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 based on agency theory 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, 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 (linear) 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? What is the effect of earnings management on other managerial decisions such as investment choices? How does the possibility of earnings management affect managerial compensation levels?

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

[1] See 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.

In the absence of earnings management (i.e., when manipulation is 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, the optimal bonus rates (pay-performance sensitivities) would increase over time. However, when the manager can manipulate earnings, such an incentive plan would induce the manager to shift earnings across periods. In particular, the manager would have incentives to shift earnings to the period with higher bonus rate from the one with lower bonus rate. While the firm could eliminate the manager's incentives to manage earnings by choosing identical bonus rates for the two periods, such a contract would be suboptimal from the perspective of providing desirable effort incentives. Consistent with Liang (2004), we find that it is optimal to reduce (but not eliminate) the spread between the two bonus rates. We also show that the optimal spread between periodic bonus rates increases as the manager's cost of earnings management increases.[2]

A number of empirical studies find a positive relationship between the use of incentive compensation and manipulation of accounting reports[3]. However, there is scant theory work on how the potential for earnings manipulation affects the equilibrium level of pay-performance sensitivity. In a single period agency setting, Goldman and Slezak (2006) show that the possibility of earnings manipulation results in lower-powered incentives; that is, the optimal pay-performance sensitivity is lower than what it would be if accounting manipulation were prohibited. Since there is no unwinding of earnings management in their setting,

[2]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.

[3]See, for instance, Bergstresser and Philippon (2006), Burns and Kedia (2006), Efendi et al. (2007), Gaver et al. (1995), Healy (1985), Holthausen et al. (1995), Johnson et al. (2009), and Ke (2004).

the manager's manipulation incentives are driven by the *level* of pay-performance sensitivity. To curtail costly manipulation, the principal finds it optimal to use lower-powered incentives. In contrast, the manager's earnings manipulation incentives depend on the *difference* between periodic bonus rates in our dynamic setting, since any accounting bias added in the first period must subsequently reverse in the second period. As a consequence, we find that the possibility of earnings manipulation can lead to either higher- or lower-powered incentives. Our analysis provides specific conditions for either of these two possibilities to emerge in equilibrium.

We next investigate how the equilibrium level of managerial compensation changes as earnings manipulation becomes more difficult (e.g., due to more stringent accounting and auditing standards or corporate governance mechanisms). While one might think that prohibiting earnings management would prevent managers from inflating their bonuses, our analysis shows that the equilibrium level of managerial compensation *increases* as earnings management becomes more difficult. Though the manager shifts income across periods to maximize his bonus, the firm rationally anticipates the manager's earnings management strategy and lowers his fixed compensation accordingly. In equilibrium, therefore, the manager is compensated only for bearing risk and his personal cost of induced efforts. When earnings manipulation becomes more difficult, the optimal incentive contract induces more productive effort from the manager, which, in turn, requires a higher level of managerial compensation.

Since the equilibrium level of earnings management decreases in the cost of manipulation, the above result predicts a *negative* association between managerial compensation and earnings management. Moreover, the manager's personal cost of accounting manipulation would be expected to increase in the effectiveness of corporate governance mechanisms. Therefore, our analysis predicts a *positive* relation between executive compensation and strength of corporate governance. This prediction is in contrast to that suggested by the rent extraction argument of Bebchuk and Fried (2004). Their theory predicts a *negative* relation between executive compensation and strength of corporate governance mechanisms, since strong corporate governance deter managers from extracting rents from shareholders.

Next we examine an extended setting where in addition to contributing efforts, the manager possesses superior information regarding the profitability of an investment opportunity available to the firm. In this setting with both hidden action and hidden information problems, we investigate how the possibility of earnings management affects optimal managerial incentives and the efficiency of the investment decision. It is well-known from the adverse selection literature that the better informed manager earns informational rents. In our model with earnings management, therefore, an optimal contact must balance the conflicting objectives of inducing efficient investment and effort decisions, while at the same time deterring earnings manipulation and curtailing managerial rents. Consistent with the finding of Dutta and Reichelstein (2002), we show that the firm optimally underinvests and provides lower powered incentives. As in the symmetric information setting, we show that the optimal bonus rates are less divergent across periods and the possibility of earnings manipulation can lead to either higher- or lower-powered incentives, depending on the specifics of the periodic agency problems.

We also find plausible circumstances under which prohibiting earnings management leads to *less* efficient investment decisions. To see why, note that the effect of the manager's cost of manipulation on the optimal investment choice depends on how the manipulation incentives change when the project is undertaken. For example, if undertaking the project leads to less divergent bonus rates across periods, the principal is less concerned about earnings manipulation in the investment region. In this case, as earnings manipulation becomes easier, the principal optimally chooses to invest more often by lowering the hurdle rate for investment. More generally, we demonstrate that whether the investment efficiency increases or decreases in the cost of earnings management depends on the intertemporal profile of the project's payoffs, since this profile determines the optimal spread between the periodic incentive rates in the investment region.

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 thus arises from (i) informational rents accrued to the manager and (ii) inefficient incentives due to 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 insights 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, (iv) may *reduce* managerial rents, and (v) may lead to a *negative* association between managerial compensation and earnings management.

In contracting contexts, earnings management has been mostly studied in static settings. 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), Feltham and Xie (1994), and Goldman and Slezak (2006) model earnings management as a form of window dressing action that changes reported earnings, but have no effect on underlying true earnings. Unlike our analysis, these papers consider single period settings which do not allow for any unwinding of earnings management. Except Goldman and Slezak (2006), these studies also focus on research questions that are quite different from the focus of our paper.

Liang (2004), Nan (2008), and Christensen *et al* (2013) investigate two-period LEN models of earnings management with reversal of discretionary accruals. While our analysis and these studies share this modeling feature, our paper is quite different from these studies in terms of its research focus and other modeling choices. Christensen *et al* (2013) and Liang (2004) primarily seek to identify conditions under which allowing earnings management can be socially efficient, while Nan (2008) focuses on the interaction between hedging and earnings management.[4] These papers do not investigate how the possibility of earnings manipulation affects incentives and production/investment decisions of privately informed managers. Furthermore, none of these papers focuses on characterizing how the potential for information manipulation affects equilibrium pay-performance sensitivities. Liang (2004) and Nan (2008) consider binary effort settings in which optimal effort incentives are exogenously fixed. Unlike our paper, Christensen *et al* (2013) examine a limited commitment setting in which contracts are subject to *ex post* renegotiation. They find that prohibiting earnings management may be inefficient because it serves as a substitute for the principal's inability to commit. In contrast, accounting manipulation serves no useful function in our model with full commitment.[5]

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 settings 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.[6] Sankar and Subramanayam (2001) also study earnings management in a capital market setting. They examine a two-period model in which accounting bias added in the first period partially reverses in the second period. However, unlike our paper which characterizes the equilibrium relationship between earnings management and incentive contacts, all of these papers assume

[4]Drymiotes and Hemmer (2013) also consider a two-period agency setting in which the agent can manipulate earnings and earnings management reverses in the final period. However, the possibility of earnings manipulation does not affect optimal contracts in their model because contacts can only be based on aggregated earnings over the two periods.

[5]Even though Liang (2004) assumes full commitment, he finds that prohibiting manipulation may be suboptimal under some circumstances. In his model, the induced level of earnings management depends on the agent's private information, which the agent cannot directly communicate. Hence, earnings management can sometimes allow for a more efficient allocation of compensation risk across periods.

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

that the manager's incentives are exogenously specified.

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 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. 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:

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

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 over time due to learning-by-doing (i.e., $\lambda_2 > \lambda_1$), or, conversely, managerial skills might become less relevant over time due to technological changes (i.e., $\lambda_1 > \lambda_2$). 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. The bias added in the first period fully reverses in the second period.[7] Therefore, the reported earnings in the second period are given by:

$$e_2 = y_2 - b.$$

The risk-neutral principal seeks to maximize the present value of future cash flows net of compensation payments. The manager is risk averse and his preferences can be described by an additively-separable exponential utility with risk aversion coefficient $\hat{\rho}$. As a function of his action choices (a_1, a_2, b), the manager's utility takes the form:

$$U = -\sum_{t=1}^{\infty} \gamma^t \cdot \exp\left[-\hat{\rho} \cdot \left(h_t - \frac{1}{2} \cdot a_t^2 - \frac{1}{2} \cdot w \cdot b_t^2\right)\right],$$

where $\gamma \equiv \frac{1}{1+r}$ denotes the discount factor. In each period, the manager's current utility depends on his current consumption of money h_t net of his disutility of productive and manipulation efforts. The disutility of productive effort in monetary units is given by $\frac{1}{2} \cdot a_t^2$ (with $a_t = 0$ for $t > 2$). The cost of manipulation effort is given by $\frac{1}{2} \cdot w \cdot b^2$ where $w \geq 0$ and $b_t = 0$ for $t > 1$ with $b_1 \equiv b$.[8] Consistent with the earlier literature, we assume that the

[7] The qualitative nature of our results remains unchanged if we allow for only a *partial* reversal of earnings management in the second period. A 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.

[8] The assumption of quadratic cost functions adds significant tractibility to our analysis and is quite common in the linear contracting literature. However, we believe that most of our results would remain valid for more general convex cost functions.

manager can borrow and lend in each period at the principal's interest rate r. Therefore, consumption in period t is given by $h_t = s_t + (1+r) \cdot W_{t-1} - W_t$, where s_t denotes the compensation payment in period t and W_t denotes the manager's savings at date t.

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.

We assume that the two parties can commit to a two-period contract at the beginning of period 1.[9] For tractibility, we restrict our attention to compensation contracts that are linear functions of reported earnings. The manager's compensation in period t takes the form:

$$s_t(e_t) = \alpha_t + \beta_t \cdot e_t, \tag{1}$$

where α_t denotes the fixed salary and β_t denotes the pay-performance sensitivity. Though s_t is assumed to depend only on current earnings, e_t, rather than on the entire history of earnings, this assumption is without loss of generality given that contracts are long-term and the manager has access to third-party banking.

