3 shows that the equilibrium cost of earnings management, $\frac{1}{2} \cdot w \cdot b^{*2}$, first increases and then decreases in w . To gain some intuition, we note that the cost of earnings management is zero when manipulation is prohibitively costly (i.e., $w = \infty$), since the manager would refrain from engaging in any manipulation activity (i.e., $b^* = 0$). At the other extreme when manipulation is costless (i.e., $w = 0$), the principal must set identical incentives across the two periods, which again results in zero cost of earnings management in equilibrium. Therefore, the equilibrium cost of earnings management reaches its peak for some intermediate value of w .

The conclusion in (iii) might seem counter-intuitive at first glance, since the manager's ability to shift earnings across periods and inflate his expected bonus pay decreases as the marginal cost of earnings management w increases. However, we recall that, in our model, the principal can perfectly anticipate the equilibrium effect of earnings management on the manager's bonus. In equilibrium, therefore, the manager is merely compensated for his costs of providing (productive and non-productive) efforts and bearing risk. As earnings manipulation becomes more difficult, the optimal bonus coefficients move towards their "unconstrained" optimal values of β_t^0 . This leads to an increase in the productive efforts over the two periods as well as in the required compensation for productive efforts and risk premium. As shown in (ii), however, the cost of earnings management can either increase or decrease in w . In general, therefore, it is hard to predict how total compensation changes with w . In our model with quadratic costs, it turns out that the expected managerial compensation is always half of the total surplus. Since the total surplus increases in the marginal cost of earnings manipulation, the expected managerial compensation also increases in w .

This result highlights that managerial compensation can be *higher* when earnings management is prohibited (i.e., $w = \infty$) than when earnings management is allowed (i.e., $w < \infty$). The level of compensation is therefore not necessarily an indicator of any opportunistic earnings management behavior on the part of management.

4 Earnings Management and Investment Decision

To investigate how the possibility of earnings management affects other managerial decisions, we now extend our analysis to a setting in which the manager is also responsible for the firm's investment choices. We assume that the manager has superior information regarding the profitability of an investment project available to the firm. The investment project requires initial cash investment of k at date 0, and generates operating cash flow in the amount of $x_t \cdot \theta$ at the two subsequent dates, $t = 1, 2$.

We interpret θ as a profitability parameter which represents the manager's superior information. In contrast, both parties are assumed to know the intertemporal distribution of the project's operating cash flows, as represented by the parameters $x \equiv (x_1, x_2)$, with $x_1 + x_2 = 1$. As before, we assume that there is no discounting so that the project's net present value is given by:

$$NPV(\theta) = \sum_{t=1}^2 \theta \cdot x_t - k = \theta - k.$$

The principal does not know the value of θ , but believes that it is drawn from a distribution $F(\theta)$ with support $[\underline{\theta}, \bar{\theta}]$ and density function $f(\theta)$. As is standard in the mechanism design literature, we assume that the inverse of the hazard rate, $H(\theta) \equiv \frac{1-F(\theta)}{f(\theta)}$, is decreasing in θ .⁶

Obviously, in the absence of private information, the principal would invest in the project if and only if $\theta > k$. To rule out the corner solutions when the project is either always undertaken or always rejected, we assume that $\underline{\theta} < k < \bar{\theta}$. To avoid corner solutions for the optimal bonus coefficients, we also assume that $\lambda_t^2 > x_t \cdot H(k)$ for each t . The initial investment expenditure k is verifiable and directly expensed in the first period.⁷ The

⁶It is well known that many common distributions, such as the uniform and (truncated) normal distribution, have decreasing inverse hazard rates.

⁷We do not focus on the choice of depreciation method in this paper, since the two parties can enter into long-term contracts at the outset. Dutta and Reichelstein (2002) investigate how alternative depreciation methods affect managerial incentives.

reported accounting earnings are thus given by:

$$\begin{aligned} e_1 &= \lambda_1 \cdot a_1 + (x_1 \cdot \theta - k) \cdot I + b + \epsilon_1 \\ e_2 &= \lambda_2 \cdot a_2 + x_2 \cdot \theta \cdot I - b + \epsilon_2, \end{aligned}$$

where, as before, a_t denotes the manager's choice of productive effort and b denotes the amount of earnings bias that the manager adds in the first period. And, $I \in \{0, 1\}$ is an indicator variable which reflects whether the investment project was undertaken at date 0.

By the revelation principal, without loss of generality, we restrict our attention to direct revelation mechanisms in which the manager reports his private information truthfully. When the project's true quality is θ , but the manager self-selects contract $s_t(\hat{\theta}) = \alpha_t(\hat{\theta}) + \beta_t(\hat{\theta}) \cdot e_t$ by reporting $\hat{\theta}$, it can be shown that the manager's certainty equivalent takes the following mean-variance form:

$$\begin{aligned} CE(\hat{\theta}, \theta | a_1, a_2, b) &= \sum_{t=1}^2 \left[\alpha_t(\hat{\theta}) + \beta_t(\hat{\theta}) \cdot [\theta \cdot x_t \cdot I(\hat{\theta}) + \lambda_t \cdot a_t] - \frac{1}{2} \cdot a_t^2 - \frac{1}{2} \cdot \rho \cdot \beta_t^2(\hat{\theta}) \cdot \sigma_t^2 \right] \\ &\quad - \beta_1(\hat{\theta}) \cdot k \cdot I(\hat{\theta}) + (\beta_1(\hat{\theta}) - \beta_2(\hat{\theta})) \cdot b - \frac{1}{2} \cdot w \cdot b^2. \end{aligned}$$

It can be easily verified that $CE(\hat{\theta}, \theta | a_1, a_2, b)$ is strictly concave in a_1, a_2 , and b . Evaluated at the optimal choices of $a_t = \beta_t(\hat{\theta}) \cdot \lambda_t$ and $b = w^{-1} \cdot [\beta_1(\hat{\theta}) - \beta_2(\hat{\theta})]$, the manager's certainty equivalent expression becomes:

$$\begin{aligned} CE(\hat{\theta}, \theta) &= \sum_{t=1}^2 \left[\alpha_t(\hat{\theta}) + \beta_t(\hat{\theta}) \cdot \theta \cdot x_t \cdot I(\hat{\theta}) + \frac{1}{2} \cdot \beta_t(\hat{\theta})^2 \cdot (\lambda_t^2 - \rho \cdot \sigma_t^2) \right] \\ &\quad - \beta_1(\hat{\theta}) \cdot k \cdot I(\hat{\theta}) + \frac{1}{2} \cdot w^{-1} \cdot (\beta_1(\hat{\theta}) - \beta_2(\hat{\theta}))^2. \end{aligned}$$

