

**The optimal timing of executive compensation**

**By**

**Pierre Chaigneau**

**DISCUSSION PAPER 660**

**LSE FINANCIAL MARKETS GROUP**

**DISCUSSION PAPER SERIES**

**August 2010**

**Pierre Chaigneau is Assistant Professor in the Department of Finance at HEC Montreal. He achieved his PhD in Finance at the London School of Economics. His research interests include Corporate Finance; Agency Theory; CEO pay and Financial Economics. Any opinions expressed here are those of the authors and not necessarily those of the FMG. The research findings reported in this paper are the result of the independent research of the authors and do not necessarily reflect the views of the LSE.**

# The optimal timing of executive compensation

Pierre Chaigneau\*

HEC Montreal

`pierre.chaigneau@hec.ca`

August 13, 2010

## **Abstract**

We propose a new continuous-time principal-agent model to study the optimal timing of stock-based incentives, when the effects of managerial actions materialize with a lag and are only progressively understood by shareholders. On the one hand, early contingent compensation hedges the manager against the accumulation of exogenous shocks. On the other hand, the fact that initial information asymmetries between the manager and shareholders are progressively resolved suggests that contingent compensation should be postponed. We introduce two possible types of managerial short-termism, and show that they both result in lower-powered incentives and more deferred compensation.

---

\*I thank Sudipto Bhattacharya, Amil Dasgupta, Denis Gromb, Ian Jewitt, David Webb, and seminar participants at McGill, for useful comments and suggestions. I acknowledge financial support from Institut de Finance Mathématique de Montréal.

This paper introduces a new stylized principal-agent model through which the power and timing of stock-based incentive schemes are analysed. This model is unique as it combines three essential elements of executive pay: (i) a noisy output realized some time after the managerial action, (ii) time-varying information asymmetries between the manager and investors, and (iii) a stock price process continuously set by rational investors, on which the manager's pay may be contingent.<sup>1</sup> In this baseline model, we show that the optimal timing of stock-based compensation trades-off the accumulation of noise against the progressive elimination of information asymmetries. The paper then addresses the issue of managerial myopia, which is closely related to the timing of compensation. We show that the manager's ability to take short-termist actions affects the optimal corporate governance system: short-termism is exacerbated by a high-powered incentive scheme, but can be abated either with deferred compensation or with costly monitoring. Finally, we argue that the model's predictions are consistent with the empirical evidence, and conclude that it markedly improves our understanding of executive compensation.

The recent travails of major companies have reignited the debate on executive compensation, and in particular on the timing of variable pay. An emphasis on the maximization of short-term shareholder value, allegedly fostered by the current structure of executive pay, has been widely condemned in the wake of the 2008 crisis. There is growing concern that executives are remunerated before the full effects of their actions are revealed, which decouples their pay from their contribution and generates perverse incentives. The model we present formalizes this intuition. In the presence of market monitoring (Holmstrom and Tirole (1993)), it relates the power and timing of managerial incentive pay to the moral hazard problem between shareholders and the manager.

Uncertainty alone cannot explain the widespread practice of delaying the contingent compensation of managers. If noise makes the performance measure (possibly the stock price) less

---

<sup>1</sup>In most discrete time agency models (see the seminal papers of Mirrlees (1975), Holmstrom (1979), Grossman and Hart (1983)), the agent exerts effort at the beginning of the period, and a contractible output is realized at the end of the period. By contrast, in the more recent agency literature in continuous time (see for example Holmstrom and Milgrom (1987), Williams (2004), de Marzo and Sannikov (2006), Sannikov (2008)), the agent exerts effort continuously, and a contractible output is realized continuously and instantaneously.

informative about the manager's action as time passes, then a mechanism with delayed compensation cannot in general be optimal in a model in which the manager's action is observable. Indeed, setting up a mechanism which translates observability into contractibility, or simply renegotiating in the spirit of Hermalin and Katz (1991) would yield the first-best outcome. For example, the manager could be compensated based on the stock price established after he took his action, but before uncertainty is realized, which does not expose him to any risk.<sup>2</sup> As a consequence, this type of model cannot explain deferred managerial compensation.<sup>3</sup>

The main counterargument, first articulated by Narayanan (1985), states that managers have private information, so that their actions are not perfectly observable. This paper adopts the same premise, and introduces progressive learning by rational investors of the manager's private information through a signalling process. We show that this progressive diminution of information asymmetries can make deferred compensation optimal, and can therefore explain the fact that deferred compensation is the norm for CEOs: restricted stock grants typically vest after three years, while close to 90% of stock-options granted to S&P500 CEOs in 2006 had a maturity of 6 to 10 years.

We start with a standard moral hazard problem: a risk averse manager must be given incentives to undertake an efficient project rather than an inefficient project with a lower expected payoff, but which provides him with private benefits of control. To this end, his pay may depend on a stock price process established by a representative rational investor. This investor determines the stock price according to his information at a given time.<sup>4</sup> On the one hand, the conditional value of the payoff progressively diverges from its ex-ante value following the arrival of additive shocks, so that noise accumulates at a constant rate in the stock price as time passes. On the other hand, the investor progressively learns the conditional value of

---

<sup>2</sup>Bhattacharyya and Cohn (2008) reach a similar conclusion, but for a different reason: short-term equity compensation allows a risk averse manager to quickly reduce his exposure to the firm's risk, which enhances his willingness to undertake risky but valuable projects.

<sup>3</sup>Deferred compensation is sometimes justified as a retention tool. However, this hypothesis can only explain the progressive vesting of stocks and stock-options grants, not the fact that they are contingent upon the future, as opposed to the current, stock price.

<sup>4</sup>This paper considers a representative investor with rational expectations. By contrast, in Bolton, Scheinkman and Xiong (2006), a speculative component in the stock price results in an optimal compensation contract which encourages managerial short-termism. In Aghion and Stein (2008), short-term stock-based compensation may induce the manager to inefficiently cater to the stock market.

the final (noisy) payoff, by continuously receiving signals whose precision is increasing with time.<sup>5</sup> This captures the progressive diminution of information asymmetries. Our modelling of this process represents a significant methodological innovation, which could more generally be used in any model of learning in continuous time.

With a risk-neutral investor, we show that the optimal timing of compensation minimizes the variance of the manager's pay. This is achieved by paying him based on the stock price which is most informative about his project choice. Intuitively, the optimal timing of compensation balances the accumulation of noise, which grows with time, against the mispricing emanating from information asymmetries, which fades with time because of learning. While the first force degrades the informativeness of the stock price over time, the second one improves it.<sup>6</sup> We identify four possible cases. If information asymmetries outweigh noise, compensation should be contingent on the end-of-period stock price, in order for learning to be complete. If noise outweighs information asymmetries, compensation should be contingent on the initial date's stock price, so that the manager is thoroughly protected from noise. If information asymmetries are eliminated at an increasing rate, the manager should be compensated either based on the initial or the end-of-period stock price. If information asymmetries are eliminated at a decreasing rate, the manager should be compensated at the time when the rate in question is equal to the rate at which noise accumulates.

However, in practice, a manager's action is typically multi-dimensional. It often does not reduce to choosing the project with the mix of expected pay and private benefits of control which maximizes his expected utility. It is therefore important to take into account the potential perverse incentives that a compensation scheme, and especially the timing of compensation,

---

<sup>5</sup>We assume that the degree of information asymmetries is exogenous. However, in Holmstrom and Tirole (1993), the degree of liquidity in the secondary market for the firm's stocks determines the incentives of shareholders to gather information. In Edmans (2009), large blockholders have strong incentives to gather information on the firm's fundamental value, which reduces information asymmetries and mitigates managerial short-termism. Endogeneizing the degree of information asymmetries is a natural extension of the model.