Solving for the manager's optimal consumption plan by backward induction, it can be shown that the manager's *ex ante* expected utility from any given contract $\{s_t = \alpha_t + \beta_t \cdot e_t\}_{t=1}^2$ simplifies to $EU = -\frac{1}{r}\exp\{-r \cdot \rho \cdot CE\}$, where

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

[9] Our 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 has no effect on the two parties's payoffs.

and $\rho \equiv \hat{\rho} \cdot (1-\gamma)$.[10] Equation (2) shows that the manager's certainty equivalent of a two-period contract of the form in (1) is equal to the discounted sum of certainty equivalent of the incentive contract for each period, and these certainty equivalent expressions take the familiar mean-variance form.

3 Optimal Contracts and Earnings Management

We now study the design of optimal (linear) compensation contracts and earnings management induced in equilibrium. 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 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.

The certainty equivalent expression in (2) shows that for a given contract $\{s_t = \alpha_t + \beta_t \cdot e_t\}_{t=1}^2$, the manager's choices of periodic productive efforts and earnings manipulation effort will satisfy the following first-order conditions:[11]

$$a_t = \lambda_t \cdot \beta_t, \tag{3}$$

$$b = w^{-1} \cdot (\beta_1 - \gamma \cdot \beta_2). \tag{4}$$

We note that the induced level of productive effort a_t is proportional to the pay-performance sensitivity β_t. 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-

[10] We skip the proof, since it is a well-known result in the multiperiod LEN literature based on additively-separable CARA preferences. See, for instance, Lemma 1 in Dutta and Reichelstein (2003).

[11] It can be easily verified that the manager's expected utility, as represented by the certainty equivalent expression in (2), is a concave function of a_1, a_2, and b, and hence these conditions are necessary as well as sufficient.

based compensation induces both productive effort as in (3) and non-productive accounting manipulation as in (4). We note that the manager's earnings manipulation incentives depend on the *difference* between (the discounted values of) the two bonus coefficients. The manager has incentives to "borrow" earnings from the future (i.e., $b > 0$) when $\beta_1 > \gamma \cdot \beta_2$ and "save" earnings for the future (i.e., $b < 0$) when $\beta_1 < \gamma \cdot \beta_2$.

The principal's problem of choosing an optimal contract can be written as:

$$\max_{\{\alpha_t,\, \beta_t\}} \sum_{t=1}^{2} \gamma^t \cdot [\lambda_t \cdot a_t \cdot (1 - \beta_t) - \alpha_t] - \gamma \cdot (\beta_1 - \gamma \cdot \beta_2) \cdot b$$

subject to

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

$$(ii) \quad b = w^{-1} \cdot (\beta_1 - \gamma \cdot \beta_2)$$

$$(iii) \; CE \geq 0.$$

The objective function represents the present value of expected future cash flows net of compensation payments to the manager. Constraint (i) and (ii) reflect the first-order conditions of the manager's incentive compatibility constraints with respect to a_t and b, respectively. Constraint (iii) represents the manager's participation constraint. Without loss of generality, we have normalized the manager's outside option to zero; that is, in each period the manager can earn a work- and risk-free wage of zero in outside employment.

Substituting (i) and (ii) into the certainty equivalent expression in (2) yield

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

We note that though the principal cannot directly observe the manager's choice of earnings manipulation, he can perfectly predict it in equilibrium. The principal rationally anticipates the incremental expected bonus of $(\gamma \cdot \beta_1 - \gamma^2 \cdot \beta_2) \cdot b$ that the manager earns from accounting 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. That is, the principal chooses the manager's fixed salaries such that the participation constraint binds in equilibrium (i.e., $CE = 0$). As a result, the principal's optimization program simplifies to the following unconstrained problem:

$$\max_{\{\beta_1,\beta_2\}} \sum_{t=1}^{2} \gamma^t \cdot \left[\lambda_t^2 \cdot \beta_t - \frac{1}{2} \cdot \beta_t^2 \cdot \Phi_t\right] - \frac{\gamma}{2} \cdot w^{-1} \cdot (\beta_1 - \gamma \cdot \beta_2)^2 , \tag{5}$$

where, for brevity, we define $\Phi_t \equiv \lambda_t^2 + \rho \cdot \sigma_t^2$.

Before characterizing the optimal solution to the above program, let us consider the choice of optimal contacts if the manager could be directly prohibited from earnings manipulation (i.e., $w = \infty$). In this benchmark setting, the objective function in (5) becomes intertemporally separable in β_1 and β_2. The principal will therefore choose period t bonus coefficient to maximize the expected surplus in that period, as given by $\pi_t(\beta_t) = \lambda_t^2 \cdot \beta_t - \frac{1}{2} \cdot \beta_t^2 \cdot \Phi_t$. The first-order condition yields

$$\beta_t^0 = \frac{\lambda_t^2}{\Phi_t}.$$

The optimal pay-performance sensitivity reflects the usual tradeoff between risk and incentives. For future reference, we note that the curvature of the expected surplus function $\pi_t(\beta_t)$ is given by $\frac{d^2\pi_t}{d\beta_t^2} = -\Phi_t$. The parameter Φ_t thus measures the decrease in the expected firm profit in period t when β_t deviates from β_t^0 by a small amount.

We now characterize the optimal pay-performance sensitivities when earnings manipulation is feasible (i.e., $w < \infty$). Let (β_1^*, β_2^*) denote the optimal bonus coefficients. Then the equilibrium level of earnings management is given by:

$$b^* = w^{-1} \cdot (\beta_1^* - \gamma \cdot \beta_2^*). \tag{6}$$

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 (5). The principal can entirely eliminate the cost of earnings manipulation by setting $\beta_1^* = \gamma \cdot \beta_2^*$.[12] Consistent

[12]Put differently, the principal can eliminate earnings management incentives by compensating the manager solely on the basis of aggregate earnings $e_1 + \gamma \cdot e_2$. This is similar to the observation of Dutta and Reichelstein (2003) who consider an agency model in which the principal seeks to motivate an investment

with Liang (2004), however, we find that this is generally suboptimal from risk-sharing perspective. In choosing the optimal pay-performance sensitivities, the principal balances the objectives of deterring costly earnings management activities and tailoring productive effort incentives to each period's agency problem.

Lemma 1 *The optimal bonus coefficients are given by:*

$$\beta_1^* = \frac{\gamma \cdot \lambda_2^2 + \lambda_1^2 \cdot (\gamma + w\Phi_2)}{\gamma \cdot \Phi_1 + \Phi_2 + w \cdot \Phi_1 \cdot \Phi_2},$$

$$\beta_2^* = \frac{\lambda_1^2 + \lambda_2^2 \cdot (1 + w\Phi_1)}{\gamma \cdot \Phi_1 + \Phi_2 + w \cdot \Phi_1 \cdot \Phi_2}.$$

Since earnings manipulation incentives depend on the difference between the periodic incentive rates, the principal chooses to set the two incentive rates closer to each other. Specifically, it can be verified that:

$$[\beta_1^* - \gamma \cdot \beta_2^*] = m \cdot [\beta_1^0 - \gamma \cdot \beta_2^0], \tag{7}$$

where $m < 1$ is given by

$$m = \frac{w \cdot \Phi_1 \cdot \Phi_2}{\gamma \cdot \Phi_1 + \Phi_2 + w \cdot \Phi_1 \cdot \Phi_2}.$$

The result below shows that the spread between the two bonus coefficients increases in the cost of earnings management w. In addition, this result characterizes how the potential for earnings manipulation affects the *average* pay-performance sensitivity, $\frac{1}{2} \cdot (\beta_1^* + \beta_2^*)$. 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 optimal pay-performance sensitivities change as earnings manipulation becomes more or less difficult. 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

choice subject to an *induced*, rather than an intrinsic, incentive problem. The principal can make the agent completely internalize her investment objectives if the manager is compensated solely on the basis of aggregate cash flows.

incentives. In contrast, the result below shows that the potential for earnings manipulation can lead to either higher or lower pay-performance sensitivity.

Proposition 1 *The spread between the two pay-performance sensitivities, $|\beta_1^* - \gamma \cdot \beta_2^*|$, increases in the cost of earnings management w. Furthermore:*

(i) If $\beta_1^0 > \gamma \cdot \beta_2^0$, the average pay-performance sensitivity decreases (increases) in the cost of earnings management w when Φ_1 is more (less) than Φ_2.

(ii) If $\beta_1^0 < \gamma \cdot \beta_2^0$, the average pay-performance sensitivity increases (decreases) in the cost of earnings management w when Φ_1 is more (less) than Φ_2.

In the knife-edge case when $\beta_1^0 = \gamma \cdot \beta_2^0$, the manager has no incentives to manipulate earnings, and hence the principal optimally sets $\beta_t^* = \beta_t^0$ and achieves the same expected payoff as he would if earnings management could be directly prohibited. In this case, both the spread between the two incentive rates and the average incentive rate are independent of w. When $\beta_1^0 \neq \gamma \cdot \beta_2^0$, 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. This need to lower the spread between the pay-performance sensitivities diminishes as earnings manipulation becomes more costly; that is, $|\beta_1^* - \gamma \cdot \beta_2^*|$ increases in w. At the other extreme when accounting manipulation is costless ($w = 0$), the manager would arbitrage any difference between β_1^* and $\gamma \cdot \beta_2^*$ to earn arbitrarily large amount of bonus. Therefore, when $w = 0$, the two bonus coefficients must be identical in real terms (i.e., $\beta_1^* = \gamma \cdot \beta_2^*$).