Let $CE(\theta) \equiv CE(\theta, \theta)$. Then the principal's optimization problem can be expressed as:

$$\max_{\{\alpha_t(\theta), \beta_t(\theta)\}, I(\theta)} \int_{\underline{\theta}}^{\bar{\theta}} \left\{ \sum_{t=1}^2 [(\theta \cdot x_t \cdot I(\theta) + \lambda_t^2 \cdot \beta_t(\theta)) \cdot [1 - \beta_t(\theta)] - \alpha_t(\theta)] + \beta_1(\theta) \cdot k \cdot I(\theta) \right\} f(\theta) d\theta$$

subject to

- (i) $CE(\theta) \geq CE(\hat{\theta}, \theta)$ for each θ and $\hat{\theta}$,
- (ii) $CE(\theta) \geq 0$ for all θ .

Constraint (i) represents the manager's incentive compatibility condition, while constraint (ii) ensures that the manager will participate in the contract at time 0. Notice that without the incentive compatibility constraint in (i), the problem will be the same as the one solved in Section 3.3. The principal will optimally set the bonus coefficients at $\{\beta_t^*\}$ and the manager will be exactly compensated for his costs of efforts and risk-bearing.

Using the standard arguments, it can be shown that the incentive compatibility condition (i) and the participation constraint in (ii) are equivalent to the condition that:

$$CE(\theta) = \int_{\underline{\theta}}^{\theta} \sum_{t=1}^2 \beta_t(u) \cdot x_t \cdot I(u) du. \quad (9)$$

Equation (9) shows that if the project is undertaken ($I = 1$) and the manager is provided with nontrivial incentives (i.e., if $\sum_{t=1}^2 \beta_t > 0$), the manager will earn informational rents since $CE(\theta)$ will exceed his reservation wages of zero. In particular, in order to maintain truth-telling, a unit increase in $\beta_t(\theta)$ for type θ must allow all higher types to earn an additional rents in the amount of x_t .

Define $G(\beta_1, \beta_2) = \sum_{t=1}^2 [\lambda_t^2 \cdot \beta_t - \frac{1}{2} \cdot \Delta_t^2 \cdot \beta_t^2] - \frac{1}{2} \cdot w^{-1} \cdot (\beta_1 - \beta_2)^2$, which is the component of firm profit related to the manager's productive and non-productive effort choices. After substituting expression (9) for $CE(\theta)$ and solving for $\alpha_t(\theta)$, the principal's problem can be restated as:

$$\max_{\{\beta_t(\theta)\}, I(\theta)} \int_{\underline{\theta}}^{\bar{\theta}} \left\{ G(\beta_1(\theta), \beta_2(\theta)) + \left[\theta - k - \sum_{t=1}^2 \beta_t(\theta) \cdot x_t \cdot H(\theta) \right] \cdot I(\theta) \right\} f(\theta) d\theta. \quad (10)$$

Lemma 1 (i) *The project is undertaken if and only if θ exceeds a cut-off level θ^* which is given by the solution to the equation:*

$$\theta^* = k + H(\theta^*) \cdot \sum_{t=1}^2 \beta_t(\theta^*) \cdot x_t + G(\beta_1^*, \beta_2^*) - G(\beta_1(\theta^*), \beta_2(\theta^*)). \quad (11)$$

(ii) *When the project is not undertaken, $\beta_t(\theta) = \beta_t^*$.*

(iii) *When the project is undertaken, $\beta_t(\theta) < \beta_t^*$, and $\beta_t(\theta)$ is increasing in θ for all $\theta \geq \theta^*$ and $\beta_t(\bar{\theta}) = \beta_t^*$.*

Similar to the conclusion in Dutta and Reichelstein (2002), the above proposition shows that in order to curtail informational rents, the principal chooses to underinvest and provide lower-powered incentives. This is because the manager gets information rents only when the investment is undertaken and the manager has non-trivial incentives. In order to economize on the informational rents, the principal optimally chooses to increase the investment threshold and lower the bonus coefficients.

We now proceed to examine how the aggregate incentive intensity and investment threshold change with the marginal cost of earnings management. It is instructive to first consider the setting in which earnings manipulation is prohibitively costly (i.e., $w = \infty$). In this case, the principal's maximization problem in (10) simplifies to:

$$\max_{\beta_t(\theta), I(\theta)} \int_{\underline{\theta}}^{\bar{\theta}} \left\{ \sum_{t=1}^2 \pi_t^v(\beta_t(\theta)) + [\theta - k] \cdot I(\theta) \right\} f(\theta) d\theta,$$

where

$$\pi_t^v(\beta_t(\theta)) \equiv [\lambda_t^2 - x_t \cdot H(\theta) \cdot I(\theta)] \cdot \beta_t(\theta) - \frac{1}{2} \cdot \beta_t(\theta)^2 \cdot \Delta_t \quad (12)$$

denotes the “virtual” surplus from managerial effort in period t . To interpret the above expression, note that a unit increase in $\beta_t(\theta)$ is now also associated with an increase in the expected informational rents in the amount of $x_t \cdot (1 - F(\theta))$ when the project is undertaken. Consequently, the firm's marginal benefit from a unit increase in β_t is reduced by $x_t \cdot H(\theta) \cdot I(\theta)$, the expected cost of maintaining truth-telling. Pointwise optimization reveals that when the principal is not concerned about mitigating earnings management incentives, the optimal bonus coefficients in the investment region are given by:

$$\beta_t^0(\theta) = \beta_t^0 - \frac{x_t}{\Delta_t} \cdot H(\theta). \quad (13)$$

When $w < \infty$, however, the principal must also take into account the effect of his choice of bonus coefficients on the manager's earnings management incentives. To curtail earnings manipulation, as in the symmetric information setting of Section 3, the principal sets a lower spread between the two bonus coefficients. It can be shown that:

$$[\beta_1(\theta) - \beta_2(\theta)] = m \cdot [\beta_1^0(\theta) - \beta_2^0(\theta)], \quad (14)$$

where $m < 1$ is as defined in connection with (8).

The following result parallels proposition 2 and characterizes how the incentive intensity changes with the cost of earnings management when there is *ex ante* information asymmetry about expected earnings.