<sup>6</sup>This result should be distinguished from the result of Bizjak, Brickley and Coles (1993) that higher information asymmetries translate into greater managerial opportunities for short-termism, which can in turn be tackled by postponing compensation. Although we address short-termism in the second part of the paper, our present argument that higher information asymmetries result in more delayed compensation is about the informativeness of the stock price, and the minimization of the agency cost of inducing the CEO to choose the efficient project.

may create on other dimensions. In particular, a risk averse manager may be tempted to artificially generate good signals of performance for long enough to benefit from a high stock price at the compensation date. In the words of Krugman (2002), “a system that lavishly rewards executives for success tempts those executives, who control much of the information available to outsiders, to fabricate the appearance of success.” We call that managerial short-termism of the first-type.<sup>7</sup> Note that inefficiently enhancing short-term payoffs at the expense of long-term payoffs can be viewed as short-termism of the first type.<sup>8</sup> Alternatively, the manager may prefer to opt for a less risky project with a shorter time horizon but a lower expected payoff so as to reduce the variability of his remuneration. We call that managerial short-termism of the second type. We expand the baseline model along these two dimensions, in order to examine their effects on the optimal compensation scheme.

Since the manager may now choose among a larger set of “inefficient projects” (in the sense that their expected payoffs are lower than the one of the efficient project), the compensation scheme derived in the baseline model may now lead him to select an inefficient project. Rational investors are not duped in equilibrium, and the manager does not derive any rent, but the outcome may still be inefficient. Consequently, it may be efficient to alter the compensation scheme derived in the baseline model.

Remarkably, the same remedies apply to both types of short-termism. First, we show that short-termism can be alleviated with lower-powered incentives, and that it is optimal to provide muted incentives when the short-termism problem is very severe.<sup>9</sup> Thus, there is a conflict between mitigating the effect of private benefits of control (or equivalently providing

---

<sup>7</sup>This could also be interpreted as “costly state falsification”, as in Lacker and Weinberg (1989). In his textbook on Corporate Finance, Tirole (2006) notes that “The management’s ability to garble signals received (...) adds an extra degree of moral hazard into the managerial incentive problem. Incentive schemes (...) that are meant to align managerial incentives with investors’ interests and thus induce high performance also tend to invite management to game the incentive system.”

<sup>8</sup>In some models, notably Narayanan (1985) and Stein (1989), the project’s payoff is divided into several components which are realized sequentially. They play the roles of early signals of performance based on which the manager may be paid. Such a compensation scheme could induce the manager to inefficiently produce early signals of high quality if his pay (or his tenure) depends on it, to the detriment of the final outcome – the discounted sum of all payoffs. This corresponds to short-termism of the first type.

<sup>9</sup>Thus, the paper is related to the multitask literature. Admittedly, the manager has only one task: selecting the firm’s project. However, when projects differ on dimensions other than their expected payoff and their private cost to the manager, we show that giving the manager strong incentives on one dimension only may be inefficient – a result reminiscent of Holmstrom and Milgrom (1991).

incentives for effort), which can be achieved with a rise in the pay-performance sensitivity, and preventing short-termism, which calls for a lessened pay-performance sensitivity. Second, we show that short-termism can be alleviated by postponing the evaluation and payment date. As discussed later, these results are consistent with empirical findings.<sup>10</sup> Finally, we postulate that a manager who is actively monitored cannot take short-termist actions, and we determine in which circumstances monitoring is valuable. We argue that our results contribute to the debate on the interaction between active monitoring and explicit incentives, and can explain why certain aspects of the corporate governance systems of publicly-listed corporations and firms controlled by a private-equity fund differ.

Since we assume that the manager has only one action (the project choice) and is paid only once, we do not consider the balance between short-term and long-term incentives (Holmstrom and Tirole (1993)), consumption smoothing (Wang (1997)), borrowing and saving, or conditioning the manager's current action on his past performances. These last three issues have been extensively studied in the dynamic moral hazard literature, notably in Fama (1980) and Holmstrom (1999). In these papers with repeated moral hazard, the passage of time enables a more precise assessment of the agent's talent, a result also obtained in Radner (1981).

In the theoretical literature on managerial short-termism, myopic behavior can be a response to early termination of projects with low short-term payoffs by uninformed financiers, as in von Thadden (1995). The manager is thus led to prefer a safer short-term project with a lower expected payoff. Short-termism can also emerge when managers can manipulate investors' expectations by increasing the short-term payoff at the expense of the long-term payoff, as in the signal-jamming models of Narayanan (1985) and Stein (1989). These papers show that short-termism may lead to inefficient investment decisions, but they do not take an optimal contracting perspective. Other papers show that managers may become overly concerned

---

<sup>10</sup>They are also in line with the existing theoretical literature. Goldman and Slezak (2006) reach a similar conclusion regarding the pay-performance sensitivity, in a model featuring what we would call short-termism of the first-type. Bizjak, Brickley and Coles (1993) show that for the manager not to be induced to undertake inefficient investments in order to "fool" the market and reap undeserved rewards in the short-run, his pay must be relatively more sensitive to long-run rather than short-run stock returns. However, these papers only consider one type of short-termism, and one instrument to discourage it. We consider both the pay-performance sensitivity and the timing of compensation. In a model of optimal contracting, we determine which one should be adjusted to discourage short-termism, depending on the parameters of the short-termism problem.

about short-term profits, whether because of takeover threats (Stein (1988)), or because the Principal may terminate them (Laffont and Tirole (1988), Manso (2007)). Giannetti (2009) shows that long-term compensation may be optimal to prevent managers from overinvesting in general skills, at the expense of firm-specific skills. Lastly, in Edmans, Gabaix, Sadzik and Sannikov (2009), a risk averse manager with stock-based pay may want to indulge in short-termism and shift stock returns from future periods to the current period because of consumption smoothing.

Section I presents the baseline model, derives the optimal timing of compensation at the second-best, and confronts the baseline model's predictions with empirical evidence. Section II introduces opportunities for two types of managerial short-termism, highlights how it could modify the second-best optimal power and timing of compensation, and confronts the model's predictions with empirical evidence. Section III concludes.

# I Optimal Timing of Compensation

## A. The Baseline Model

Consider a firm initially owned by a risk-neutral founder and run by a manager with CARA utility and coefficient of absolute risk aversion  $\gamma$ . The sequence of events is the following. At  $t = -2$ , the founder offers a compensation contract  $W$  to the manager. If he accepts, the manager then chooses between two projects and invests in the chosen project at  $t = -1$ . The efficient project has a publicly observed payoff of  $\bar{A} + \sigma^N B_T^N$  at time  $T$ , where  $B_t^N$  is an unobserved Brownian motion,<sup>11</sup> The inefficient project has a publicly observed payoff  $\underline{A} + \sigma^N B_T^N$  at time  $T$ , with  $\underline{A} < \bar{A}$ , and confers private benefits of control worth  $P$  to the manager. The parameters  $\sigma^N$  and  $P$  are common knowledge.

The founder is committed to selling the firm<sup>12</sup> at  $t = 0$  to a risk-neutral, unconstrained,

---

<sup>11</sup>It is therefore characterized by the standard properties of Brownian motions. In particular, it is equal to 0 at  $t = 0$ , and it writes as  $B_t^N = \int_0^t dB_s^N$ , for any  $t \geq 0$ . For any  $s > t$ , the term  $B_s^N - B_t^N$  is normally distributed with mean 0 and variance  $s - t$ .

<sup>12</sup>This assumption may be microfounded by assuming that the founder is an insider, and wants to protect himself against charges of insider trading. This can be achieved by placing at  $t = -1$  a sell order at the market price prevailing at  $t = 0$ .



and competitive representative investor, who is the only agent allowed to trade its stock. At any time  $t \in [0, T]$ , the stock price  $S_t$  is endogenously determined. At  $t = T$ , the firm's stock entitles its owner to the project's payoff. A liquidation of the firm at any time between  $t = 0$  and  $t = T$  is infinitely costly, so that investment is irreversible.<sup>13</sup> The objective of the founder is to maximize the expected (as of  $t = -2$ ) stock price of the firm at  $t = 0$ ,  $E_{-2}[S_0]$ , net of expected compensation costs  $E_{-2}[W]$ . For simplicity, the discount factor is zero.

### *Contracting*

For simplicity and tractability, we assume that the manager's contractual pay can depend linearly on the stock price at one predetermined point in time,  $\tau$ , where  $\tau \in [0, T]$ . The non-negative parameter  $b$  is the sensitivity of pay to performance at this time. Contract parameters are common knowledge. The manager's contingent pay writes as

$$W(S_\tau) = w + bS_\tau \tag{1}$$

where  $w$  is the fixed wage. Any compensation contract may therefore be described by the triplet  $\{w, \tau, b\}$ .