An immediate implication of Proposition 1 is that equilibrium pay-performance sensitivity can be *higher* when managers can manipulate earnings (e.g., $w = 0$) than when they cannot (i.e., $w = \infty$). This result is in sharp contrast to the main finding of Goldman and Slezak (2006). The reason for this difference is that Goldman and Slezak (2006) model a single period setting in which the manager is not concerned about any subsequent reversal of earnings manipulation. The manager thus has incentives to inflate current earnings, and these incentives increase in the pay-performance sensitivity of the compensation scheme. To curtail costly manipulation activities, the principal finds it optimal to lower the pay-performance sensitivity. We note that this result can be easily derived as a special case of our model when either the manager is myopic (i.e., $\gamma = 0$) or earnings management reverses after the end of the manager's planning horizon. It then follows that first-period optimal bonus rate becomes:

$$\tilde{\beta}_1 = \frac{\lambda_1^2}{\Phi_1 + w^{-1}},$$

which is clearly less than β_1^0 for all values of $w < \infty$.

In our model with reversal of earnings management, the manager's manipulation incentives are determined by the *difference* between, rather than the *levels* of, the bonus coefficients for the two periods. To mitigate earnings manipulation, the principal sets a spread between the bonus coefficients that is lower than what would be optimal if earnings management could be directly prohibited; that is, $|\beta_1^* - \gamma \cdot \beta_2^*| < |\beta_1^0 - \gamma \cdot \beta_2^0|$. Proposition 1 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 recall that the parameter Φ_t measures the rate at which period-t expected surplus $\pi_t(\beta_t)$ declines as the bonus rate in that period deviates from its "unconstrained" optimal value of β_t^0. When $\Phi_1 = \Phi_2$, a unit deviation of β_1 from β_1^0 has the same impact on the net firm profit as a unit deviation of β_2 from β_2^0. As earnings management becomes easier, the principal optimally deviates each bonus coefficient from its "unconstrained optimal value of β_t^0 by the same (absolute) amount. Therefore, the average pay-performance sensitivity $\beta_1^* + \beta_2^*$ remains constant as the marginal cost of earnings manipulation w varies.

When $\Phi_1 > \Phi_2$, it is more costly to distort the bonus coefficient in the first period than in the second period. Consequently, as earnings manipulation becomes easier, the principal prefers to reduce the spread between the two bonus coefficients by adjusting β_2 more than the amount by which he adjusts β_1. This implies that when $\beta_1^0 > \gamma \cdot \beta_2^0$, the principal will optimally choose to increase β_2 more than the amount by which he decreases β_1. The average bonus coefficient moves towards β_1^0, and thus *increases* in the ease of earnings management. Conversely, when $\Phi_1 < \Phi_2$, it is optimal to increase β_2 by an amount that is lesser than the amount by which β_1 is decreased. Hence, the average pay-performance sensitivity *decreases* as the earning manipulation becomes easier. A similar intuition applies for the case $\beta_1^0 < \gamma \cdot \beta_2^0$.

Proposition 2 *While the equilibrium amount of earnings management decreases in w, the expected firm profit and managerial compensation both increase in w.*

Equation (6) shows that the equilibrium level of earnings management $|b^*|$ depends on w directly as well as indirectly through its effect on the optimal bonus coefficients. The direct effect posits a negative relationship between $|b^*|$ and w because the manager's marginal cost of manipulation increases in w. However, Proposition 1 shows that the spread between the optimal bonus rates increases in w, and hence the manager's marginal benefit of manipulation increases in w. This indirect effect leads to a countervailing force on the relationship between $|b^*|$ and w. However, the direct effect dominates and the amount of earnings manipulation is unambiguously decreasing in w. The intuition for the result that the expected firm profit increases in the cost of earnings management is straightforward. In our model with full commitment, earnings manipulation is a costly window-dressing activity without any benefit. Earnings management is costly to the firm because (i) the manager must be compensated 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 might seem counter-intuitive at first glance that the manager's expected compensation is increasing in the cost of earnings management, since the manager's ability to inflate his bonus by shifting earnings across periods decreases as manipulation becomes more costly. In our model, however, 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 accounting 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. Hence, the expected managerial compensation unambiguously increases in w.

This result predicts that managerial compensation will be *higher* when earnings management is prohibited than when earnings management is allowed. This implies that the level of compensation is *not* a reliable indicator of any opportunistic earnings management behavior on the part of management. In fact, taken together, parts (i) and (iii) of Proposition 2 predict a *negative* association between managerial compensation and the amount of earning management.

The parameter w can be interpreted as a measure of the effectiveness of the firm's internal governance mechanisms. All else equal, stronger corporate governance would make it more difficult for the manager to engage in accounting manipulation. Our analysis thus predicts a *positive* association between executive compensation and strength of corporate governance. This is in contrast to the prediction based on the rent extraction theory of Bebchuk and Fried (2004). Their theory predicts a *negative* relation between executive compensation and corporate governance because strong corporate governance structures, such as an independent boards, deter managers from extracting rents from shareholders.

In contrast to our result, Christensen *et al* (2013) find that the principal's payoffs are maximized when the agent is allowed to manipulate earnings at no cost (i.e., $w = 0$). This difference between the findings of the two papers arises from different commitment scenarios envisioned in the two papers.[13] While the principal can make long-term commitments in our model, Christensen *et al* assume that any initial two-period contract is subject to not only *interperiod* renegotiation at the end of the first period, but also to *intraperiod* renegotiation in the first period (after the agent has exerted productive effort, but before he chooses his manipulation action).[14] Since first-period productive effort is already sunk, it is

[13]Another difference is that unlike our setting in which earnings are assumed to be independently distributed, Christensen *et al* (2013) allows for earnings to be positively correlated. It is, however, easy to show that Proposition 2 (and all other results in our paper) readily extend to the case when earnings are correlated, e.g., $Cov(\varepsilon_1, \varepsilon_2) \neq 0$.

[14]However, they do not allow for any intraperiod renegotiation in the second period.

sequentially optimal to insulate the agent from any risk associated with first-period earnings (i.e., $\beta_1 = 0$) at the intraperiod renegotiation stage (Fudenberg and Tirole, 1990). This is, however, suboptimal from an *ex ante* perspective. The principal can curtail this temptation by allowing the agent to manage earnings. For instance, if accounting manipulation is made entirely costless, first-period incentive rate must be the same as the sequentially optimal value of second-period bonus rate. Earnings management can thus serve as a substitute for the principal's inability to commit in their model.

We note that without the possibility of *intraperiod* renegotiation, the principal would continue to prefer the most strict accounting regime (i.e., $w = \infty$). If the initial two-period contract were subject to only *interperiod* renegotiation, the firm's expected profit would be lower (than that in the full commitment setting) because of the additional constraint that second-period bonus rate must be sequentially optimal (i.e., $\beta_2^* = \beta_2^0$). However, this constraint would have no effect on the result that the firm's equilibrium payoffs are increasing in the cost of earnings management w.[15]

Though Liang (2004) also assumes full commitment, he finds that prohibiting manipulation may be suboptimal under some circumstances. In his model, the induced level of earnings management depends on the agent's private information about second-period cash flows. Since the agent is not allowed to directly communicate his private information, earnings management can sometimes lead to a more efficient allocation of compensation risk across periods.

4 Earnings Management and Investment Decisions

To investigate how the possibility of earnings management affects other managerial decisions and manager's informational rents, we now extend our analysis to a setting in which the manager, in addition to contributing productive and manipulation efforts, has private information regarding the profitability of an investment project. Though the manager is in-

[15]The analysis of the next section shows that the principal's expected payoffs are increasing in w even when the manager is privately informed.

trinsically indifferent about accepting or rejecting this project, he must be given appropriate investment incentives due to lack of separability in the periodic operating results. Specifically, the principal is assumed to observe only the total earnings in each period without being able to identify the components related to the project and those related to the agents periodic effort.

The investment project requires initial cash investment of k at date 0, and generates operating cash flows in the amounts of $x_t \cdot \theta$ at the end of period t for $t \in \{1, 2\}$. 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_1 and x_2. Without loss of generality, we normalize $x_1 + x_2 = 1$. When x_1 equals to one (zero), the investment project is entirely front-loaded (back-loaded) since all of the project payoffs are realized in the first (second) period. The project's net present value is given by

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

When the two parties enter into a contract at date 0, the manager is assumed to know the value of the profitability parameter θ. 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.[16]

In the absence of private information, the principal would invest in the project if and only if $NPV(\theta) \geq 0$. We denote the first best investment threshold as θ^0, i.e., $NPV(\theta^0) = 0$. To rule out the corner solutions when the project is either always undertaken or always rejected, we assume that $\theta^0 \in (\underline{\theta}, \bar{\theta})$. To ensure that the marginal product of managerial productive effort is sufficiently high so that the principal seeks to provide non-zero effort for each θ, we assume that $\lambda_t^2 \geq H(k)$ for each t.

[16] It is well known that many common distributions, such as uniform and normal, have decreasing inverse hazard rates.

The initial investment expenditure k is verifiable and directly expensed in the first period.[17] The reported accounting earnings are thus given by

$$e_1 = \lambda_1 \cdot a_1 + (x_1 \cdot \theta - k) \cdot I + b + \varepsilon_1,$$

$$e_2 = \lambda_2 \cdot a_2 + x_2 \cdot \theta \cdot I - b + \varepsilon_2,$$

where 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. As before, we assume that ε_1 and ε_2 are independent and $\varepsilon_t \sim N(0, \sigma_t^2)$.

By the revelation principal, we restrict our attention to incentive schemes in which the manager reports his private information truthfully. We characterize optimal revelation schemes in which compensation contracts are restricted to be linear in accounting earnings. As a function of his report $\hat{\theta}$ about the project profitability, the manager's period t compensation is given by

$$s_t(\hat{\theta}) = \alpha_t(\hat{\theta}) + \beta_t(\hat{\theta}) \cdot e_t, \tag{8}$$

where $\alpha_t(\hat{\theta})$ denotes period t salary as a function of his report $\hat{\theta}$. Similarly, the bonus coefficient $\beta_t(\hat{\theta})$ can depend on the manager's report $\hat{\theta}$.