Proposition 4 (i) When $\Delta_1 = \Delta_2$,

$$\frac{\partial [\beta_1(\theta) + \beta_2(\theta)]}{\partial w} = 0.$$

(ii) When $\Delta_i > \Delta_j$,

$$\text{sgn} \left[\frac{\partial [\beta_1(\theta) + \beta_2(\theta)]}{\partial w} \right] = \text{sgn} [\beta_j^0(\theta) - \beta_i^0(\theta)].$$

We note from the expression for the virtual surplus in (12) that the “curvature” of the firm’s profit function is unaffected by the information asymmetry about investment profitability. Consequently, Δ_t still measures the sensitivity of the loss in firm profit associated with the deviation of $\beta_t(\theta)$ from $\beta_t^0(\theta)$. When $\Delta_1 > \Delta_2$, therefore, a unit deviation of $\beta_1(\theta)$ is more costly than a unit deviation of $\beta_2(\theta)$. As earnings management becomes easier, in order to reduce the spread between the two bonus coefficients, the principal distorts $\beta_2(\theta)$ more than $\beta_1(\theta)$ from their “unconstrained” values of $\beta_1^0(\theta)$ and $\beta_2^0(\theta)$. Therefore, the average pay-performance sensitivity $\beta_1(\theta) + \beta_2(\theta)$ increases (decreases) when $\beta_2^0(\theta)$ is greater (less) than $\beta_1^0(\theta)$.

The result below characterizes how the efficiency of investment decision changes in the marginal cost of earnings manipulation.

Proposition 5 Let $\beta_1^0 < \beta_2^0$. The investment threshold θ^* decreases (increases) in the cost of earnings management for extreme (intermediate) values of $\frac{x_2}{x_1}$. More specifically:

(i) When $\frac{x_2}{x_1} < \frac{\Delta_2}{\Delta_1}$, $\frac{\partial \theta^*}{\partial w} < 0$.

(ii) When $\frac{x_2}{x_1} = \frac{\Delta_2}{\Delta_1}$, $\frac{\partial \theta^*}{\partial w} = 0$.

(iii) When $\frac{x_2}{x_1} > \frac{\Delta_2}{\Delta_1}$, $\frac{\partial \theta^*}{\partial w} > (<) 0$ for small (large) values of $\frac{x_2}{x_1}$.

An interesting implication is that there are plausible scenarios under which prohibiting earnings management can lead to *less* efficient investment decisions. In particular, part (iii) of Proposition 5 shows that the investment threshold θ^* increases in the cost of earnings management for positive and small values of $\frac{x_2}{\Delta_2} - \frac{x_1}{\Delta_1}$.

To understand the intuition, notice from the objective function in (10) that the cost parameter w affects the investment threshold only indirectly through its effect on the choice of bonus coefficients. When the bonus coefficients are more (less) divergent in the investment region than in the non-investment region, the principal is more (less) concerned with earnings manipulation in the investment region, and will thus adjust investment threshold upward (downward) as earnings management becomes easier. Equations (8) and (14) reveal that the difference between the spreads in the two bonus coefficients in the investment and non-investment regions is given by:

$$[\beta_1(\theta) - \beta_2(\theta)] - [\beta_1^* - \beta_2^*] = m \cdot H(\theta) \cdot \left[\frac{x_2}{\Delta_2} - \frac{x_1}{\Delta_1} \right]. \quad (15)$$

Obviously, depending on the relative magnitude of x_1 and x_2 , the divergence between the bonus coefficients can be enlarged, reduced, or even reversed in the investment region relative to the non-investment region. We note that $\beta_1^* < \beta_2^*$ given our assumption of $\beta_1^0 < \beta_2^0$. Whenever $\frac{x_2}{\Delta_2}$ is smaller than $\frac{x_1}{\Delta_1}$, undertaking the investment enlarges the divergence between the bonus coefficients. Hence, as w decreases, the investment threshold θ^* will increase to mitigate earnings management. When $\frac{x_2}{\Delta_2} = \frac{x_1}{\Delta_1}$, the cost associated with truth-telling imposes the same magnitude of downward pressure on β_1 and β_2 so that the wedge between the two bonus coefficients remains unchanged. Consequently, the cost of earnings management has no impact on the investment threshold. As $\frac{x_2}{\Delta_2}$ increases above $\frac{x_1}{\Delta_1}$, the divergence between the periodic bonus coefficients in the investment region is initially less than that in the non-investment region. In this case, the investment threshold increases in the cost of earnings management w . However, when $\frac{x_2}{\Delta_2}$ is sufficiently large relative to $\frac{x_1}{\Delta_1}$, the sign of $[\beta_1(\theta) - \beta_2(\theta)]$ switches from negative to positive. Consequently, the *difference* between the spreads in the two bonus coefficients in the investment and non-investment regions increases in $\frac{x_2}{\Delta_2}$ for sufficiently large values of $\frac{x_2}{\Delta_2}$, and hence the investment threshold

decreases as w increases.

The above two propositions show that the investment threshold and the bonus coefficients change in different ways as w changes. Since the manager's expected informational rents increase in both the size of the investment region and the bonus coefficients over the investment region, we next study how the expected informational rents change as w changes.

As argued before, when $\frac{x_1}{\Delta_1} = \frac{x_2}{\Delta_2} = \frac{1}{\Delta_1 + \Delta_2}$, the need to curtail informational rents exerts the same amount of downward pressure on the two bonus coefficients so that undertaking the investment does not affect the divergence between periodic bonus coefficients. Consequently the investment threshold is unaffected by changes in w . Furthermore, as w decreases, the relative speed at which $\beta_1(\theta)$ and $\beta_2(\theta)$ converge toward each other is equal to $\frac{\Delta_2}{\Delta_1}$. Consequently, when $\frac{x_1}{\Delta_1} = \frac{x_2}{\Delta_2} = \frac{1}{\Delta_1 + \Delta_2}$, $\sum_{i=1}^2 x_i \cdot \beta_i(\theta)$ is independent of w . More specifically, as w decreases, the changes in $x_1 \cdot \beta_1(\theta)$ and $x_2 \cdot \beta_2(\theta)$ exactly offset each other so that $\sum_{i=1}^2 x_i \cdot \beta_i(\theta)$ stays constant. Since the manager's expected informational rents depends on both the size of the investment region and the weighted bonus coefficients over the investment region, managerial rents are independent of w when $x_1 = \frac{\Delta_1}{\Delta_1 + \Delta_2}$ and $x_2 = \frac{\Delta_2}{\Delta_1 + \Delta_2}$.