We assume that the manager has outside employment opportunities which give him a reservation utility of  $\bar{U}$ . He will therefore accept the contract if and only if his expected utility in equilibrium exceeds  $\bar{U}$ . Define his reservation wage as  $\bar{W}$ , where  $-exp\{-\gamma\bar{W}\} \equiv \bar{U}$ .

Since the manager is risk averse and the founder is risk-neutral, the first-best risk sharing rule consists in paying the manager a fixed wage, so that  $b = 0$  and  $w = \bar{W}$  if the efficient project is to be undertaken. Deviating from this rule by making the manager's pay variable for incentive reasons will be costly. For any given compensation contract  $\{w, \tau, b\}$ , we call the agency cost the difference between the manager's expected pay if he chooses  $A = \bar{A}$  in equilibrium, which is  $E_{-1}[w + bS_\tau | A = \bar{A}]$ , and his reservation wage  $\bar{W}$ .<sup>14</sup>

---

<sup>13</sup>It is possible that, ex-post, at  $t = 0$ , the stock price is lower than the expected payment to the manager, so that the firm is expected to operate at a loss. Since liquidation is infinitely costly, the firm must keep on operating from  $t = 0$  to  $t = T$ . This implies that no profitable renegotiation is possible, and any possible expected losses, as of  $t = 0$ , are incurred by the firm's founder.

<sup>14</sup> $E_{-1}$  denotes the conditional expectation operator at  $t = -1$ . The information of the founder is admittedly

### *The information structure*

From  $t = -2$ , only the manager and the founder know  $\underline{A}$  and  $\bar{A}$  (the representative investor never does). We assume that the founder cannot credibly communicate this information to the representative investor. We also assume that neither the founder nor the representative investor observe the manager's choice of  $A$  – although the founder may infer it from the parameters of the contract and his knowledge of  $\underline{A}$  and  $\bar{A}$ , as will be clear shortly. However, the representative investor progressively learns the value of the project's conditional expected payoff  $A + \sigma^N B_t^N$ : for all  $t \in [0, T]$ , he observes a noncontractible signal  $v_t$  at time  $t$ . His initial information is therefore crystallized in the signal  $v_0$ , which may be viewed as his prior.<sup>15</sup>

Assume that the time 0 signal,  $v_0$ , and the time  $t$  signal,  $v_t$ , are respectively

$$v_0 = A - \int_0^T \sigma_s^U dB_s^U \quad (2)$$

$$v_t = A + \sigma^N B_t^N - \int_t^T \sigma_s^U dB_s^U \quad (3)$$

where  $B_t^U$  is another Brownian motion, uncorrelated with  $B_t^N$ , with time-varying, deterministic, and common knowledge diffusion process  $\sigma_t^U$ . For simplicity and tractability, we assume that the diffusion process  $\sigma_t^U$  is either constant, or monotonically increasing or decreasing with  $t$ . The Brownian motion  $B_t^U$  is fully realized before  $t = 0$ , and never observed by any agent at any time (however, the signal  $v_t$  is observed by the representative investor at time  $t$ ).

The dynamics of the  $\sigma_t^U$  process determine whether information asymmetries are resolved at the beginning or at the end of the time interval  $[0, T]$ : they are mostly resolved at the beginning if  $\sigma_t^U$  is decreasing in  $t$ , and mainly towards the end if  $\sigma_t^U$  is increasing in  $t$ . The overall magnitude of  $\sigma_t^U$  is the extent of information asymmetries: the less private information the manager possesses relative to the investor, the smaller the overall magnitude of  $\sigma_t^U$ . If

---

the same at  $t = -2$  and  $t = -1$ : the manager chooses in which project to invest at  $t = -1$ , but the founder already knows whether or not he will invest in the efficient project, given the parameters of the contract that he offers at  $t = -2$ . There is no arrival of new information at  $t = -1$  in equilibrium.

<sup>15</sup>Since neither the manager nor the founder do anything after  $t = -1$ , it is inconsequential whether or not they observe the process  $v_t$  at any time  $t \in [0, T]$ . Likewise, since the representative investor only acts from  $t = 0$ , his information prior to  $t = 0$  is irrelevant.

$\sigma_t^U$  were identically zero, there would not be any information asymmetries, and the passage of time would only add noise to the signal process  $v_t$ , where noise is represented by the Brownian motion  $B_t^N$ .

This representation of the signal process has the advantage of being very tractable, and also has three desirable properties. First, the signal is an unbiased estimate of  $A$ , since its probability distribution is centered around  $A$ . Second, the variance between the signal  $v_t$  and the conditional expected payoff  $A + \sigma^N B_t^N$  is decreasing in  $t$ , which is consistent with the progressive attenuation of the mispricing due to information asymmetries. Third, at any time  $t$ ,  $v_t$  is a sufficient statistic for the project's payoff  $A + \sigma^N B_T^N$  (this result is proven in the Appendix). Thus,  $v_0$  may be viewed as an uninformative prior over the project's payoff.

### *Profitability*

We make two assumptions on ex-ante profitability, from the founder's perspective. First, as of  $t = -2$ , the expected payoff net of the expected payment to the manager in equilibrium is assumed to be nonnegative with the inefficient project with private benefits of control. Second, as of  $t = -2$ , the expected payoff net of the expected payment to the manager in equilibrium is assumed to be larger with the efficient project at the second-best than with the inefficient project with private benefits of control. Formally, and as will be clearer later, this reduces to assuming the following:

$$\bar{A} - \bar{W} - \frac{\gamma}{2} \left( \frac{P}{\bar{A} - \underline{A}} \right)^2 \left( \sigma^{N^2} \tau^\star + \int_{\tau^\star}^T \sigma_t^{U^2} dt \right) > \underline{A} - \bar{W} + P \geq 0 \quad (4)$$

where  $\tau^\star$  is defined in Proposition 1. When the contract  $\{w, \tau, b\}$  is such that the manager optimally chooses the efficient project, the objective function of the founder is

$$E_{-1}[S_0 - (w + bS_\tau) | A = \bar{A}] \quad (5)$$

### *The stock price*

The discount factor is zero, the representative investor is competitive and risk-neutral, and a sufficient statistic for his information at time  $t$  is  $v_t$ . For any  $t \in [0, T]$  and  $j \in [t, T]$ , we therefore have in equilibrium:

$$S_t = E_t[S_j|v_t] \quad (6)$$

At  $t = T$ , the payoff  $A + \sigma^N B_T^N$  of the stock is known, so

$$S_T = A + \sigma^N B_T^N \quad (7)$$

Setting  $j = T$  in (6) and substituting,

$$S_t = E_t[A + \sigma^N B_T^N | v_t] \quad (8)$$

At any time  $t \in [0, T]$ , the market clearing price  $S_t$ , at which the net demand from the representative investor equals the net supply of the stock, is equal to the conditional expectation of the project's payoff.<sup>16</sup> Using (3),

$$S_t = E_t \left[ v_t + \int_t^T \sigma_s^U dB_s^U | v_t \right] = v_t \quad (9)$$

Applying this equality to (2) and (3) respectively yields the time 0 and time  $t$  stock prices:

$$S_0 = A - \int_0^T \sigma_s^U dB_s^U \quad (10)$$

$$S_t = A + \sigma^N B_t^N - \int_t^T \sigma_s^U dB_s^U \quad (11)$$

---

<sup>16</sup>Since we work with one representative investor, there would admittedly not be any trading in the model, for any  $t \in (0, T]$ . This being said, we could imagine a mechanism in which a market-maker receives orders from this representative investor, which he must balance against a net supply of the stock of zero. The stock price announced by the market-maker will therefore be the market clearing price, which ensures that the net demand from the representative investor is zero.