Suppose the project's true profitability is θ, but the manager reports $\hat{\theta}$. Solving for the manager's optimal consumption plan by backward induction, it can be shown that the manager's *ex ante* expected utility from any given contract of the form in (8) simplifies to $EU = -\frac{1}{r} \exp\left\{-r \cdot \rho \cdot CE(\hat{\theta}, \theta)\right\}$, where the manager's certainty equivalent takes the following mean-variance form:

$$CE(\hat{\theta}, \theta) = \sum_{t=1}^{2} \gamma^t \cdot \left[E[s_t(\hat{\theta}, \theta)] - \frac{a_t^2}{2} - \frac{\rho}{2} \cdot \beta_t^2(\hat{\theta}) \cdot \sigma_t^2 \right] - \frac{\gamma}{2} \cdot w \cdot b^2,$$

[17] We do not focus on the choice of depreciation method in this paper. Dutta and Reichelstein (2002) investigate how alternative depreciation methods affect managerial incentives.

with

$$\sum_{t=1}^{2} \gamma^t \cdot E[s_t(\hat{\theta}, \theta)] = \sum_{t=1}^{2} \gamma^t \cdot \left[\alpha_t(\hat{\theta}) + \beta_t(\hat{\theta}) \cdot \left\{\lambda_t \cdot a_t + x_t \cdot \theta \cdot I(\hat{\theta})\right\}\right]$$
$$+ \gamma \cdot b \cdot [\beta_1(\hat{\theta}) - \gamma \cdot \beta_2(\hat{\theta})] - \gamma \cdot \beta_1(\hat{\theta}) \cdot k \cdot I(\hat{\theta}).$$

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 offered by the principal. Given the manager's response functions, we then determine the optimal contract that maximizes the principal's expected payoff.

Since $CE(\hat{\theta}, \theta)$ is strictly concave in a_1, a_2, and b, the manager's optimal response is given by the following first-order conditions: $a_t = \beta_t(\hat{\theta}) \cdot \lambda_t$ and $b = w^{-1} \cdot [\beta_1(\hat{\theta}) - \gamma \cdot \beta_2(\hat{\theta})]$. The principal's optimization problem can then be expressed as:

$$\max_{\{\alpha_t(\theta), \beta_t(\theta)\}, I(\theta)} \int_{\underline{\theta}}^{\bar{\theta}} \left\{ \sum_{t=1}^{2} \gamma^t \cdot [\lambda_t \cdot a_t(\theta) - E\{s_t(\theta, \theta)\}] + NPV(\theta) \cdot I(\theta) \right\} f(\theta) d\theta$$

subject to

(i) $a_t(\theta) = \beta_t(\theta) \cdot \lambda_t$,

(ii) $b(\theta) = w^{-1} \cdot [\beta_1(\theta) - \gamma \cdot \beta_2(\theta)]$,

(iii) $CE(\theta, \theta) \geq CE(\hat{\theta}, \theta)$ for each θ and $\hat{\theta}$,

(iv) $CE(\theta, \theta) \geq 0$ for all θ.

Constraints (i) and (ii) represent the manager's incentive compatibility conditions with regard to his choices of productive and manipulation efforts. Constraint (iii) ensures that the manager will report his private information truthfully, while (iv) represents the manager's participation constraint. Notice that without the incentive compatibility constraint in (iii), the problem will be the same as the one solved in Section 3. The principal will optimally set bonus coefficients equal to β_t^* and the manager will be exactly compensated for his costs of effort and risk-bearing.

Following the standard approach, it can be shown that the incentive compatibility conditions in (iii) in combination with the participation constraint in (iv) imply that the managers certainty equivalent must satisfy the following condition:[18]

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

Equation (9) shows that if the project is undertaken $(I = 1)$ and the manager is provided with nontrivial incentives (i.e., $\beta_t > 0$), the manager will earn informational rents since $CE(\theta, \theta)$ will exceed his reservation wages of zero. To understand why, note that when the manager is compensated based on a linear incentive scheme of the form in (8), the investment project contributes $\sum_{t=1}^{2} \gamma^t \cdot \beta_t(\theta) \cdot x_t \cdot \theta$ to his expected bonus. Ideally, the principal would like to lower the fixed payments α_t so that the managers participation constraint would hold with equality. This would, however, induce the manager to understate the project's profitability in order to earn a higher level of fixed salary. To ensure that the manager does not benefit from such misreporting, the manager must be provided with informational rents and these rents must increase in θ at the rate of $\sum_{t=1}^{2} \gamma^t \cdot \beta_t(\theta) \cdot x_t$, a condition satisfied by the certainty equivalent expression in (9).

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

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

In the above expression for the principal's expected profit, the term $\sum_{t=1}^{2} \gamma^t \cdot \beta_t(\theta) \cdot x_t \cdot H(\theta)$ can be thought of as the "virtual" cost of investment associated with informational rents. The optimization problem in (10) can be solved pointwise, which leads to the following result:

[18] See, for instance, Laffont and Tirole (1993).

Lemma 2 *(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:*

$$NPV(\theta^*) = H(\theta^*) \cdot \sum_{t=1}^{2} \gamma^t \cdot \beta_t^*(\theta^*) \cdot x_t + G\left(\beta_1^*, \beta_2^*\right) - G\left(\beta_1^*\left(\theta^*\right), \beta_2^*\left(\theta^*\right)\right). \tag{11}$$

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

(iii) When the project is undertaken, the optimal bonus rates are given by:

$$\beta_1^*(\theta) = \beta_1^* - \frac{\gamma + w \cdot x_1 \cdot \Phi_2}{\gamma \cdot \Phi_1 + \Phi_2 + w \cdot \Phi_1 \cdot \Phi_2} \cdot H(\theta),$$

$$\beta_2^*(\theta) = \beta_2^* - \frac{1 + w \cdot x_2 \cdot \Phi_1}{\gamma \cdot \Phi_1 + \Phi_2 + w \cdot \Phi_1 \cdot \Phi_2} \cdot H(\theta).$$

The optimal contract in Lemma 2 balances the principal's conflicting objectives of inducing efficient investment and effort decisions, while at the same time deterring costly earnings manipulation and minimizing the manager's informational rents. Similar to the conclusion in Dutta and Reichelstein (2002), this result shows that the manager receives lower-powered incentives in the investment region (i.e., $\beta_t^*(\theta) < \beta_t^*$) and the optimal investment policy entails underinvestment (i.e., $\theta^* > \theta^0$).[19] As evidenced by the incentive compatibility condition in expression (9), the principal can reduce the manager's informational rent either by creating lower powered effort incentives (there will be no rents if $\beta_t = 0$ for all t) or, alternatively, by curtailing the set of states θ in which the project is undertaken. To economize on the informational rents, the principal optimally chooses to increase the investment threshold and lower the bonus coefficients in the investment region.

It is again useful to consider the choice of optimal bonus rates in the benchmark setting when earnings manipulation is prohibitively costly (i.e., $w = \infty$). In this case, the principal's maximization problem in (10) simplifies to:

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

[19]Since $G(\cdot,\cdot)$ achieves its maximum value at (β_1^*, β_2^*), $G(\beta_1^*, \beta_2^*) - G(\beta_1^*(\theta^*), \beta_2^*(\theta^*)) \geq 0$, and hence equation (11) implies $NPV(\theta^*) > 0$. It thus follows that $\theta^* > \theta^0$.

where

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

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 $x_t \cdot (1 - F(\theta))$ if 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 the optimal bonus coefficients in the investment region are given by:

$$\beta_t^0(\theta) = \beta_t^0 - \frac{x_t}{\Phi_t} \cdot H(\theta), \tag{13}$$

where, as before, we use superscript 0 to indicate the absence of earnings management possibility.

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 verified from the expressions in Lemma 2 that:

$$[\beta_1^*(\theta) - \gamma \cdot \beta_2^*(\theta)] = m \cdot [\beta_1^0(\theta) - \gamma \cdot \beta_2^0(\theta)], \tag{14}$$

where $m < 1$ is as defined in connection with (7).

We now proceed to characterize how the average incentive intensity changes with the cost of earnings management. Our comparative statics result in Proposition 1 applies unchanged to the optimal bonus rates in the non-investment region, since $\beta_t^*(\theta) = \beta_t^*$ for all $\theta < \theta^*$. The following result describes how the average incentive intensity changes with the cost of earnings management in the investment region.

Proposition 3 *(i) Suppose $\beta_1^0(\theta) > \gamma \cdot \beta_2^0(\theta)$. Then the average pay-performance sensitivity is decreasing (increasing) in w when Φ_1 is more (less) than Φ_2.*

(ii) Suppose $\beta_1^0(\theta) < \gamma \cdot \beta_2^0(\theta)$. The average pay-performance sensitivity is increasing (decreasing) in w when Φ_1 is more (less) than Φ_2.

In the knife-edge case when $\beta_1^0(\theta) = \gamma \cdot \beta_2^0(\theta)$, the manager has no incentives to manipulate earnings, and hence the average pay-performance sensitivity is independent of w. When $\beta_1^0(\theta) \neq \gamma \cdot \beta_2^0(\theta)$, we can verify from (12) that the presence of information asymmetry problem does not alter the "curvature" of the expected surplus function. Consequently, Φ_t still measures the sensitivity of the loss in the periodic surplus associated with the deviation of $\beta_t^*(\theta)$ from its unconstrained optimal value of $\beta_t^0(\theta)$. When $\Phi_1 > \Phi_2$, it is more costly to distort $\beta_1(\theta)$ than $\beta_2(\theta)$. Suppose $\beta_1^0(\theta) > \gamma \cdot \beta_2^0(\theta)$. As earnings management becomes easier, in order to reduce the spread between the two bonus coefficients, the principal finds it optimal to increase $\beta_2^*(\theta)$ more than the amount by which he decreases $\beta_1(\theta)$. Therefore, the average pay-performance sensitivity $\frac{1}{2} \cdot [\beta_1^*(\theta) + \beta_2^*(\theta)]$ gravitates towards $\beta_1^0(\theta)$; i.e., the average pay-performance sensitivity increases as the cost of earnings management w declines. A similar intuition applies for the cases when $\Phi_1 < \Phi_2$ and $\beta_1^0(\theta) < \gamma \cdot \beta_2^0(\theta)$.