Without loss of generality, again let us assume that $\beta_1^0 < \beta_2^0$. Now consider a slight perturbation so that $x_1 \lesssim \frac{\Delta_1}{\Delta_1 + \Delta_2}$ and $x_2 \gtrsim \frac{\Delta_2}{\Delta_1 + \Delta_2}$. As w decreases and $\beta_1(\theta)$ and $\beta_2(\theta)$ converge toward each other, $\sum_{t=1}^2 x_t \cdot \beta_t(\theta)$ decreases because the increase in $x_1 \cdot \beta_1(\theta)$ is smaller than the decrease in $x_2 \cdot \beta_2(\theta)$. This effect tends to decrease the manager's informational rents. On the other hand, since $\beta_1^0 < \beta_1^* < \beta_2^* < \beta_2^0$ and $\frac{x_1}{\Delta_1} < \frac{x_2}{\Delta_2}$, a decrease in w decreases the investment threshold. This effect tends to increase the manager's informational rents. Which of these two effects dominates depends on the distribution of θ . The following proposition shows that when θ is uniformly distributed between $[\underline{\theta}, \bar{\theta}]$, the investment threshold is not as sensitive to changes in w and the first effect dominates.

Proposition 6 *Let $\beta_1^0 < \beta_2^0$. Suppose θ is uniformly distributed between $[\underline{\theta}, \bar{\theta}]$. Then, for values of x_1 in a neighborhood of $\frac{\Delta_1}{\Delta_1 + \Delta_2}$, the manager's expected rents are increasing (decreasing) in w when x_1 is less (higher) than $\frac{\Delta_1}{\Delta_1 + \Delta_2}$.*

To illustrate the above result, Figure 1 plots the expected informational rents as a function

of w when $\theta \sim U[0, 1]$, $\Delta_1 = \Delta_2 = 5$, $\lambda_1^2 = 3$, $\lambda_2^2 = 4$, and $k = 0.6$. We note that in this example, $\frac{\Delta_1}{\Delta_1 + \Delta_2} = 0.5$. The expected informational rents are increasing in w for $x_1 = 0.4$, and decreasing in w for $x_1 = 0.6$.

An implication of Proposition 6 is that there are plausible circumstances under which the manager actually earns *less* rents as earnings manipulation becomes *easier*. It is often argued that earnings management benefits opportunistic managers at the expense of shareholders. In contrast, our analysis shows that, in equilibrium, managers can sometimes earn *higher* rents when earnings management is prohibited.

The result below characterizes how the equilibrium amount of earnings management changes with the underlying profitability of the firm.

Proposition 7 *The equilibrium level of earnings management b^* increases (decreases) in the profitability of the investment project θ if $\frac{x_1}{x_2}$ is large (small). Specifically,*

$$\text{sgn} \left(\frac{\partial b^*}{\partial \theta} \right) = \text{sgn} \left(\frac{x_1}{\Delta_1} - \frac{x_2}{\Delta_2} \right).$$

Recall that b^* is the amount of earnings “borrowed” from the second period. The manager chooses b by equating $\beta_1(\theta) - \beta_2(\theta)$, the marginal increase in his compensation from increasing b , to $w \cdot b$, the marginal cost of increasing b . We note from equation (15) that in the investment region, the spread between $\beta_1(\theta)$ and $\beta_2(\theta)$ is related to $\left(\frac{x_2}{\Delta_2} - \frac{x_1}{\Delta_1} \right) \cdot H(\theta)$. Because $H(\theta)$ is a decreasing function, b^* will increase (decrease) in θ if $\frac{x_1}{\Delta_1} - \frac{x_2}{\Delta_2}$ is positive (negative). Therefore, depending on the time-profile of the project payoff, earnings management could either increase or decrease in the profitability of investment project θ . In particular, earnings management increases in the profitability for “front-loaded” payoffs (i.e., x_1 is large), and decrease for “back-loaded” payoffs (i.e., x_2 is large).

All else equal, one might expect a positive association between the level of reported earnings and the amount of (hidden) earnings management. In contrast, our analysis predicts a more nuanced relationship between reported accounting profits and earnings manipulation. For instance, Proposition 7 predicts a *negative* association between accounting earnings and earnings management for firms with back-loaded projects.

Another interesting observation is that even the direction of earnings management might change with the profitability of the project. To illustrate, suppose $\beta_1^0 > \beta_2^0$ so that when the investment project is not undertaken, the manager would want to "borrow" earnings from the second period. Now suppose x_1 is sufficiently large relative to x_2 so that $\beta_1(\theta^*)$ is smaller than $\beta_2(\theta^*)$, then when the investment is undertaken, the manager would want to "save" earnings for the second period. As θ increases, $\beta_t(\theta)$ converges to β_t^* and the direction of earnings manipulation eventually reverses.

5 Concluding Remarks

We study earnings management in a two-period agency setting in which the manager can shift earnings across periods. This discretion allows the manager to increase his compensation by moving earnings from the period with low pay-performance sensitivity to the period with high pay-performance sensitivity. To counteract the manager's earnings management incentives, the firm must bring periodic pay-performance sensitivities closer to each other. We demonstrate that the potential for earnings manipulation can lead to either higher or lower average incentive intensity in equilibrium, depending on the characteristics of the agency problem. Our analysis provides specific conditions for either of these two possibilities to emerge in equilibrium. This conclusion challenges the conventional view that lower-powered incentives are needed to counteract earnings management. We also show that in equilibrium, managerial compensation may be actually higher when earnings management is prohibited.

We also consider a setting in which the manager has private pre-contract information about the profitability of an available investment project whose payoff can not be separated from realized earnings. We investigate how earnings management affects the optimal managerial compensation and investment decision. We show that prohibiting earnings management may result in a less efficient investment decision for the firm and more rents for the manager.