Combining (10) and (11) gives another expression for  $S_t$ :

$$S_t = S_0 + \sigma^N B_t^N + \int_0^t \sigma_s^U dB_s^U \quad (12)$$

For  $t = T$ ,

$$S_T = S_0 + \sigma^N B_T^N + \int_0^T \sigma_s^U dB_s^U \quad (13)$$

Finally, the dynamics of  $S_t$  may be derived from either (11) or (12):

$$dS_t = \sigma^N dB_t^N + \sigma_t^U dB_t^U \quad (14)$$

This deserves clarification. The investor does not know the value of  $A$ , and at time  $t$  he does not observe any of the different terms on the right-hand-side of (11). Instead, at any time  $t$  he observes  $v_t$ , and sets the stock price  $S_t$  according to this information. Equation (11) shows how information asymmetries fade away as  $t$  approaches  $T$ . Loosely speaking, this method of unwinding a Brownian motion allows to use the Brownian motion  $B_t^U$  to *reduce* uncertainty, from the investor's perspective.

As is apparent in (11), a manager compensated at  $t = \tau$  is exposed to two sources of risk: the accumulated noise from  $t = 0$  to  $t = \tau$  on the one hand, and the remaining information asymmetries at  $t = \tau$  on the other hand (the higher  $\tau$  is, the less information asymmetries remain). A higher  $\tau$  results in more noise in the stock price used for managerial compensation, but less information asymmetries. In addition, the longer the time horizon  $T$  of the project, the more the manager is exposed to risk. In this sense, longer-term projects are more costly in terms of agency costs.<sup>17</sup> This will be crucial in the next section.

## B. The Optimal Contract

Because of (4), we know that it is optimal for the founder to design the compensation contract  $\{w, \tau, b\}$  so as to maximize his objective function in (5) conditional on the manager

---

<sup>17</sup>Shleifer and Vishny (1990) provide another reason, related to financial arbitrage, as to why long-term projects are prone to greater mispricing than short-term projects.

accepting the contract and choosing the efficient project. If this is the case, using (10) and (11), the objective function of the founder rewrites as

$$E_{-1}[S_0 - (w + bS_\tau)|A = \bar{A}] = (1 - b)\bar{A} - w \quad (15)$$

The value of  $\bar{A}$  being given, the objective of the founder reduces to minimizing the expected cost of the manager's pay, subject to the participation constraint and the incentive constraint defined below. We begin by setting  $b$  and  $w$  so as to bind these two constraints. Then we optimize over the compensation date,  $\tau$ .

In a CARA-normal framework with a contract linear in the outcome, the expected utility of pay is fully described by the expected pay and the variance of pay. The variance of the manager's pay given his information at  $t = -1$ , which includes the value of  $A$  and contract parameters, is obtained from (11):

$$var_{-1}[w + bS_\tau|A] = b^2 \left( \sigma^{N^2} \tau + \int_\tau^T \sigma_t^{U^2} dt \right) \quad (16)$$

This expression is independent of  $A$ .

The manager will therefore opt for the efficient project if and only if his expected pay (including private benefits of control) is higher with the efficient project than with the inefficient project. The incentive constraint, which ensures that this is the case, is

$$w + b\bar{A} \geq w + b\underline{A} + P \quad (17)$$

Or, since it is binding in equilibrium,<sup>18</sup> it gives the second-best optimal pay-performance sensitivity, denoted by  $b^*$ :

$$b^* = \frac{P}{\bar{A} - \underline{A}} \quad (18)$$

---

<sup>18</sup>The standard argument applies. If it is not binding, decrease  $b$  until the point where it is binding, and adjust  $w$  so that the manager's expected pay is unchanged. The founder is therefore indifferent between these two schemes since they are characterized by the same expected cost. But the variance of the manager's pay in (16) is lower with the new scheme, since  $b$  is lower. It follows that  $w$  can be reduced until the manager reaches his reservation utility, which reduces the expected cost of the scheme. This shows that a nonbinding incentive constraint cannot be optimal.

The fixed wage  $w$  is set to bind the participation constraint. Using the certainty equivalent approach with a given contract  $\{w, \tau, b\}$ , the participation constraint with  $A = \bar{A}$  and no private benefits of control is

$$w + bE_{-1}[S_\tau|A = \bar{A}] - \frac{\gamma}{2}b^2var_{-1}[S_\tau|A = \bar{A}] \geq \bar{W} \quad (19)$$

This gives the equilibrium value of the fixed wage at the second-best, denoted by  $w^*$ :

$$w^* = \bar{W} - b^*\bar{A} + \frac{\gamma}{2}b^2\left(\sigma^{N^2}\tau + \int_\tau^T \sigma_t^{U^2} dt\right) \quad (20)$$

In equilibrium, the expected cost of the contract  $\{w^*, \tau, b^*\}$  is equal to

$$w^* + E_{-1}[b^*S_\tau|A = \bar{A}] \quad (21)$$

Substituting for the value of  $w^*$  from (20), the expected cost of compensation at the second-best is

$$\bar{W} + \frac{\gamma}{2}b^{*2}\left(\sigma^{N^2}\tau + \int_\tau^T \sigma_t^{U^2} dt\right) \quad (22)$$

It decomposes as the reservation wage plus the agency cost, which is proportional to the variance of the manager's pay. As already discussed, the objective of the founder reduces to minimizing the expected cost of compensation. Since the pay-performance sensitivity  $b^*$  is already set in (18), (22) shows that this is achieved by paying the manager at the time  $t = \tau$  which minimizes the ex-ante variance of the stock price  $S_t$ , for  $t \in [0, T]$ .

The agency cost can be eliminated in three special cases. If there are no information asymmetries ( $\sigma_t^U \equiv 0$ ), full hedging against the accumulation of noise is possible: compensation is then contingent on  $S_0$  ( $\tau = 0$ ), and the manager does not face any risk. In the absence of noise ( $\sigma^N = 0$ ), it is costless to wait for information asymmetries to unwind: compensation is then contingent on  $S_T$  ( $\tau = T$ ), and the manager does not face any risk either. Lastly, if the manager is risk-neutral ( $\gamma = 0$ ), the timing of payments does not matter. If one of these three cases does not apply, the problem is nontrivial.

In view of (22), the problem of the founder can be written as<sup>19</sup>

$$\min_{\tau} \frac{\gamma}{2} b^{\star 2} \left( \sigma^{N^2} \tau + \int_{\tau}^T \sigma_t^{U^2} dt \right) \quad \text{where} \quad b^{\star} = \frac{P}{\bar{A} - \underline{A}} \quad (23)$$

Then we have the following result:

**Proposition 1:** The second-best optimal timing of compensation,  $\tau^{\star}$ , is as follows:

- If  $\sigma_t^U \geq \sigma^N$  for all  $t$ , then  $\tau^{\star} = T$ .
- If  $\sigma_t^U \leq \sigma^N$  for all  $t$ , then  $\tau^{\star} = 0$ .
- If none of the above applies and  $\sigma_t^U$  is increasing in  $t$ ,  $\tau^{\star} = 0$  if  $\int_0^T \sigma_t^{U^2} dt < \sigma^{N^2} T$ , and  $\tau^{\star} = T$  if  $\int_0^T \sigma_t^{U^2} dt > \sigma^{N^2} T$ .
- If none of the above applies and  $\sigma_t^U$  is decreasing in  $t$ , then  $\tau^{\star}$  is implicitly defined by  $\sigma_{\tau^{\star}}^U = \sigma^N$ .

The proof is in the Appendix. We call  $\{w^{\star}, \tau^{\star}, b^{\star}\}$  the second-best optimal contract parameters. Given the complexity of the model, it is remarkable that the rate at which noise accumulates and the rate at which information asymmetries are resolved fully determine the optimal timing of compensation. Paying the manager early hedges him against the noise which accumulates in the stock price. Paying the manager late ensures that most of his private information has been incorporated in the stock price, and so reduces his exposure to mispricing attributable to information asymmetries. As a rule, the stronger the noise is relative to information asymmetries, the earlier the manager should be paid. In view of (7), it is noteworthy that paying the manager at time  $T$  is equivalent to using an accounting-based measure of performance, the payoff of the project, rather a stock-market-based measure of performance. In

---

<sup>19</sup>Although we omit a thorough discussion, it should be clear that, given this agency cost of implementing the efficient project, undertaking this project at the second-best rather than the inefficient project with private benefits of control maximizes the objective function of the founder, because of (4).