Next we consider how the possibility of earnings manipulation changes the efficiency of the investment decision. We note from (11) that the cost parameter w affects the investment threshold only indirectly through its effect on the choice of bonus coefficients. Differentiating (11) with respect to w and applying the Envelope theorem yield

$$sgn\left[\frac{d\theta^*}{dw}\right] = sgn\left[(\beta_1^* - \gamma \cdot \beta_2^*)^2 - (\beta_1^*(\theta^*) - \gamma \cdot \beta_2^*(\theta^*))^2\right],$$

which shows that the sign of $\frac{d\theta^*}{dw}$ depends on the difference between the spreads in incentive rates in the investment and non-investment regions. This is intuitive because when the bonus coefficients are more (less) divergent in the investment region, the principal is more (less) concerned about earnings manipulation in the investment region, and will thus adjust investment cutoff upward (downward) as earnings manipulation becomes easier (i.e., as w declines). Using $x_2 = 1 - x_1$, the difference between the spreads in the effective bonus coefficients in the investment and non-investment regions can be written as:

$$[\beta_1^*(\theta^*) - \gamma \cdot \beta_2^*(\theta^*)] = [\beta_1^* - \gamma \cdot \beta_2^*] - q \cdot w \cdot H(\theta^*) \cdot (x_1 - \delta), \tag{15}$$

where q is a positive constant and $\delta \equiv \frac{\gamma \cdot \Phi_1}{\gamma \cdot \Phi_1 + \Phi_2} \in [0, 1]$.

Obviously, depending on the relative magnitude of x_1, the divergence between the bonus coefficients can be enlarged, reduced, or even reversed in the investment region relative to the non-investment region. When $x_1 = \delta$, the need to curtail informational rents exerts the same amount of downward pressure on the two bonus rates so that undertaking the investment does not affect the divergence between periodic bonus rates. Consequently, in this knife-edge case, the investment threshold is unaffected by the changes in the cost of earnings management.

We present our next two results for the case when $\beta_1^0 > \gamma \cdot \beta_2^0$ (that is, $\frac{\lambda_1^2}{\Phi_1} > \gamma \cdot \frac{\lambda_2^2}{\Phi_2}$). However, this restriction is merely for expositional convenience and none of our results depends on it.

Proposition 4 *The investment decision θ^* is independent of the cost of earnings management w when $x_1 = \delta$. Let $\beta_1^0 > \gamma \cdot \beta_2^0$.*

(i) For large values of $\beta_1^0 - \gamma \cdot \beta_2^0$, the optimal investment threshold θ^* increases (decreases) in w for values of x_1 more (less) than δ.

(ii) For small values of $\beta_1^0 - \gamma \cdot \beta_2^0$, there exists a $\bar{x} \in (\delta, 1)$ such that the optimal investment threshold θ^* increases in w for $x_1 \in (\delta, \bar{x})$, and decreases in w for $x_1 < \delta$ and $x_1 > \bar{x}$.

An interesting implication is that there are plausible scenarios under which prohibiting earnings management can lead to *less* efficient investment decisions.[20] For example, part (i) of Proposition 4 shows that when β_1^0 is sufficiently large relative to $\gamma \cdot \beta_2^0$, the investment threshold θ^* increases in the cost of earnings management for values of x_1 greater than δ. That is, when the manager has a sufficiently strong natural incentive to inflate earnings and the project payoffs are not too back-loaded, the optimal investment decision becomes *less* efficient as the cost of earnings management increases.

To understand the intuition, we note from that when $x_1 < \delta$, the asymmetric information problem is relatively more severe in the second period than in the first period. As

[20]However, we note that a less efficient investment decision does not imply lower payoffs for the firm. To the contrary, a straightforward application of the Envelope theorem reveals that the firm's expected payoff is always increasing in the manager's cost of earnings manipulation w.

(15) shows, this implies that undertaking the project results in an enlargement of the divergence between the bonus coefficients in the investment region. Hence, the principal is more concerned about minimizing the cost of earnings management in the investment region. Consequently, as earnings manipulation becomes easier, the principal finds it optimal to set a higher investment threshold to economize on the cost of earnings management. For values of $x_1 > \delta$, the project's payoffs are sufficiently front-loaded such that the need to curtail informational rents exerts a greater downward pressure on the bonus rate in the first period than in the second period. If the difference between the two bonus rates in the non-investment region (i.e., $\beta_1^* - \gamma \cdot \beta_2^*$) is not too small, equation (15) implies that $0 < [\beta_1^*(\theta^*) - \gamma \cdot \beta_2^*(\theta^*)] < [\beta_1^* - \gamma \cdot \beta_2^*]$.[21] In this case, the principal is more concerned about earnings management in the non-investment region and hence the investment threshold increases in w. However, if $\beta_1^* - \gamma \cdot \beta_2^*$ is relatively small, the sign of $[\beta_1^*(\theta) - \gamma \cdot \beta_2^*(\theta)]$ switches from positive to negative when x_1 is sufficiently close to one. In this case, the *difference* between the spreads in the discounted values of bonus coefficients in the investment and non-investment regions increases in x_1 for sufficiently large values of x_1, and hence the investment threshold decreases as w increases.

Figure 1 illustrates this intuition for the case when $\beta_1^0 = \gamma \cdot \beta_2^0$ and the investment project is entirely front-loaded ($x_1 = 1$). In this case, the manager has no incentives to manipulate earnings in the non-investment region because $\beta_1^0 = \gamma \cdot \beta_2^0$ implies $\beta_1^* = \gamma \cdot \beta_2^*$. If earnings management is prohibitively costly (i.e., $w = \infty$), the cost associated with truth-telling drives down the optimal value of first-period bonus rate below β_1^0. However, as shown in Figure 1, second-period incentive rate remains unchanged (i.e., $\beta_2^0(\theta) = \beta_2^0$) because the manager earns no rent in the second period ($x_2 = 0$). This implies that the principal is concerned with earnings manipulation only in the investment region. Hence, the optimal investment threshold increases as the cost of manipulation w decreases from ∞.

We next investigate how the potential for accounting manipulation affects the manager's

[21] We recall from equation (7) that $(\beta_1^* - \gamma \cdot \beta_2^*)$ is proportional to, and of the same sign as, $(\beta_1^0 - \gamma \cdot \beta_2^0)$.

informational rents. Note that the expected informational rents

$$R = \int_{\theta^*}^{\bar{\theta}} \sum_{t=1}^{2} \left[\gamma^t \cdot \beta_t^*(\theta) \cdot x_t \right] (1 - F(\theta)) d\theta,$$

increase in both the size of the investment region and the bonus coefficients over the investment region. As noted earlier, when $x_1 = \delta$, 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 $\gamma \cdot \beta_2^*(\theta)$ converge toward each other is equal to $\frac{\Phi_2}{\gamma \cdot \Phi_1}$. Consequently, $\sum_{i=1}^{2} \gamma^i \cdot x_i \cdot \beta_i^*(\theta)$ is independent of w, since $x_1 = \delta$ implies $\frac{x_1}{x_2} = \frac{\gamma \Phi_1}{\Phi_2}$. It thus follows that managerial rents are independent of w when $x_1 = \delta$.

Consider now a slight perturbation so that x_1 is slightly above δ. As w decreases and $\beta_1^*(\theta)$ and $\gamma \cdot \beta_2^*(\theta)$ converge toward each other, $\sum_{t=1}^{2} \gamma^t \cdot x_t \cdot \beta_t^*(\theta)$ decreases because the decrease in $x_1 \cdot \beta_1^*(\theta)$ is larger than the increase in $\gamma \cdot x_2 \cdot \beta_2^*(\theta)$. This effect tends to decrease the manager's informational rents. On the other hand, since x_1 is slightly above δ, Proposition 4 shows that a decrease in w also decreases the investment threshold. This effect tends to increase the manager's informational rents. Figure 2 plots the manager's expected informational rents as a function of w when θ is uniformly distributed between 5 and 10, $k = 7$, and $\delta = 0.44$. The expected informational rents are increasing in w for $x_1 = 0.4 < \delta$, and decreasing in w for $x_1 = 0.6 > \delta$. This numerical example suggests that the first effect, as described above, dominates. The result below shows that this is indeed the case when θ is uniformly distributed.

Proposition 5 *Suppose θ is uniformly distributed and $\beta_1^0 > \gamma \cdot \beta_2^0$. The manager's expected rents are increasing (decreasing) in w when x_1 is higher (less) than δ in a neighborhood of $x_1 = \delta$.*

An implication of Proposition 5 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.

Our last result characterizes how the equilibrium amount of earnings management changes with the underlying profitability of the firm.

Proposition 6 *The equilibrium level of earnings management in the investment region, $b^*(\theta)$, increases (decreases) in the profitability of the investment project θ if x_1 is more (less) than δ.*

We recall that the amount of earnings management $b^*(\theta)$ is directly proportional to the difference between the discounted values of the two bonus rates, $\beta_1^*(\theta) - \gamma \cdot \beta_2^*(\theta)$. Equation (15) shows that the divergence between the two bonus rates in the investment region decreases in $H(\theta) \cdot (x_1 - \delta)$. Because $H(\theta)$ is a decreasing function, $b^*(\theta)$ will increase (decrease) in θ if $x_1 - \delta$ is positive (negative). Therefore, depending on the time-profile of the project's 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, the above result predicts a more nuanced relationship between reported accounting profits and earnings manipulation. For instance, Proposition 6 predicts a *negative* association between accounting earnings and earnings management for firms with back-loaded projects.

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 is 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. 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.

There are several promising directions for extending the analysis in this paper. First, it might be interesting to consider settings in which investors have information beyond that contained in accounting reports and compensation contracts can be based on stock prices. Such an extension might be particularly interesting when investors cannot perfectly predict the manager's choice of earnings management. Another avenue to explore will be to relax the assumption that earnings manipulation reverses with certainty in the next period. It would be interesting to explore how the possibility of stochastic accrual reversal would impact on the choice of optimal contracts.