APPENDIX

Proof of Proposition 1

It can be easily verified that the principal's objective function in (7) is globally concave in β_1 and β_2 . Hence, the optimal bonus coefficients β_i^* are given by the following first-order conditions:

$$\begin{aligned}\lambda_1^2 - \beta_1^* \cdot (\lambda_1^2 + \rho \cdot \sigma_1^2) - \frac{(\beta_1^* - \beta_2^*)}{w} &= 0, \\ \lambda_2^2 - \beta_2^* \cdot (\lambda_2^2 + \rho \cdot \sigma_2^2) + \frac{(\beta_1^* - \beta_2^*)}{w} &= 0.\end{aligned}$$

The above equations can be solved to yield:

$$\beta_i^* = \frac{\lambda_j^2 + \lambda_i^2 \cdot (1 + w \cdot \Delta_j)}{\Delta_1 + \Delta_2 + w \cdot \Delta_1 \cdot \Delta_2},$$

where $i \neq j$. Hence,

$$\beta_1^* - \beta_2^* = \frac{w \cdot (\lambda_1^2 \cdot \Delta_2 - \lambda_2^2 \cdot \Delta_1)}{\Delta_1 + \Delta_2 + w \cdot \Delta_1 \cdot \Delta_2}.$$

Consequently, we have

$$\begin{aligned}\text{sgn}(\beta_1^* - \beta_2^*) &= \text{sgn}(\lambda_1^2 \cdot \Delta_2 - \lambda_2^2 \cdot \Delta_1) \\ &= \text{sgn}(\beta_1^0 - \beta_2^0), \text{ and} \\ \frac{\partial (|\beta_1^* - \beta_2^*|)}{\partial w} &\geq 0,\end{aligned}$$

Notice that $\frac{\partial (|\beta_1^* - \beta_2^*|)}{\partial w} = 0$ if and only if $\lambda_1^2 \cdot \Delta_2 - \lambda_2^2 \cdot \Delta_1$, i.e., $\beta_1^0 = \beta_2^0$.

Proof of Proposition 2

It follows from the expressions for the optimal bonus coefficients in the proof of Proposition 1 that:

$$\beta_1^* + \beta_2^* = \frac{2 \cdot (\lambda_1^2 + \lambda_2^2) + w \cdot (\lambda_1^2 \cdot \Delta_2 + \lambda_2^2 \cdot \Delta_1)}{\Delta_1 + \Delta_2 + w \cdot \Delta_1 \cdot \Delta_2}.$$

Differentiating with respect to w and simplifying yield

$$\frac{\partial (\beta_1^* + \beta_2^*)}{\partial w} = \frac{(\lambda_2^2 \Delta_1 - \lambda_1^2 \Delta_2) \cdot (\Delta_1 - \Delta_2)}{(\Delta_1 + \Delta_2 + w \cdot \Delta_1 \cdot \Delta_2)^2}.$$

The conclusion of Proposition 2 then follows, since

$$\begin{aligned} \operatorname{sgn} \left[\frac{\partial (\beta_1^* + \beta_2^*)}{\partial w} \right] &= \operatorname{sgn} [(\lambda_2^2 \Delta_1 - \lambda_1^2 \Delta_2) \cdot (\Delta_1 - \Delta_2)] \\ &= \operatorname{sgn} [(\Delta_1 - \Delta_2) (\beta_2^0 - \beta_1^0)]. \end{aligned}$$

Proof of Corollary 1

Since

$$\beta_i^* = \frac{\lambda_j^2 + \lambda_i^2 \cdot (1 + w \cdot \Delta_j)}{\Delta_1 + \Delta_2 + w \cdot \Delta_1 \cdot \Delta_2},$$

it is easy to see that when $w = 0$, $\beta_1^* = \beta_2^* = \frac{\lambda_1^2 + \lambda_2^2}{\Delta_1 + \Delta_2}$.

Proof of Proposition 3

The firm's expected profit is given by

$$\Pi(\beta_1^*(w), \beta_2^*(w), w) = \sum_{t=1}^2 \pi_t(\beta_t^*) - \frac{1}{2} \cdot w^{-1} \cdot (\beta_1^* - \beta_2^*)^2,$$

where $\pi_t(\cdot)$ is as defined in (2). Differentiating with respect to w and applying the Envelope Theorem reveal that

$$\frac{d\Pi}{dw} = \frac{1}{2} \cdot w^{-2} \cdot (\beta_1^* - \beta_2^*)^2 > 0.$$

This proves the first part of the proposition.

Since $b^* = \frac{\beta_1^* - \beta_2^*}{w}$, substituting in the expressions for β_1^* and β_2^* yields

$$\begin{aligned} \frac{\partial \left(\frac{1}{2} \cdot w \cdot b^{*2} \right)}{\partial w} &= \frac{1}{2} \cdot \left(\frac{\lambda_1^2 \cdot \Delta_2 - \lambda_2^2 \cdot \Delta_1}{\Delta_1 + \Delta_2 + w \cdot \Delta_1 \cdot \Delta_2} \right)^2 - \frac{w \cdot \Delta_1 \cdot \Delta_2 \cdot (\lambda_1^2 \cdot \Delta_2 - \lambda_2^2 \cdot \Delta_1)^2}{(\Delta_1 + \Delta_2 + w \cdot \Delta_1 \cdot \Delta_2)^3} \\ &= \frac{1}{2} \frac{(\lambda_1^2 \cdot \Delta_2 - \lambda_2^2 \cdot \Delta_1)^2}{(\Delta_1 + \Delta_2 + w \cdot \Delta_1 \cdot \Delta_2)^2} (\Delta_1 + \Delta_2 - w \cdot \Delta_1 \cdot \Delta_2). \end{aligned}$$

Thus,

$$\operatorname{sgn} \left[\frac{\partial \left(\frac{1}{2} \cdot w \cdot b^{*2} \right)}{\partial w} \right] = \operatorname{sgn}(\Delta_1 + \Delta_2 - w \cdot \Delta_1 \cdot \Delta_2).$$

It therefore follows that the equilibrium cost of earnings management is increasing in w for $w < \frac{\Delta_1 + \Delta_2}{\Delta_1 \cdot \Delta_2}$, and decreasing in w for $w > \frac{\Delta_1 + \Delta_2}{\Delta_1 \cdot \Delta_2}$. This proves the second part of the proposition.