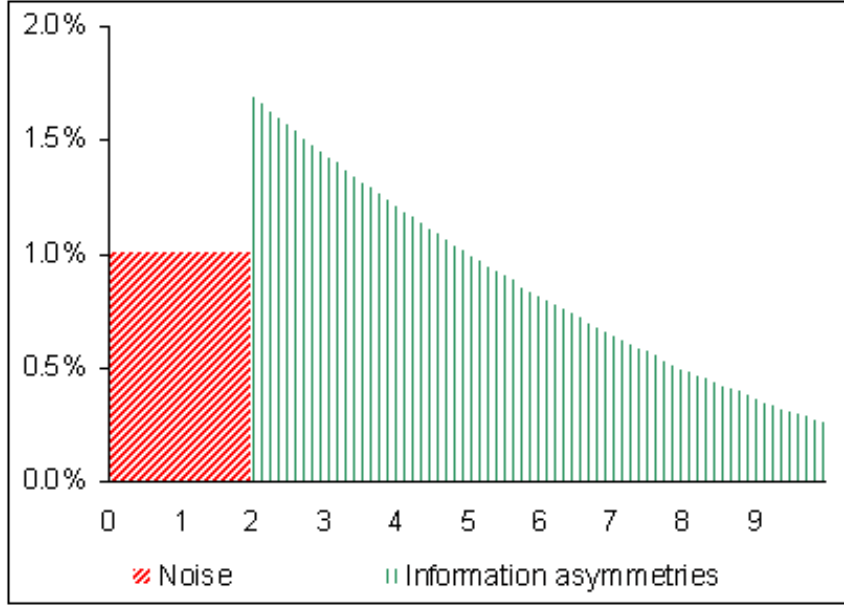


Figure 1: Suboptimal timing: the manager is paid at time 2. The agency cost of compensation is proportional to the sum of the two areas.

general, however, using the stock price as a measure of performance reduces the agency cost of the contract, thereby improving the efficiency of managerial compensation.

Figures 1 and 2 illustrate these arguments. Suppose that  $\sigma^N = 10\%$ , and the process  $\sigma_t^U$  decreases linearly from a level of 15% at  $t = 0$ , to a level of 5% at  $t = 10$ . In Figure 1, the manager is paid based on the stock price at  $t = 2$ . The sum of the two areas in Figure 1 gives its variance, from the manager's ex-ante perspective. This is precisely the criterion which is minimized at the optimum, as can be seen in (23). The diagonally hashed area is the part of the stock price variance attributable to noise, which accumulates from  $t = 0$  to  $t = 2$ , while the vertically hashed area is the part of the stock price variance due to information asymmetries which are not resolved yet at  $t = 2$ . Clearly, it is possible to reduce the variance of the manager's pay by paying him based on the stock price at  $t = 5$  rather than the stock price at  $t = 2$ , as shown in Figure 2. More noise will then accumulate, which increases the variance of his pay, and more information asymmetries will be resolved, which decreases the variance of his pay. But the second effect will dominate, since  $\sigma_t^U > \sigma^N$  from  $t = 2$  to  $t = 5$ .

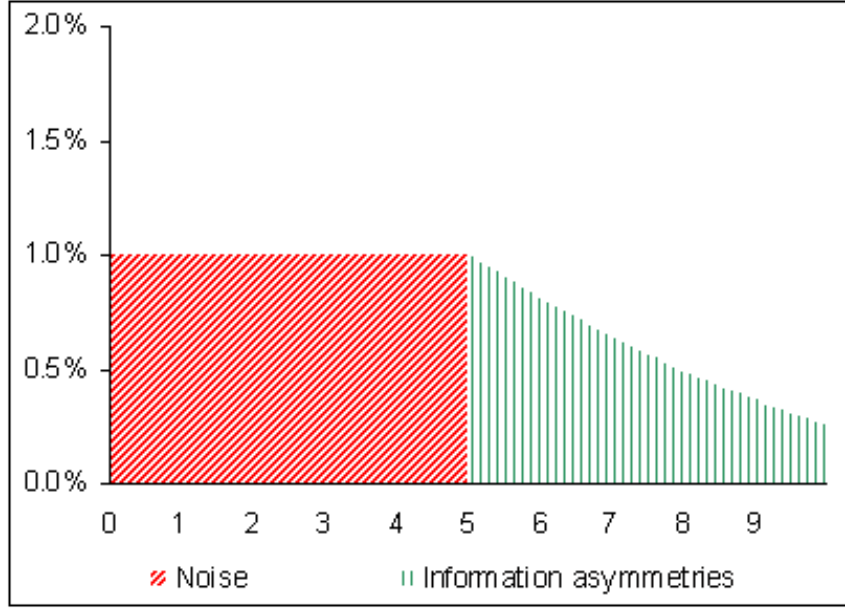


Figure 2: Optimal timing: the manager is paid at time 5. The agency cost of compensation is proportional to the sum of the two areas.

### C. Predictions and Empirical Evidence: the Baseline Model

The baseline model predicts that the level of information asymmetries relative to the level of noise determines the optimal timing of compensation. First, firms which manage to produce an almost noise-free performance measure, whether because their profits are not significantly affected by noise, or because they can filter it out, will delay compensation more, *ceteris paribus*. This will mainly depend on the industrial sector of the firm. Second, for a given level of noise, firms whose managers do not have a lot of private information (think about firms with recurring investments, or firms in traditional industries that investors easily comprehend) will pay managers early. Firms where information asymmetries are strong (think about firms with new projects, investment banks with opaque strategies, and firms in ascending industries that investors do not fully understand yet) will delay compensation more.<sup>20</sup>

<sup>20</sup>The banking industry provides a good case study. Prior to 2007, banks tended to make relatively steady profits, but their strategies left observers perplex. The financial crisis of 2007-2008 had three effects. It made bank profits much more volatile, it shed light on the strategies they use, and it prompted some of them to scale back rocket-science banking and go back to basics. In this context, the baseline model makes two predictions – or recommendations. First, the stock-based compensation of banks' top managers should have been tilted toward the long-term prior to 2007. Second, the financial crisis should have shortened the time horizon of their compensation. To the extent that the financial crisis exacerbated their opportunities for short-termism,

Kole (1997) finds that chemicals, machinery and producer firms have higher mean minimum and average waits to exercise stock-options award. Furthermore, this group of firms imposes a longer vesting period on restricted stock grants (50 months) than metals, foods, and consumer firms (20 months). Kole describes the former group of firms as belonging to highly innovative industries which require specialized knowledge. These are precisely the characteristics we would associate with a higher degree of information asymmetries between the management and shareholders. Our model's prediction that more information asymmetries result in a more delayed compensation concurs with this finding.

Besides the industrial sector, another good measure of information asymmetries is the growth rate of the firm. For example, Smith and Watts (1992) assume that information asymmetries are greater in high-growth firms, whereas managerial effort is more easily observable in low-growth firms. In line with our model's predictions, Bizjak, Brickley and Coles (1993) present evidence that "high-growth firms place less emphasis on current performance relative to future performance in managerial compensation plans than low-growth firms".

## II Optimal Timing of Compensation with Short-Termism

The model is now extended to allow for managerial short-termism. We expand the action set of the manager, to allow him to take (second-best) inefficient actions. We analyze two possible types of short-termism in turn, and we emphasize how the second-best outcome of the previous section is generally not robust to enlarging the action set of the manager. We then show how the optimal timing and power of compensation should be altered under third-best efficiency, which allows for short-termism. In a separate sub-section, we put forward monitoring as a solution to the short-termism problem. Finally, we review empirical evidence in light of these results.

---

however, the next section will show that it could instead have been optimal to defer their compensation even more from 2007.