APPENDIX

Proof of Lemma 1

Let $G(\beta_1, \beta_2)$ denote the principal's objective function in (5). It can be easily checked that $G_{11} < 0$, $G_{22} < 0$, and $G_{11} \cdot G_{22} - G_{12}^2 > 0$. Therefore, $G(\beta_1, \beta_2)$ is globally concave and the optimal bonus coefficients β_t^* are given by the following first-order conditions:

$$\lambda_1^2 - \beta_1^* \cdot \Phi_1 - \frac{(\beta_1^* - \gamma \cdot \beta_2^*)}{w} = 0, \tag{16}$$

$$\lambda_2^2 - \beta_2^* \cdot \Phi_2 + \frac{(\beta_1^* - \gamma \cdot \beta_2^*)}{w} = 0. \tag{17}$$

The result then follows by the solution to the above two linear equations in β_1^* and β_2^*.

Proof of Proposition 1

Let us first consider the case when $\beta_1^0 = \gamma \cdot \beta_2^0$. We note from (7) that $\beta_1^* - \gamma \cdot \beta_2^* = 0$. Substituting this in (16) and (17) reveals that

$$\lambda_t^2 - \beta_t^* \cdot \Phi_t = 0,$$

and hence $\beta_t^* = \frac{\lambda_t^2}{\Phi_t} = \beta_t^0$. It thus follows that when $\beta_1^0 = \gamma \cdot \beta_2^0$, the spread between the discounted bonus rates $(\beta_1^* - \gamma \cdot \beta_2^*)$ and the average bonus rate (i.e., $\frac{\beta_1^* + \beta_2^*}{2}$) are both independent of w.

For the case when $\beta_1^0 \neq \gamma \cdot \beta_2^0$, we have

$$\frac{\partial \left(|\beta_1^* - \gamma \cdot \beta_2^*|\right)}{\partial w} = \frac{\partial m}{\partial w} > 0.$$

From the expressions for the optimal bonus coefficients in Lemma 1, we get:

$$\beta_1^* + \beta_2^* = \frac{(1+\gamma) \cdot (\lambda_1^2 + \lambda_2^2) + w \cdot \lambda_2^2 \cdot \Phi_1 + w \cdot \lambda_1^2 \cdot \Phi_2}{\gamma \cdot \Phi_1 + \Phi_2 + w \cdot \Phi_1 \cdot \Phi_2}.$$

Differentiating with respect to w and simplifying yield

$$\frac{\partial \left(\beta_1^* + \beta_2^*\right)}{\partial w} = \frac{(\gamma \lambda_2^2 \Phi_1 - \Phi_2 \lambda_1^2) \cdot (\Phi_1 - \Phi_2)}{(\gamma \cdot \Phi_1 + \Phi_2 + w \cdot \Phi_1 \cdot \Phi_2)^2}.$$

It thus follows that

$$sgn\left[\frac{\partial\left(\beta_1^*+\beta_2^*\right)}{\partial w}\right] = sgn\left[\left(\gamma\lambda_2^2\Phi_1 - \Phi_2\lambda_1^2\right)\cdot\left(\Phi_1-\Phi_2\right)\right]$$
$$= sgn\left[\left(\Phi_2-\Phi_1\right)\left(\beta_1^0-\gamma\cdot\beta_2^0\right)\right].$$

The conclusions in parts (i) and (ii) of Proposition 1 then follow.

Proof of Proposition 2

Recall that $|b^*| = \frac{|\beta_1^* - \gamma\cdot\beta_2^*|}{w}$. Substituting for $\beta_1^* - \gamma\cdot\beta_2^*$ from (7) and simplifying yield:

$$|b^*| = \frac{|\lambda_1^2\cdot\Phi_2 - \gamma\cdot\lambda_2^2\cdot\Phi_1|}{\gamma\cdot\Phi_1+\Phi_2+w\cdot\Phi_1\cdot\Phi_2}.$$

It therefore follows that the equilibrium amount of earnings management $|b^*|$ is decreasing in w.

The firm's expected profit can be expressed as

$$G(\beta_1^*(w),\beta_2^*(w),w) = \sum_{t=1}^{2}\gamma^t\cdot\left(\lambda_t^2\cdot\beta_t^* - \frac{1}{2}\cdot\beta_t^{*2}\cdot\Phi_t\right) - \frac{\gamma}{2}\cdot w^{-1}\cdot(\beta_1^*-\beta_2^*)^2.$$

Differentiating with respect to w and applying the Envelope Theorem reveal that

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

To prove the last part, we note that the present value of the manager's expected compensation is given by:

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

Substituting the expressions for the optimal bonus coefficients yields

$$E(\gamma\cdot s_1+\gamma^2\cdot s_2)$$
$$= \frac{\gamma\cdot\Phi_1}{2}\cdot\left(\frac{\lambda_2^2+\lambda_1^2\left(1+w\Phi_2\right)}{\gamma\Phi_1+\Phi_2+w\Phi_1\Phi_2}\right)^2 + \frac{\gamma^2\cdot\Phi_2}{2}\cdot\left(\frac{\lambda_1^2+\lambda_2^2\left(1+w\Phi_1\right)}{\gamma\Phi_1+\Phi_2+w\Phi_1\Phi_2}\right)^2 + \frac{\gamma\cdot w}{2}\cdot\left(\frac{\lambda_1^2\Phi_2-\lambda_2^2\Phi_1}{\gamma\Phi_1+\Phi_2+w\Phi_1\Phi_2}\right)^2$$
$$= \frac{\gamma}{2}\frac{\gamma\lambda_1^4+\gamma\lambda_2^4+2\gamma\lambda_1^2\lambda_2^2+w\Phi_2\lambda_1^4+w\gamma\Phi_1\lambda_2^4}{\gamma\cdot\Phi_1+\Phi_2+w\cdot\Phi_1\cdot\Phi_2}.$$

Differentiating with respect to w gives

$$\begin{aligned}\frac{dE(\gamma \cdot s_1 + \gamma^2 \cdot s_2)}{dw} &= -\frac{\gamma \Phi_1 \Phi_2 \left(\gamma \left(\lambda_1^2 + \lambda_2^2\right)^2 + \left(\gamma \Phi_1 \lambda_2^4 + \Phi_2 \lambda_1^4\right) w\right)}{2 \cdot \left(\gamma \cdot \Phi_1 + \Phi_2 + w \cdot \Phi_1 \cdot \Phi_2\right)^2} + \frac{\gamma \cdot \left(\Phi_2 \lambda_1^4 + \gamma \Phi_1 \lambda_2^4\right)}{2 \cdot \left(\gamma \cdot \Phi_1 + \Phi_2 + w \cdot \Phi_1 \cdot \Phi_2\right)} \\ &= \frac{\gamma \cdot \left(\gamma \Phi_1 \lambda_2^2 - \Phi_2 \lambda_1^2\right)^2}{2 \cdot \left(\gamma \cdot \Phi_1 + \Phi_2 + w \cdot \Phi_1 \cdot \Phi_2\right)^2} \\ &> 0.\end{aligned}$$

This proves that the expected compensation is increasing in w.

Proof of Lemma 2

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

$$\lambda_1^2 - x_1 \cdot H(\theta) \cdot I(\theta) - \beta_1^*(\theta) \cdot \Phi_1 - w^{-1}[\beta_1^*(\theta) - \gamma \cdot \beta_2^*(\theta)] = 0$$

$$\lambda_2^2 - x_2 \cdot H(\theta) \cdot I(\theta) - \beta_2^*(\theta) \cdot \Phi_2 + w^{-1}[\beta_1^*(\theta) - \gamma \cdot \beta_2^*(\theta)] = 0.$$

The above equations simplify to the first-order conditions in (16) and (17) for the case when $I(\theta) = 0$, and hence $\beta_t^*(\theta) = \beta_t^*$ in the non-investment region. When $I(\theta) = 1$, the above equations solve to yield the following optimal bonus coefficients:

$$\beta_1^*(\theta) = \frac{\gamma \left(\lambda_2^2 - x_2 \cdot H(\theta)\right) + \left(\lambda_1^2 - x_1 \cdot H(\theta)\right)\left(\gamma + w\Phi_2\right)}{\gamma \cdot \Phi_1 + \Phi_2 + w \cdot \Phi_1 \cdot \Phi_2}, \tag{18}$$

and

$$\beta_2^*(\theta) = \frac{\lambda_1^2 - x_1 \cdot H(\theta) + \left(\lambda_2^2 - x_2 \cdot H(\theta)\right)\left(1 + w\Phi_1\right)}{\gamma \cdot \Phi_1 + \Phi_2 + w \cdot \Phi_1 \cdot \Phi_2}. \tag{19}$$

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

$$NPV(\theta) - \sum_{t=1}^{2} \gamma^t \cdot \beta_t^*(\theta) \cdot x_t \cdot H(\theta) + G(\beta_1^*(\theta), \beta_2(\theta)) \geq G(\beta_1^*, \beta_2^*), . \tag{20}$$

Applying the Envelope Theorem, it can be easily verified that the left hand side of (20) is increasing in θ.

Note that $\beta_t^*(\bar{\theta}) = \beta_t^*$, since $H(\bar{\theta}) = 0$. Hence, (20) holds as an inequality at $\theta = \bar{\theta}$. On the other hand, the inequality in (20) fails to hold at θ^0. Consequently, there exists a unique $\theta^* \in (\theta^0, \bar{\theta})$ such that the principal invests if and only if $\theta \geq \theta^*$.