To prove part (iii), we note that:

$$E(s_1 + s_2) = \frac{1}{2} \cdot \lambda_1^2 \cdot \beta_1^{*2} + \frac{1}{2} \cdot \lambda_2^2 \cdot \beta_2^{*2} + \frac{1}{2} \cdot \rho \cdot \beta_1^{*2} \cdot \sigma_1^2 + \frac{1}{2} \cdot \rho \cdot \beta_2^{*2} \cdot \sigma_2^2 + \frac{1}{2} \cdot w^{-1} \cdot (\beta_1^* - \beta_2^*)^2.$$

Substituting the expressions for the optimal bonus coefficients yields

$$\begin{aligned} E(s_1 + s_2) &= \frac{\Delta_1}{2} \cdot \left(\frac{\lambda_2^2 + \lambda_1^2(1 + w\Delta_2)}{\Delta_1 + \Delta_2 + w\Delta_1\Delta_2} \right)^2 + \frac{\Delta_2}{2} \cdot \left(\frac{\lambda_1^2 + \lambda_2^2(1 + w\Delta_1)}{\Delta_1 + \Delta_2 + w\Delta_1\Delta_2} \right)^2 + \frac{w}{2} \cdot \left(\frac{\lambda_1^2\Delta_2 - \lambda_2^2\Delta_1}{\Delta_1 + \Delta_2 + w\Delta_1\Delta_2} \right)^2 \\ &= \frac{(\lambda_1^2 + \lambda_2^2)^2 + w \cdot (\Delta_1\lambda_2^4 + \Delta_2\lambda_1^4)}{2(\Delta_1 + \Delta_2 + w\Delta_1\Delta_2)}. \end{aligned}$$

Differentiating with respect to w gives

$$\begin{aligned} \frac{\partial E(s_1 + s_2)}{\partial w} &= -\frac{\Delta_1\Delta_2 \left((\lambda_1^2 + \lambda_2^2)^2 + (\Delta_1\lambda_2^4 + \Delta_2\lambda_1^4)w \right)}{2 \cdot (\Delta_1 + \Delta_2 + w\Delta_1\Delta_2)^2} + \frac{(\Delta_1\lambda_2^4 + \Delta_2\lambda_1^4)}{2 \cdot (\Delta_1 + \Delta_2 + w\Delta_1\Delta_2)} \\ &= \frac{(\Delta_1\lambda_2^2 - \Delta_2\lambda_1^2)^2}{2(\Delta_1 + \Delta_2 + w\Delta_1\Delta_2)^2} \\ &> 0. \end{aligned}$$

This proves the third part of Proposition 3.

Proof of Lemma 1

The objective function in (10) can be maximized pointwise. The optimal bonus coefficients will solve the following first-order conditions:

$$\begin{aligned} \lambda_1^2 - x_1 \cdot H(\theta) \cdot I(\theta) - \beta_1(\theta) \cdot \Delta_1 - w^{-1}[\beta_1(\theta) - \beta_2(\theta)] &= 0 \\ \lambda_2^2 - x_2 \cdot H(\theta) \cdot I(\theta) - \beta_2(\theta) \cdot \Delta_2 + w^{-1}[\beta_1(\theta) - \beta_2(\theta)] &= 0. \end{aligned}$$

It thus follows that $\beta_t(\theta) = \beta_t^*$ when $I(\theta) = 0$. When $I(\theta) = 1$, the above two equations solve to yield the following optimal bonus coefficients:

$$\beta_1(\theta) = \frac{\lambda_2^2 - x_2 \cdot H(\theta) + (\lambda_1^2 - x_1 \cdot H(\theta)) \cdot (1 + w \cdot \Delta_2)}{\Delta_1 + \Delta_2 + w \cdot \Delta_1 \cdot \Delta_2}, \quad (16)$$

and

$$\beta_2(\theta) = \frac{\lambda_1^2 - x_1 \cdot H(\theta) + (\lambda_2^2 - x_2 \cdot H(\theta)) \cdot (1 + w \cdot \Delta_1)}{\Delta_1 + \Delta_2 + w \cdot \Delta_1 \cdot \Delta_2}. \quad (17)$$

Since $H(\cdot)$ is decreasing, it can be easily verified that $\beta_t^*(\theta)$ is increasing in θ for each t .

With respect to the investment policy, the principal will accept the project if and only if:

$$\theta - k - \sum_{t=1}^2 \beta_t(\theta) \cdot x_t \cdot H(\theta) + G(\beta_1(\theta), \beta_2(\theta)) \geq G(\beta_1^*, \beta_2^*), \quad (18)$$

where $\beta_t(\theta)$ denotes the optimal bonus coefficient in the investment region. Applying the Envelope Theorem, it can then be verified that the left hand side of (18) is increasing in θ .

Note that $\beta_t(\bar{\theta}) = \beta_t^*$, since $H(\bar{\theta}) = 0$. Hence, (18) holds as an inequality at $\theta = \bar{\theta}$. On the other hand, the inequality in (18) fails to hold at $\theta = k$. Consequently, there exists a unique $\theta^* \in (k, \bar{\theta})$ such that the principal invests if and only if $\theta \geq \theta^*$.

Proof of Proposition 4

Using the expressions for the optimal bonus coefficients in (16) and (17), it can be shown that:

$$\frac{\partial (\beta_1(\theta) + \beta_2(\theta))}{\partial w} = \frac{[(\lambda_2^2 - x_2 \cdot H(\theta)) \cdot \Delta_1 - (\lambda_1^2 - x_1 \cdot H(\theta)) \cdot \Delta_2] \cdot [\Delta_1 - \Delta_2]}{[\Delta_1 + \Delta_2 + w \cdot \Delta_1 \cdot \Delta_2]^2}.$$

Hence,

$$\begin{aligned} \text{sgn} \left[\frac{\partial (\beta_1(\theta) + \beta_2(\theta))}{\partial w} \right] &= \text{sgn} [(\lambda_2^2 - x_2 \cdot H(\theta)) \cdot \Delta_1 - (\lambda_1^2 - x_1 \cdot H(\theta)) \cdot \Delta_2] \cdot (\Delta_1 - \Delta_2) \\ &= \text{sgn} [(\Delta_1 - \Delta_2) \cdot (\beta_2^0(\theta) - \beta_1^0(\theta))]. \end{aligned}$$

The conclusion in Proposition 4 follows.

Proof of Proposition 5

Note that the optimal cutoff θ^* is given by

$$\theta^* - k - [x_1 \cdot \beta_1(\theta^*) + x_2 \cdot \beta_2(\theta^*)] \cdot H(\theta^*) + G(\beta_1(\theta^*), \beta_2(\theta^*)) - G(\beta_1^*, \beta_2^*) = 0$$

where

$$(i) \quad G(\beta_1, \beta_2) \equiv \sum_{t=1}^2 \left[\lambda_t^2 \cdot \beta_t - \frac{1}{2} \cdot \Delta_t \cdot \beta_t^2 \right] - \frac{1}{2} \cdot w^{-1} \cdot (\beta_1 - \beta_2)^2,$$

(ii) $\beta_t(\theta)$ uniquely maximizes $G(\beta_1, \beta_2) - [x_1 \cdot \beta_1 + x_2 \cdot \beta_2] \cdot H(\theta)$, and

(iii) β_t^* uniquely maximizes $G(\beta_1, \beta_2)$.