### A. Short-Termism of the First Type

Assume that, at  $t = -1$ , the manager can either invest in one of the two projects already described, or in an inefficient short-term project, whose time  $T$  payoff is  $\underline{A} + \sigma^N B_T^N$ . A manager who selects this project must choose  $s \in [0, T)$ , which is unobservable to other agents. On the one hand, he then incurs a monetary cost  $\frac{c}{2}(s + \epsilon)^2$ , where  $c > 0$  and  $\epsilon \geq 0$  are common knowledge. On the other hand, the signal process  $v_t$  then has an unconditional mean of  $\hat{A} > \bar{A}$  from  $t = 0$  to  $t = s$ , and of  $\underline{A}$  from  $t = s$  to  $t = T$ :

$$v_t = \hat{A} + \sigma^N B_t^N - \int_t^T \sigma_z^U dB_z^U \quad (24)$$

for  $t \leq s$ , and

$$v_t = \underline{A} + \sigma^N B_t^N - \int_t^T \sigma_z^U dB_z^U \quad (25)$$

for  $t > s$ . We assume that the difference  $\hat{A} - \bar{A}$  is common knowledge, in order for the investor to be able to assess ex-ante whether it is in the manager's interests to invest in the inefficient short-term project rather than the efficient project, given contract parameters.<sup>21</sup>

A natural interpretation is that the manager can manipulate the signal process at a cost, so that it (misleadingly) indicates that he has invested in a project with a high expected payoff ( $\hat{A}$ ). In turn, manipulating the signal process until the time when he is paid enables him to enjoy the high pay associated with a high expected payoff.

Our approach is the following. First of all, we note that it is never optimal for the founder to induce the manager to invest in the short-term inefficient project at the third-best (see the Proof of Proposition 2 for a formal demonstration). Indeed, it is always better to induce him to invest in the inefficient project with private benefits of control instead: the final payoffs of these two projects have the same distribution, but the latter provides private benefits of control to the manager, which relaxes the participation constraint and enables a diminution of the fixed wage. We therefore know that the equilibrium contract will be such that it is optimal

---

<sup>21</sup>The investor will therefore not be misled in equilibrium, as we make clear below. But should it be in the manager's interests to manipulate the signal process, he will do it, which will be anticipated by investors. The manager will therefore not derive any rent in equilibrium, but the outcome will be inefficient. This is a typical signal-jamming equilibrium.

for the manager not to invest in the inefficient short-term project. Thus, we take as given the representative investor's belief that the manager invests either in the efficient project or in the inefficient project with private benefits of control in equilibrium. Then we verify that the representative investor cannot be misled in that regard, and we show in Proposition 2 that this belief is verified in equilibrium (when the stock price is determined in accordance with this belief, and the manager acts optimally conditional on this stock price process and on his contract).

We begin by determining the manager's optimal behavior regarding the inefficient short-term project:

**Claim 1:** If  $\tau = T$ , then it is suboptimal for the manager to select the inefficient short-term project. If  $\tau < T$ , and if the manager selects the inefficient short-term project in equilibrium, then he chooses  $s = \tau$ .

If the investor believes that the manager does not invest in the inefficient short-term project in equilibrium, then the stock price is determined as in the previous section, so that

$$S_t = v_t \tag{26}$$

for any  $t \in [0, T]$ .

If the manager is compensated at time  $\tau = T$ , then we know from Claim 1 that he will not invest in the inefficient short-term project, so that we know from the previous section and the incentive constraint in (17) that he selects the efficient project if and only if  $b \geq b^*$ . If the manager is compensated at time  $\tau < T$ , then the condition that must be satisfied for the investor's belief that he will invest in the efficient project rather than in the inefficient short-term project to be verified in equilibrium is, given Claim 1, the signal processes described in (3) and (24) respectively, the stock price process described in (26) and contract parameters:

$$w + b\bar{A} \geq w + b\hat{A} - \frac{c}{2}(\tau + \epsilon)^2 \tag{27}$$

The left-hand side of (27) is the expected pay of a manager who invests in the efficient project, while the right-hand side is the expected pay net of costs of a manager who invests in the inefficient short-term project and manipulates the signal process up to the time  $\tau$  when he is compensated (since both projects are associated with the same variance of pay, it was omitted). The parameters  $c$  and  $\epsilon$ , the difference  $\hat{A} - \bar{A}$  and contract parameters being common knowledge, the representative investor knows whether it is the interests of the manager to invest in the inefficient short-term project, given his compensation contract: the representative investor cannot be misled.

We know from the previous section that for  $b \geq b^*$ , the manager had rather invest in the efficient project than in the inefficient project with private benefits of control. Therefore, if  $b \geq b^*$ , then the manager invests in the efficient project, and the investor knows that he does, if and only if condition (27) is satisfied. With second-best optimal contract parameters (notably given the value of  $b^*$  in (18)) and  $\tau^* \neq T$ , this condition is rewritten as

$$\tau^* \geq \sqrt{2b^* \frac{\hat{A} - \bar{A}}{c}} - \epsilon = \sqrt{2 \frac{P}{c} \frac{\hat{A} - \bar{A}}{\bar{A} - \underline{A}}} - \epsilon \equiv \underline{\tau} \quad (28)$$

Should the second-best optimal timing of compensation  $\tau^* \neq T$  defined in Proposition 1 be lower than  $\underline{\tau}$ , a manager compensated at time  $\tau^*$  will select the inefficient short-term project rather than the efficient project: the second-best outcome described in the previous section is then not feasible anymore. In this case, the inequality in (28) highlights the three possible ways to ensure that the manager still selects the efficient project rather than the inefficient short-term project. First and foremost, this can be achieved by postponing the compensation date and choosing  $\tau = \min\{\underline{\tau}, T\}$ , at the cost of a deviation from the second-best optimal timing  $\tau^*$  and the resulting increase in the agency cost. A second response consists in making it more costly to manipulate the signal process, by raising  $c$  or  $\epsilon$ . Auditing, or scrutiny from independent equity research analysts, could help. Third, the pay-performance sensitivity  $b$ , which fuels short-termism, could be reduced. However, with  $b < b^*$ , the manager would not invest in the efficient project, since he would then rather invest in the inefficient project with private benefits of control. Hence this important conclusion: the higher the power  $b^*$  of incentives needed to

prevent investment in the inefficient project with private benefits of control, the smaller the set of parameter values for which the second-best outcome (the second-best optimal contract parameters  $\{w^*, \tau^*, b^*\}$  and the manager opting for the efficient project) is feasible.

Given the founder's maximizing behavior, the next Proposition shows for which set of parameter values the efficient project is implemented, and for which set of parameter values the inefficient project with private benefits of control is implemented.

**Proposition 2:** If

$$\bar{A} - \underline{A} > \frac{\gamma}{2} \left( \frac{P}{\bar{A} - \underline{A}} \right)^2 \left( \sigma^{N^2} h + \int_h^T \sigma_t^{U^2} dt \right) + P \quad (29)$$

where  $h = T$  if  $\sigma_t^U$  is increasing in  $t$ ,  $\sigma^{N^2} T > \int_0^T \sigma_t^{U^2} dt$ ,  $0 < \underline{\tau} < T$ , and  $\int_{\underline{\tau}}^T \sigma_t^{U^2} dt > \sigma^{N^2} (T - \underline{\tau})$ , and  $h = \max\{\tau^*, \min\{\underline{\tau}, T\}\}$  otherwise, then the optimal contract parameters are  $b = b^*$  and  $\tau = h$ , and the manager selects the efficient project. Otherwise, it is optimal to set  $b = 0$ , and the manager selects the inefficient project with private benefits of control.

In summary, with short-termism of the first-type, either no explicit incentives are provided ( $b = 0$ ), or the timing of compensation is postponed relative to the second-best optimal timing ( $\tau \geq \tau^*$ ).

Even though the short-term inefficient project is never implemented in equilibrium, its mere existence may make it too costly to provide incentives for the manager to pick the efficient project. When  $\hat{A}$  is high and  $c$  and  $\epsilon$  are low,  $\underline{\tau}$  is high, so that a deviation from the second-best optimal contract parameters may be needed if the efficient project is to be implemented (since we then need to have  $\tau \geq \min\{\underline{\tau}, T\}$ , by definition of  $\underline{\tau}$ ). Should this deviation be too costly in terms of agency cost, it may then become more efficient to implement the inefficient project with private benefits of control.<sup>22</sup> This is achieved by giving only a fixed wage to the manager

---

<sup>22</sup>This is how condition (29) should be interpreted: the first-term on the right-hand side is the agency cost of inducing the manager to invest in the efficient project. Setting  $b = b^*$  ensures that the manager chooses the efficient project rather than the inefficient project with private benefits of control;  $h$  is the timing of pay which minimizes the agency cost under the constraint that the manager chooses the efficient project rather than the inefficient short-term project.

( $b = 0$ ), which ensures that he will prefer this project to the inefficient short-term project.