To complete the proof, we need to show that the resulting incentive scheme is globally incentive compatible. It is well-known that an incentive scheme is incentive compatible provided it is locally incentive compatible (i.e., the incentive compatibility condition in (9) holds), and $\frac{\partial}{\partial \theta} CE(\hat{\theta}, \theta)$ is (weakly) increasing in $\hat{\theta}$. For the incentive scheme identified above,

$$\frac{\partial}{\partial \theta} CE(\hat{\theta}, \theta) = I(\hat{\theta}) \cdot \sum_{t=1}^{2} \gamma^t \cdot x_t \cdot \beta_t^*(\hat{\theta}),$$

which is increasing in $\hat{\theta}$ since $\beta_t^*(\cdot)$ is increasing, and the optimal $I(\cdot)$ is an upper-tail investment policy.

Proof of Proposition 3

Using the expressions for the optimal bonus coefficients in (18) and (19), it can be shown that:

$$\frac{\partial \left(\beta_1^*(\theta) + \beta_2^*(\theta)\right)}{\partial w} = \frac{[\Phi_1 - \Phi_2] \cdot [\gamma \cdot (\lambda_2^2 - H(\theta) \cdot x_2) \cdot \Phi_1 - (\lambda_1^2 - H(\theta) \cdot x_1) \cdot \Phi_2]}{(\Phi_2 + \gamma \Phi_1 + w \Phi_1 \Phi_2)^2}$$

Hence,

$$sgn\left[\frac{\partial \left(\beta_1^*(\theta) + \beta_2^*(\theta)\right)}{\partial w}\right] = sgn\left[(\Phi_1 - \Phi_2) \cdot \left(\gamma \cdot \beta_2^0(\theta) - \beta_1^0(\theta)\right)\right].$$

The conclusion in Proposition 3 follows.

Proof of Proposition 4

Note that the optimal cutoff θ^* is given by

$$NPV(\theta^*) - [\gamma \cdot x_1 \cdot \beta_1^*(\theta^*) + \gamma^2 \cdot x_2 \cdot \beta_2^*(\theta^*)] \cdot H(\theta^*) + G(\beta_1^*(\theta^*), \beta_2^*(\theta^*)) - G(\beta_1^*, \beta_2^*) = 0,$$

where

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

(ii) $\beta_t^*(\theta)$ uniquely maximizes $G(\beta_1, \beta_2) - [\gamma \cdot x_1 \cdot \beta_1 + \gamma^2 \cdot x_2 \cdot \beta_2] \cdot H(\theta)$, 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

$$\begin{aligned}&\left[\gamma \cdot x_1 + \gamma^2 \cdot x_2 - \left(\gamma \cdot x_1 \cdot \beta_1^*(\theta^*) + \gamma^2 \cdot x_2 \cdot \beta_2^*(\theta^*)\right) \cdot H'(\theta^*)\right] \frac{d\theta^*}{dw} \\ &= \frac{\partial}{\partial w}[G(\beta_1^*, \beta_2^*) - G(\beta_1^*(\theta^*), \beta_2^*(\theta^*))].\end{aligned}$$

Since

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

substituting for β_t^* and $\beta_t(\theta^*)$ and simplifying yield

$$\frac{d\theta^*}{dw} = \frac{\gamma(\Phi_1\Phi_2)^2}{2(\gamma\Phi_1 + \Phi_2 + w\Phi_1\Phi_2)^2}\left[\frac{x_1}{\Phi_1} - \frac{\gamma x_2}{\Phi_2}\right] \frac{\left(2(\beta_1^0 - \gamma\beta_2^0) - H(\theta) \cdot \left(\frac{x_1}{\Phi_1} - \frac{\gamma x_2}{\Phi_2}\right)\right) H(\theta)}{[\gamma x_1 + \gamma^2 x_2 - (\gamma x_1 \beta_1(\theta^*) + \gamma^2 x_2 \beta_2(\theta^*)) H'(\theta^*)]}.$$

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

$$sgn\left[\frac{d\theta^*}{dw}\right] = sgn\left[\left(\frac{x_1}{\Phi_1} - \frac{\gamma \cdot x_2}{\Phi_2}\right) \cdot \left\{2\left(\beta_1^0 - \gamma \cdot \beta_2^0\right) - H(\theta^*)\left(\frac{x_1}{\Phi_1} - \frac{\gamma \cdot x_2}{\Phi_2}\right)\right\}\right]. \tag{21}$$

Since $x_2 = 1 - x_1$, we note that:

$$sgn\left(\frac{x_1}{\Phi_1} - \frac{\gamma x_2}{\Phi_2}\right) = sgn(x_1 - \delta).$$

It thus follows that $\frac{d\theta^*}{dw} = 0$ when $x_1 = \delta$. When $x_1 < \delta$, the term inside the curly brackets on the right hand side of (21) is positive because $\beta_1^0 > \gamma \cdot \beta_2^0$. Hence, $\frac{d\theta^*}{dw} < 0$ when $x_1 < \delta$.

Consider now the case when $x_1 > \delta$. Let $\psi(x_1)$ denote the term inside the curly brackets on the right hand side of (21). Note that when $x_1 > \delta$, $sgn\left[\frac{d\theta^*}{dw}\right] = sgn[\psi(x_1)]$. If $[\beta_1^0 - \gamma \cdot \beta_2^0] > \frac{H(\theta^*)}{2 \cdot \Phi_1}$, we note that $\psi(x_1)$ is positive for $x_1 = 1$ (which implies $x_2 = 0$). Since $\psi(\cdot)$ is decreasing, this implies that $\psi(x_1) > 0$ for all values of $x_1 \in [0, 1]$. It therefore follows that $\frac{d\theta^*}{dw} > 0$ for all $x_1 \in (\delta, 1]$.

Suppose now $0 < [\beta_1^0 - \gamma \cdot \beta_2^0] < \frac{H(\theta^*)}{2 \cdot \Phi_1}$. In this case, we note that $\psi(1) < 0$ and $\psi(\delta) > 0$. Since $\psi(\cdot)$ is monotonically decreasing, this implies that there exists a unique cutoff $\bar{x}$ such that $\frac{\partial \theta^*}{\partial w} > 0$ for all $x_1 \in (\delta, \bar{x})$ and $\frac{d\theta^*}{dw} < 0$ for all $x_1 > \bar{x}$.

This completes the proof of Proposition 4.

Proof of Proposition 5

Let

$$R \equiv \int_{\theta^*}^{\bar{\theta}} \left[\gamma \beta_1^* (\theta) \, x_1 + \gamma^2 \beta_2^* (\theta) \, x_2\right] [1 - F (\theta)] \, d\theta$$

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

$$\frac{\partial R}{\partial w} = \int_{\theta^*}^{\bar{\theta}} \frac{\partial \left[\gamma \beta_1^* (\theta) \, x_1 + \gamma^2 \beta_2^* (\theta) \, x_2\right]}{\partial w} (1 - F (\theta)) \, d\theta - \frac{\partial \theta^*}{\partial w} \cdot \left[\gamma \beta_1^* (\theta^*) \cdot x_1 + \gamma^2 \beta_2^* (\theta^*) \cdot x_2\right] (1 - F (\theta^*)) \, .$$

Using the expressions (18) and (19) for the optimal bonus coefficients, it can be easily verified that

$$\frac{\partial \left[\gamma \beta_1^* (\theta) \cdot x_1 + \gamma^2 \beta_2^* (\theta) \cdot x_2\right]}{\partial w} = \Omega \cdot \gamma \cdot \left[\frac{x_1}{\Phi_1} - \frac{\gamma x_2}{\Phi_2}\right] \left[\left(\beta_1^0 - \gamma \beta_2^0\right) - H (\theta) \cdot \left(\frac{x_1}{\Phi_1} - \frac{\gamma x_2}{\Phi_2}\right)\right],$$

where, for brevity, we define $\Omega = \frac{(\Phi_1 \Phi_2)^2}{(\gamma \Phi_1 + \Phi_2 + w \cdot \Phi_1 \cdot \Phi_2)^2}$.

It thus follows that:

$$\frac{\partial \theta^*}{\partial w} = \frac{\gamma \Omega}{2} \left[\frac{x_1}{\Phi_1} - \frac{\gamma x_2}{\Phi_2}\right] \frac{\left(2 \left(\beta_1^0 - \gamma \beta_2^0\right) - H (\theta^*) \cdot \left(\frac{x_1}{\Phi_1} - \frac{\gamma \cdot x_2}{\Phi_2}\right)\right) H (\theta^*)}{\left[\gamma x_1 + \gamma^2 x_2 - \left(\gamma x_1 \beta_1^* (\theta^*) + \gamma^2 x_2 \beta_2^* (\theta^*)\right) H' (\theta^*)\right]}.$$

When $x_1 = \delta$, we have $\frac{x_1}{\Phi_1} = \frac{\gamma \cdot x_2}{\Phi_2} \equiv \frac{\gamma}{\gamma \Phi_1 + \Phi_2}$. Therefore,

$$\frac{\partial R}{\partial w} = 0, \text{ and}$$

$$\sum_{i=1}^{2} \gamma^i \cdot x_i \cdot \beta_i^* (\theta^*) = \gamma^2 \left(\frac{\lambda_1^2 + \lambda_2^2}{\gamma \Phi_1 + \Phi_2} - \frac{H (\theta^*)}{\gamma \Phi_1 + \Phi_2}\right).$$