Differentiating the above expression for θ^* with respect to w and using the Envelope Theorem yield

$$\begin{aligned} & [1 - (x_1 \cdot \beta_1(\theta^*) + x_2 \cdot \beta_2(\theta^*)) \cdot H'(\theta^*)] \frac{\partial \theta^*}{\partial w} \\ &= \frac{\partial}{\partial w} [G(\beta_1^*, \beta_2^*) - G(\beta_1(\theta^*), \beta_2(\theta^*))]. \end{aligned}$$

Since

$$\frac{\partial G(\beta_1, \beta_2)}{\partial w} = \frac{1}{2} \cdot w^{-2} \cdot (\beta_1 - \beta_2)^2,$$

substituting the expressions for $\{\beta_t^*\}$ and $\{\beta_t(\theta^*)\}$ and simplifying yield

$$\frac{\partial \theta^*}{\partial w} = \frac{1}{2} \cdot \frac{(\Delta_1 \Delta_2)^2}{(\Delta_1 + \Delta_2 + w \Delta_1 \Delta_2)^2} \left[\frac{x_1}{\Delta_1} - \frac{x_2}{\Delta_2} \right] \frac{\left(2(\beta_1^0 - \beta_2^0) - H(\theta) \cdot \left(\frac{x_1}{\Delta_1} - \frac{x_2}{\Delta_2} \right) \right) H(\theta)}{[1 - (x_1 \cdot \beta_1(\theta^*) + x_2 \cdot \beta_2(\theta^*)) \cdot H'(\theta^*)]}.$$

Since $H'(\cdot) < 0$, we get

$$\text{sgn} \left[\frac{\partial \theta^*}{\partial w} \right] = \text{sgn} \left[\left(\frac{x_1}{\Delta_1} - \frac{x_2}{\Delta_2} \right) \cdot \left(2(\beta_1^0 - \beta_2^0) - H(\theta^*) \left(\frac{x_1}{\Delta_1} - \frac{x_2}{\Delta_2} \right) \right) \right].$$

The conclusion in Proposition 5 then follows.

Proof of Proposition 6

Let

$$R \equiv \int_{\theta^*}^{\bar{\theta}} [\beta_1(\theta) x_1 + \beta_2(\theta) x_2] [1 - F(\theta)] d\theta$$

denote the manager's expected information rents. Differentiating with respect to w yields

$$\frac{\partial R}{\partial w} = \int_{\theta^*}^{\bar{\theta}} \frac{\partial [\beta_1(\theta) x_1 + \beta_2(\theta) x_2]}{\partial w} (1 - F(\theta)) d\theta - \frac{\partial \theta^*}{\partial w} \cdot [\beta_1(\theta^*) \cdot x_1 + \beta_2(\theta^*) \cdot x_2] (1 - F(\theta^*)).$$

Using the expressions (16) and (17) for the optimal bonus coefficients, it can be easily verified that

$$\frac{\partial [\beta_1(\theta) \cdot x_1 + \beta_2(\theta) \cdot x_2]}{\partial w} = \Omega \cdot \left[\frac{x_1}{\Delta_1} - \frac{x_2}{\Delta_2} \right] \left[(\beta_1^0 - \beta_2^0) - H(\theta) \cdot \left(\frac{x_1}{\Delta_1} - \frac{x_2}{\Delta_2} \right) \right],$$

where, for brevity, we define $\Omega = \frac{(\Delta_1 \Delta_2)^2}{(\Delta_1 + \Delta_2 + w \cdot \Delta_1 \cdot \Delta_2)^2}$.

It thus follows that:

$$\frac{\partial \theta^*}{\partial w} = \frac{1}{2} \cdot \Omega \cdot \left[\frac{x_1}{\Delta_1} - \frac{x_2}{\Delta_2} \right] \frac{\left(2(\beta_1^0 - \beta_2^0) - H(\theta) \cdot \left(\frac{x_1}{\Delta_1} - \frac{x_2}{\Delta_2} \right) \right) H(\theta)}{\left[1 - (x_1 \cdot \beta_1(\theta^*) + x_2 \cdot \beta_2(\theta^*)) \cdot H'(\theta^*) \right]}.$$

When $\frac{x_1}{\Delta_1} = \frac{x_2}{\Delta_2} \equiv \frac{1}{\Delta_1 + \Delta_2}$, we have:

$$\begin{aligned} \frac{\partial R}{\partial w} &= 0, \text{ and} \\ \sum_{i=1}^2 x_i \cdot \beta_i(\theta^*) &= \frac{\lambda_1^2 + \lambda_2^2}{\Delta_1 + \Delta_2} - \frac{H(\theta^*)}{\Delta_1 + \Delta_2}. \end{aligned}$$

Now we study how $\frac{\partial R}{\partial w}$ changes with x_1 at the point where $\frac{x_1}{\Delta_1} = \frac{x_2}{\Delta_2} = \frac{1}{\Delta_1 + \Delta_2}$. Without loss of generality, assume that $\beta_1^0 < \beta_2^0$. Since $\frac{x_1}{\Delta_1} - \frac{x_2}{\Delta_2}$ increases as x_1 increases,

$$\begin{aligned} \text{sgn} \left(\frac{\partial R}{\partial w \partial x_1} \Big|_{x_1 = \frac{\Delta_1}{\Delta_1 + \Delta_2}} \right) &= -\text{sgn} \left(\int_{\theta^*}^{\bar{\theta}} [1 - F(\theta)] d\theta - \frac{\sum_{i=1}^2 x_i \cdot \beta_i(\theta^*) \cdot H(\theta^*)}{1 - \sum_{i=1}^2 x_i \cdot \beta_i(\theta^*) \cdot H'(\theta^*)} \cdot [1 - F(\theta^*)] \right) \\ &= -\text{sgn} \left(\int_{\theta^*}^{\bar{\theta}} [1 - F(\theta)] d\theta - \frac{\left(\frac{\lambda_1^2 + \lambda_2^2}{\Delta_1 + \Delta_2} - \frac{H(\theta^*)}{\Delta_1 + \Delta_2} \right) \cdot H(\theta^*)}{1 - \left(\frac{\lambda_1^2 + \lambda_2^2}{\Delta_1 + \Delta_2} - \frac{H(\theta^*)}{\Delta_1 + \Delta_2} \right) \cdot H'(\theta^*)} \cdot [1 - F(\theta^*)] \right). \end{aligned}$$