## B. Short-Termism of the Second Type

Now assume that, at  $t = -1$ , the manager can either invest in the inefficient project with private benefits of control already described in the baseline model, or invest in a project with a “time horizon” of  $r$ ,  $0 \leq r \leq T$  and expected payoff  $\bar{A}_r$ . As we explain below, the time horizon only denotes the time at which information asymmetries are fully resolved – the payoff is still realized at  $t = T$ , exactly as before. As in the baseline model, the manager choice is unobservable.

To introduce a potential conflict of interest between the founder and the manager, we need two elements. First, we assume that the expected payoff  $\bar{A}_r$  is increasing in the time horizon  $r$  (the inefficient project with private benefits of control is still characterized by an expected payoff of  $\underline{A}$ ). For simplicity, assume a linear relationship: for a given  $\mu > 0$  and any  $r \in [0, T]$ ,

$$\bar{A}_r = \bar{A} - \mu(T - r) \quad (30)$$

Second, from the manager’s ex-ante perspective, the variability of the stock price due to information asymmetries is increasing in the time horizon  $r$  of the project. Formally, if the manager chooses a project with time horizon  $r$  and expected payoff  $\bar{A}_r$ , we assume that the signal process is described by:

$$v_t = \bar{A}_r + \sigma^N B_t^N - \int_t^r \sigma_s^U dB_s^U \quad (31)$$

for  $t \leq r$ , and

$$v_t = \bar{A}_r + \sigma^N B_t^N \quad (32)$$

for  $t > r$  (if the manager opts for the inefficient project with private benefits of control, the signal process is still described in (2) and (3), as in the preceding section<sup>23</sup>). The manager

---

<sup>23</sup>Equivalently, the signal he receives in this case is described by the signal process described in (31) and (32), except that  $\bar{A}_r$  is replaced by  $\underline{A}$  and  $r$  is replaced by  $T$ .



effectively chooses when information asymmetries vanish. Notice that the project with  $r = T$  is the efficient project of the baseline model. Following the same steps as in section I, we get

$$S_t = v_t \tag{33}$$

for any  $t \in [0, T]$ .

In the baseline model, the only alternative to the inefficient project with private benefits of control is the efficient project. Now, as an alternative to the inefficient project with private benefits of control, the manager may choose among a set of projects with different expected returns and time horizons – where the time horizon determines the time at which information asymmetries are fully resolved. At one end of the spectrum (a low  $r$ ), some projects have relatively low expected returns but are less plagued by information asymmetries. One example is for the manager to reinvest in existing lines of business. At the other end of the spectrum (a high  $r$ ), some projects have higher expected returns but are characterized by strong information asymmetries. One example is for the manager to launch a brand new project involving lots of changes which are hard to apprehend for outside investors.

We are now going to analyze the manager's problem, given a compensation contract. First, we show in the Appendix that, conditional on the manager not choosing the inefficient project with private benefits of control,  $r \geq \tau$  at the optimum: the manager optimally chooses a time horizon  $r$  higher than the time  $\tau$  at which he is paid. Intuitively, as long as  $r < \tau$ , the manager's expected compensation is an increasing function of  $r$ , while his exposure to noise is independent of  $r$ , and he is not exposed at all to any variance of pay emanating from information asymmetries. Second, given parameters  $\{w, \tau, b\}$  of the compensation contract, the manager's certainty equivalent wealth of choosing the project with a time horizon of  $r \geq \tau$  is

$$CE(r) = w + b\bar{A}_r - \frac{\gamma}{2}b^2\left(\sigma^{N^2}\tau + \int_{\tau}^r \sigma_s^{U^2}ds\right) \tag{34}$$

where  $\bar{A}_r$  is defined in (30). The manager clearly faces a tradeoff. On the one hand, shortening the project's time horizon  $r$  diminishes the expected payoff of the project, which diminishes

his expected pay. On the other hand, shortening the project's time horizon  $r$  reduces the variability of the signal process, which reduces the variance of his stock-based pay.

The problem of the manager is solved in the Appendix. For the manager to select a project with a long time horizon  $r$ , superior expected returns must adequately compensate him for the extra risk borne. More precisely, the manager tends to optimally select a time horizon lower than  $T$  when  $\mu$  is low, and when his risk aversion  $\gamma$  and the pay-performance sensitivity  $b$  are high. The higher  $\mu$  is, the more a longer time horizon project is valuable in terms of expected payoffs; the higher the manager's risk aversion  $\gamma$ , the more expected pay he is willing to forgo to reduce the variance of his pay; the higher the pay-performance sensitivity  $b$  is, the larger the weight he assigns to the variance of his pay relative to his expected pay. As  $b$  approaches zero, the manager only cares about his expected pay, so that the value of  $b$  which maximizes (34) is  $r = T$ . As with short-termism of the first-type, the higher the power  $b^*$  of incentives needed to prevent investment in the inefficient project with private benefits of control, the smaller the set of parameter values for which the second-best outcome (the second-best optimal contract parameters  $\{w^*, \tau^*, b^*\}$  and the manager opting for the project with  $r = T$ ) is feasible.

Short-termism of the second-type is not an issue if, given the second-best optimal contract parameters  $\{w^*, \tau^*, b^*\}$ , the manager chooses  $r = T$ . Contract parameters are then as in the previous section. In particular, this is always the case when the second-best optimal timing is  $\tau^* = T$ , since we know that  $r \geq \tau$ .

However, just as with short-termism of the first-type, implementing the efficient project is so costly for certain parameter values that it is then optimal not to provide any incentives to the manager:

**Proposition 3:** When  $\mu > \frac{\bar{A}-A}{T}$ ,  $\sigma^N > \sigma_t^U$  for all  $t$ , and  $\gamma$  is sufficiently high, then it is optimal to set  $b = 0$ .

First, a sufficiently risk averse manager will opt for  $r = \tau$ . Second, for a sufficiently high  $\gamma$ , the agency cost of setting  $\tau > \tau^* = 0$  is too large. Third, when  $\mu > \frac{\bar{A}-A}{T}$  (short-termism of the

second-type greatly lowers the firm's expected value), the expected payoff of a project with a time horizon of  $r = 0$  is even lower than  $\underline{A}$ . It is then more efficient to induce the manager to pick the inefficient project with private benefits of control, whose expected payoff is  $\underline{A}$ . This is achieved by giving him only a fixed wage.

We now address the effect of short-termism of the second-type on the optimal timing of compensation:

**Proposition 4:** If the manager does not choose  $r = T$  when  $\tau = \tau^*$ , then the value of  $\tau$  which results in  $r = T$  is larger than  $\tau^*$ .

If the second-best optimal contract parameters are not robust to short-termism of the second-type, then a preservation of the manager's incentives to invest in the efficient project ( $r = T$ ) requires that he be paid later than at the second-best. This result is all the more remarkable that it applies to all four cases distinguished in Proposition 1.

Information asymmetries are directly responsible for short-termism of the second type. However, the best cure against both moral hazard and short-termism may paradoxically be to reduce the amount of noise which accumulates in the stock price. Indeed, in the baseline model with moral hazard, more information asymmetries result in a more delayed compensation (a higher  $\tau^*$ ), while more noise results in earlier compensation. The latter is more problematic because it renders the prevention of short-termism more difficult. If there were no noise, the second-best optimal timing of compensation would be  $\tau^* = T$ , and short-termism, whether of the first or the second type, would not occur under the second-best optimal contract parameters. Diminishing  $\sigma^N$  is therefore doubly worthwhile in the presence of potential short-termism: not only does it lower the agency cost, but it also mitigates the short-termism problem. The best remedy for short-termism could thus consist in filtering the noise out of the stock price process, so as to obtain a precise performance measure (relative to the manager's choice of  $A$ ) at time  $T$ . This could be achieved with relative performance evaluation and the hedging of risks at the corporate level.

## C. Monitoring

In this section on short-termism, we have assumed that the manager has some leeway to take inefficient actions such as manipulating the signal process or investing in a short-term project with lower expected returns. In reality, some firms set up monitoring mechanisms to deal with these problems. Von Thadden (1995) argues that monitoring by investors could decrease information asymmetries and be the remedy to what we would call short-termism of the second-type. Likewise, Goldman and Slezak (2006) postulate that monitoring can limit earnings manipulation, and therefore short-termism of the first-type.