Now we study how $\frac{\partial R}{\partial w}$ changes with x_1 at $x_1 = \delta$ (i.e., at $\frac{x_1}{\Phi_1} = \frac{\gamma \cdot x_2}{\Phi_2} \equiv \frac{\gamma}{\gamma \Phi_1 + \Phi_2}$). Recall that we have assumed $\beta_1^0 > \gamma \beta_2^0$ without loss of generality. Since $\frac{x_1}{\Phi_1} - \frac{\gamma \cdot x_2}{\Phi_2}$ increases as x_1

increases,

$$sgn\left(\frac{\partial}{\partial x_1}\left[\frac{\partial R}{\partial w}\right]\Big|_{x_1=\delta}\right)$$

$$= sgn\left(\int_{\theta^*}^{\bar{\theta}}[1-F(\theta)]\,d\theta - \frac{\sum_{i=1}^{2}\gamma^i\cdot x_i\cdot\beta_i^*(\theta^*)\cdot H(\theta^*)}{\gamma^2\cdot\frac{\Phi_1+\Phi_2}{\gamma\Phi_1+\Phi_2}-\sum_{i=1}^{2}\gamma^i\cdot x_i\cdot\beta_i^*(\theta^*)\cdot H'(\theta^*)}\cdot[1-F(\theta^*)]\right)$$

$$= sgn\left(\int_{\theta^*}^{\bar{\theta}}[1-F(\theta)]\,d\theta - \frac{\left(\frac{\lambda_1^2+\lambda_2^2}{\gamma\Phi_1+\Phi_2}-\frac{H(\theta^*)}{\gamma\Phi_1+\Phi_2}\right)\cdot H(\theta^*)}{\frac{\Phi_1+\Phi_2}{\gamma\Phi_1+\Phi_2}-\left(\frac{\lambda_1^2+\lambda_2^2}{\gamma\Phi_1+\Phi_2}-\frac{H(\theta^*)}{\gamma\Phi_1+\Phi_2}\right)\cdot H'(\theta^*)}\cdot[1-F(\theta^*)]\right).$$

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

$$sgn\left(\int_{\theta^*}^{\bar{\theta}}[1-F(\theta)]\,d\theta - \frac{\left(\frac{\lambda_1^2+\lambda_2^2}{\gamma\Phi_1+\Phi_2}-\frac{H(\theta^*)}{\gamma\Phi_1+\Phi_2}\right)\cdot H(\theta^*)}{\frac{\Phi_1+\Phi_2}{\gamma\Phi_1+\Phi_2}-\left(\frac{\lambda_1^2+\lambda_2^2}{\gamma\Phi_1+\Phi_2}-\frac{H(\theta^*)}{\gamma\Phi_1+\Phi_2}\right)\cdot H'(\theta^*)}\cdot[1-F(\theta^*)]\right)$$

$$= -sgn\left[\frac{\left(\frac{\lambda_1^2+\lambda_2^2}{\gamma\Phi_1+\Phi_2}-\frac{H(\theta^*)}{\gamma\Phi_1+\Phi_2}\right)}{\frac{\Phi_1+\Phi_2}{\gamma\Phi_1+\Phi_2}+\left(\frac{\lambda_1^2+\lambda_2^2}{\gamma\Phi_1+\Phi_2}-\frac{H(\theta^*)}{\gamma\Phi_1+\Phi_2}\right)}-\frac{\int_{\theta^*}^{\bar{\theta}}\left(\bar{\theta}-\theta\right)d\theta}{\left(\bar{\theta}-\theta^*\right)^2}\right]$$

$$= -sgn\left[\frac{\left(\frac{\lambda_1^2+\lambda_2^2}{\gamma\Phi_1+\Phi_2}-\frac{H(\theta^*)}{\gamma\Phi_1+\Phi_2}\right)}{\frac{\Phi_1+\Phi_2}{\gamma\Phi_1+\Phi_2}+\left(\frac{\lambda_1^2+\lambda_2^2}{\gamma\Phi_1+\Phi_2}-\frac{H(\theta^*)}{\gamma\Phi_1+\Phi_2}\right)}-\frac{1}{2}\right]>0.$$

Hence, $\frac{\partial}{\partial x_1}\left[\frac{\partial R}{\partial w}\right]>0$ when evaluated at $x_1=\delta$. Since $\frac{\partial R}{\partial w}=0$ at $x_1=\delta$, it follows that $\frac{\partial R}{\partial w}$ is positive (negative) for values of x_1 greater (less) than δ in a neighborhood of $x_1=\delta$. This completes the proof of Proposition 5.

Proof of Proposition 6

$$\begin{aligned}b^*(\theta) &= w^{-1}\cdot[\beta_1^*(\theta)-\gamma\cdot\beta_2^*(\theta)]\\ &= w^{-1}\cdot m\cdot\left[(\beta_1^0-\gamma\cdot\beta_2^0)-H(\theta)\cdot\left(\frac{x_1}{\Phi_1}-\frac{\gamma\cdot x_2}{\Phi_2}\right)\right],\end{aligned}$$

where $m>0$ is as defined in connection with (7).

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

$$sgn\left(\frac{db^*(\theta)}{d\theta}\right)=sgn\left(\frac{x_1}{\Phi_1}-\frac{\gamma\cdot x_2}{\Phi_2}\right)=sgn(x_1-\delta).$$

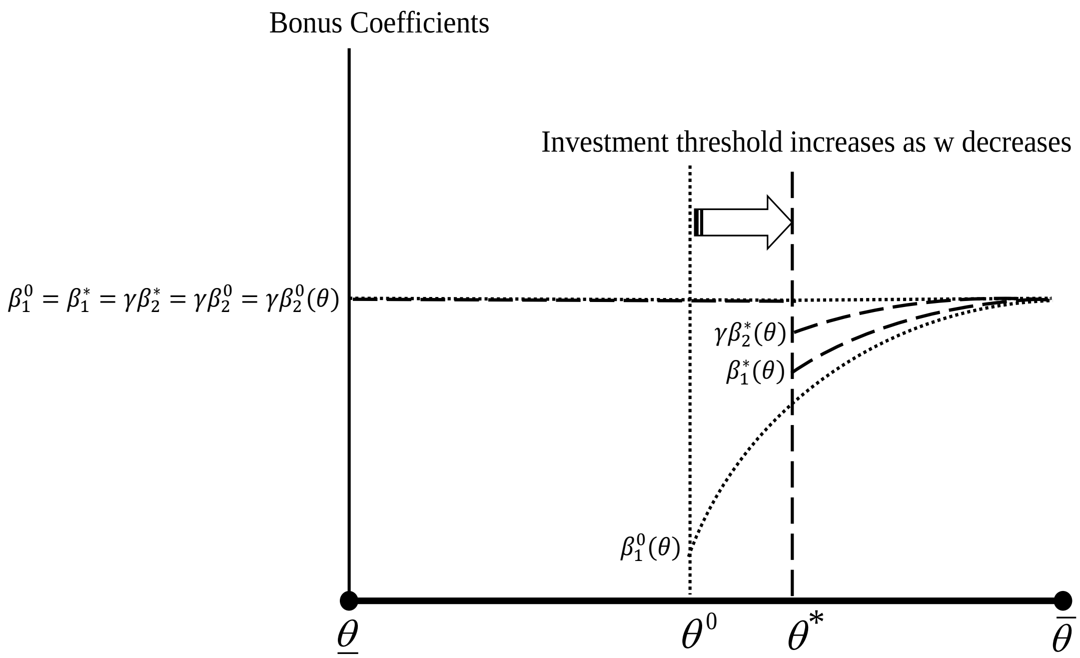

Figure 1: Investment Threshold for a front-loaded project $(x_1 = 1,\ x_2 = 0)$

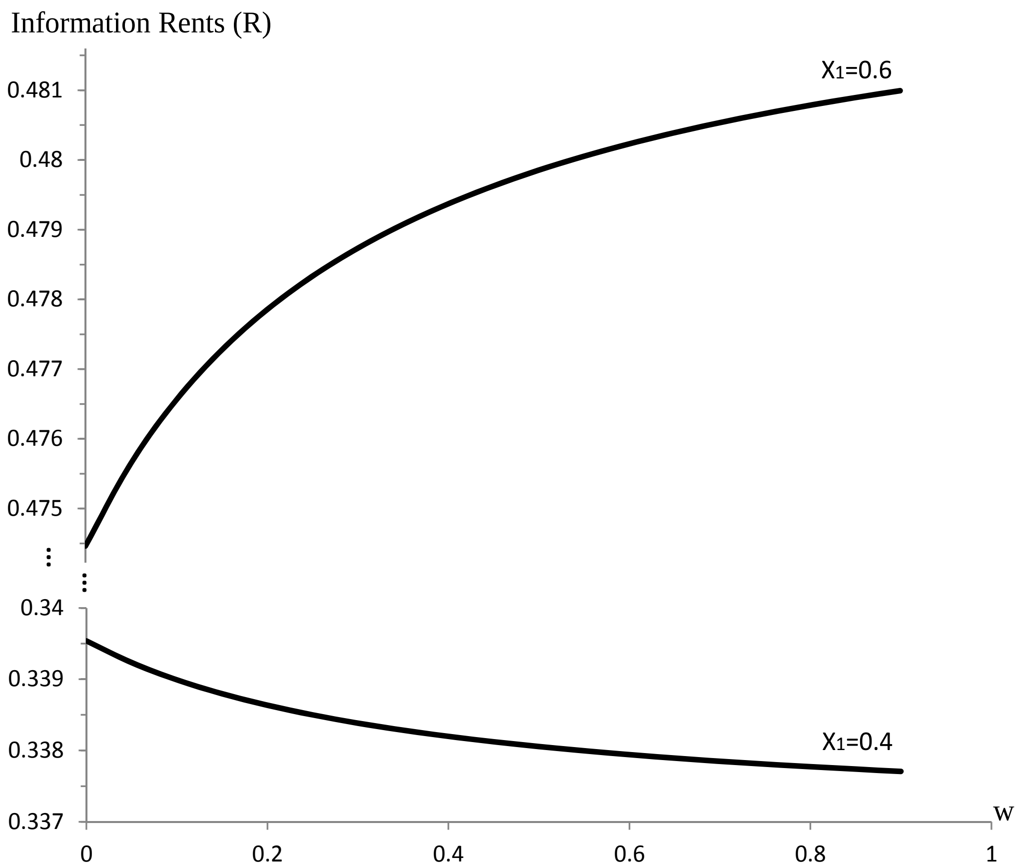

Figure 2: Information rents as a function of w

$(\theta \sim U[5,10],\ \Phi_1 = \Phi_2 = 5,\ \lambda_1^2 = 4,\ \lambda_2^2 = 3,\ k = 7,\ \gamma = 0.8)$

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