For uniform distribution, $H'(\cdot) = -1$. Hence,

$$\begin{aligned} & -\text{sgn} \left(\int_{\theta^*}^{\bar{\theta}} [1 - F(\theta)] d\theta - \frac{\left(\frac{\lambda_1^2 + \lambda_2^2}{\Delta_1 + \Delta_2} - \frac{H(\theta^*)}{\Delta_1 + \Delta_2} \right) \cdot H(\theta^*)}{1 - \left(\frac{\lambda_1^2 + \lambda_2^2}{\Delta_1 + \Delta_2} - \frac{H(\theta^*)}{\Delta_1 + \Delta_2} \right) \cdot H'(\theta^*)} \cdot [1 - F(\theta^*)] \right) \\ &= \text{sgn} \left[\frac{\left(\frac{\lambda_1^2 + \lambda_2^2}{\Delta_1 + \Delta_2} - \frac{H(\theta^*)}{\Delta_1 + \Delta_2} \right)}{1 + \left(\frac{\lambda_1^2 + \lambda_2^2}{\Delta_1 + \Delta_2} - \frac{H(\theta^*)}{\Delta_1 + \Delta_2} \right)} - \frac{\int_{\theta^*}^{\bar{\theta}} (\bar{\theta} - \theta) d\theta}{(\bar{\theta} - \theta^*)^2} \right] \\ &= \text{sgn} \left[\frac{\left(\frac{\lambda_1^2 + \lambda_2^2}{\Delta_1 + \Delta_2} - \frac{H(\theta^*)}{\Delta_1 + \Delta_2} \right)}{1 + \left(\frac{\lambda_1^2 + \lambda_2^2}{\Delta_1 + \Delta_2} - \frac{H(\theta^*)}{\Delta_1 + \Delta_2} \right)} - \frac{1}{2} \right] < 0. \end{aligned}$$

Hence, there exists $\{x_1, x_2\}$ in the neighborhood of $\left\{ \frac{\Delta_1}{\Delta_1 + \Delta_2}, \frac{\Delta_2}{\Delta_1 + \Delta_2} \right\}$ such that $\frac{\partial R}{\partial w}$ is positive (negative) for the values of x_1 less (greater) than $\frac{\Delta_1}{\Delta_1 + \Delta_2}$.

Proof of Proposition 7

$$\begin{aligned} b(\theta) &= w^{-1} \cdot (\beta_1(\theta) - \beta_2(\theta)) \\ &= w^{-1} \cdot m \cdot \left[(\beta_1^0 - \beta_2^0) - H(\theta) \cdot \left(\frac{x_1}{\Delta_1} - \frac{x_2}{\Delta_2} \right) \right], \end{aligned}$$

where m is as defined in connection with (8).

Since $H'(\theta) < 0$, we have

$$\operatorname{sgn} \left(\frac{\partial b(\theta)}{\partial \theta} \right) = \operatorname{sgn} \left(\frac{x_1}{\Delta_1} - \frac{x_2}{\Delta_2} \right).$$

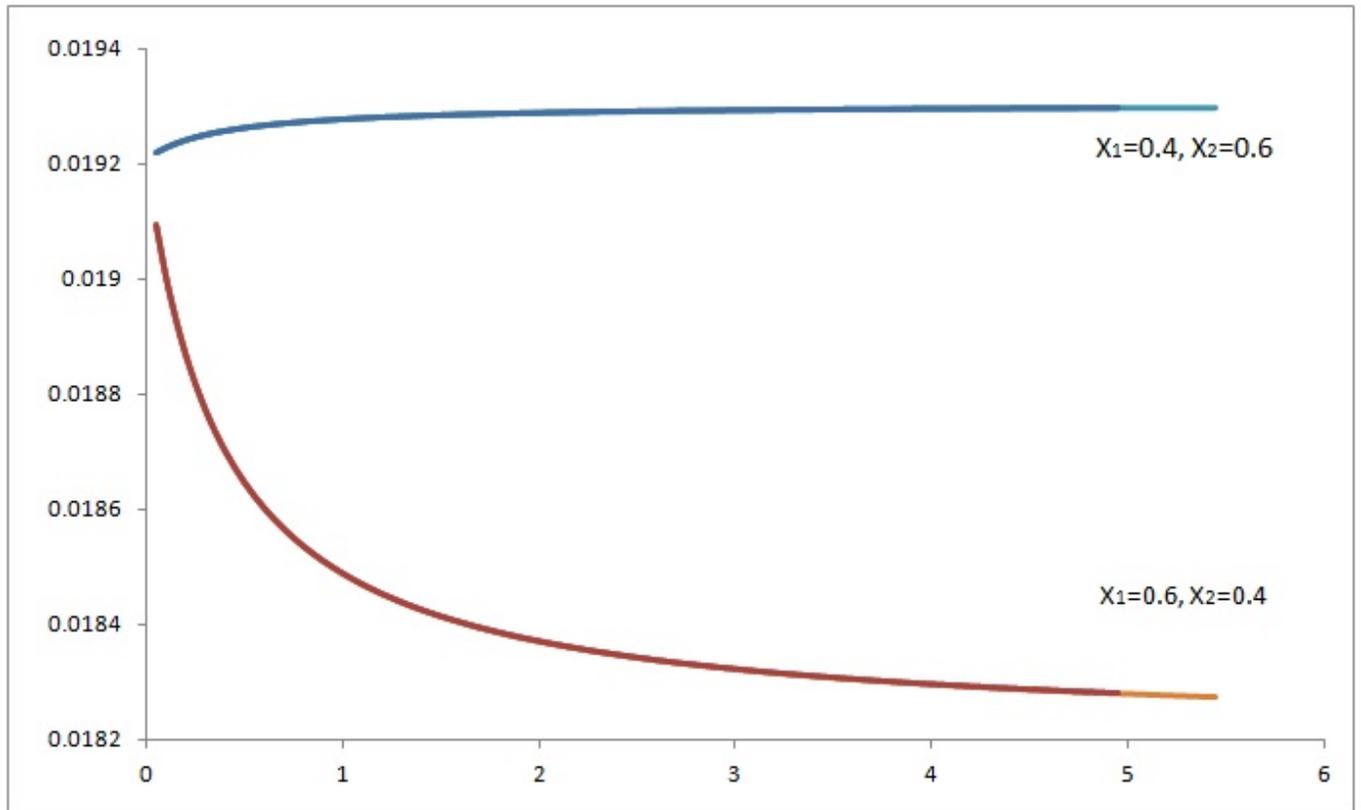


Figure 1: Information rents as a function of w

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