We now assume that, at  $t = -2$ , the founder decides whether to monitor the manager, at a given fixed cost, or not.<sup>24</sup> A manager who is monitored can neither invest in an inefficient short-term project nor set  $r \neq T$ .<sup>25</sup> Thus, monitoring prevents the manager from taking second-best-inefficient actions. With monitoring, as in the baseline model, the manager therefore only makes choices along one dimension: he trades off the expected payoff of a project against the private benefits of control it yields. In this setting, incentives can be high-powered ( $b = b^*$ ) without perverse effects.

Monitoring will be valuable whenever its cost is lower than the difference between the objective function of the founder at the second-best (i.e., in the baseline model) and at the third-best (with short-termism of either the first or second type). Since these two values coincide for  $\tau^* = T$ , costly monitoring is suboptimal when the manager is compensated at time  $T$ , i.e., based on the realized payoff of the project.

In the subsection below, we discuss which form monitoring could take in practice.

---

<sup>24</sup>Monitoring could also be performed by the representative investor or by a third-party, as long as the founder incurs its cost in fine.

<sup>25</sup>This assumption is standard in the literature. For example, in his textbook on corporate finance, Tirole (2006) “[assumes] that the active monitor could reduce the extent of moral hazard by ruling out some egregious forms of managerial misbehavior.”

#### **D. Predictions and Empirical Evidence: Short-Termism and the Timing of Pay**

The model first predicts that the more the pay of managers is sensitive to their performance, the more they will adopt short-termist behaviors.<sup>26</sup> With regards to the first type of short-termism, this is consistent with the positive correlation between the propensity to misreport or “manage” earnings and the level of the pay-performance sensitivity empirically identified in Bergstresser and Philippon (2005), Burns and Kedia (2006), Efendi, Srivastava and Swanson (2007), and Johnson, Ryan and Tian (2009). With regards to the second type of short-termism, Coles, Daniel and Naveen (2006) find that a higher pay-performance sensitivity results in lower R&D expenditures, while Francis, Hasan, and Sharma (2009) find that the pay-performance sensitivity is negatively related to patents and citations to patents. These results are consistent with our prediction that managers with higher-powered incentives have a stronger propensity to avoid projects for which the time  $r$  to wait until information asymmetries are fully resolved is long (this includes innovative projects), since these projects are more risky from a manager’s perspective.

A stronger prediction is that firms which are particularly vulnerable to managerial short-termism should have lower pay-performance sensitivities. If we consider that risk-taking and short-termism of the second type are bigger issues in small, rapidly growing firms rather than big firms, then the evidence presented in Graham, Harvey, and Puri (2009) and in the Figure 3 in Murphy (1999) is consistent with this prediction: the larger the firm, the larger is the proportion of CEO pay which takes the form of stocks and stock-options. Conversely, the smaller the firm, the larger is the contribution of the base salary to total CEO pay. In the same vein, Bizjak, Brickley and Coles (1993) find that pay-performance sensitivities tend to be lower in high-growth firms, a result they describe as “surprising given the conventional arguments”. Graham, Harvey, and Puri (2009) also find that the fixed salary component is proportionally lower in public companies. This finding may appear counterintuitive, but could be explained by a less acute short-termism problem in public companies. Finally, as already discussed, monitors can detect short-termism or at least increase its cost. Hartzell and Starks

---

<sup>26</sup>All else equal, a higher value of  $b$  expands the set of parameter values for which short-termism of either the first or the second type is optimal, from the manager’s perspective.

(2003) argue that institutional investors serve as monitors, and find a positive correlation between the pay-performance sensitivity of executives and institutional ownership. This is what the model would lead us to expect.

The model also predicts that postponing compensation should mitigate short-termist behaviors.<sup>27</sup> Regarding the first type of short-termism, this explains the fact that long-term performance plans are associated with lower levels of manipulation of short-term earnings, as documented in Richardson and Waagelein (2002). Moreover, Johnson, Ryan, and Tian (2009) and Peng and Roell (2008) respectively find that unrestricted stockholdings (which can be sold immediately) and vested options (which can be exercised immediately) encourage earnings manipulation. Regarding the second type of short-termism, the model explains the finding of Richardson and Waagelein (2003) that investment in R&D is increased following the adoption of long-term performance plans. Similarly, Francis, Hasan, and Sharma (2009) find that long-term equity incentives are positively related to patents and citations to patents. In addition, Kumar and Sopariwala (1992) document a positive association between the adoption of a long-term performance plan and long-term growth in profitability (in our model, short-term projects have lower payoffs). Larcker (1983) also finds that firms which adopt long-term performance plans exhibit a stronger growth in capital expenditures than other similar firms – which suggests that their managers are more willing to depress short-term cash-flows in order to boost long-term cash-flows.

A stronger prediction is that firms which are particularly vulnerable to managerial short-termism should postpone compensation more. Kole (1997) finds that the minimum and average wait times until stock-options are exercised are longer in R&D intensive firms, although the minimum vesting period for restricted stocks is shorter. Richardson and Waagelein (2003) find that these firms are more likely to adopt long-term performance plans. Lastly, Bizjak, Brickley and Coles (1993) show that the higher the growth rate of the firm, the more compensation is postponed.

More controversially, the model shows that when the short-termism problem is acute, it is

---

<sup>27</sup>All else equal, a later compensation date  $\tau$  shrinks the set of parameter values for which short-termism of either the first or the second type is optimal, from the manager's perspective.

optimal not to provide any significant incentives to the manager, and let him enjoy private benefits of control instead. This contributes to explaining low pay-performance sensitivities (Jensen and Murphy (1990)), the fact that poorly performing CEOs bear little risk of being dismissed (Jensen and Murphy (1990), Kaplan (1994)),<sup>28</sup> and the fact that some managers seem to “enjoy the quiet life” (Bertrand and Mullainathan (2003)). In our model, all this is third-best optimal when the short-termism problem, either of the first or the second type, is very severe (see Propositions 2 and 3).

In such a case, mitigating the short-termism problem, for instance with increased monitoring, would make it possible to provide stronger incentives to the manager. Thus, our model predicts that stock-based monetary incentives and monitoring are complements rather than substitutes when the manager may take short-termist actions.<sup>29</sup> This is because these two mechanisms perform different functions: while monetary incentives ensure that the manager invests in high payoff projects rather than projects associated with private benefits of control, monitoring ensures that he does not indulge in short-termism. This prediction is in line with the empirical findings of Mehran (1995) and Hartzell and Starks (2003) in the case of publicly-held companies, Gomez-Mejia, Tosi and Hinkin (1987) in the case of big manufacturers, Leslie and Oyer (2009) in the case of private-equity-owned companies, Kaplan (1989) in the case of management buyouts, and Kaplan and Stromberg (2001) in the case of companies financed by venture capitalists, although it is not consistent with Fahlenbrach (2009). Interestingly, leveraged buyouts and private equity transactions (including venture capital) involve a change of ownership, with a strong hands-on monitor, *and* high-powered managerial incentives (Kaplan (1989), Shleifer and Vishny (1997), Leslie and Oyer (2009)). In the perspective of our model, the latter may only be optimal because the monitor prevents management from indulging in short-termism (if providing higher-powered managerial incentives created value per se, publicly listed firms could do it as well). Similarly, takeovers may solve the short-termism problem

---

<sup>28</sup>More recent studies, for example Kaplan and Minton (2005) find a stronger relation between firm performance and CEO turnover. However, Brickley (2003) asserts that “firm performance continues to explain very little of the variation in CEO turnover.”

<sup>29</sup>To use the terminology of Tirole (2006), active and passive monitoring (the latter involves an assessment of past managerial decisions on profits) are complements. In his words, “This question is central to the design of the financial system (...) and yet it has not been investigated in detail in the literature.”

with an organizational change. If these conjectures are correct, then these three types of deals notably create value by solving the short-termism problem, thereby unlocking the target firm’s potential.

To the extent that monitoring is costly, we would finally like to determine in which circumstances it is most valuable. We have already seen that monitoring is worthless when  $\tau^* = T$ , which happens when information asymmetries are strong relative to noise. Monitoring, which addresses the short-termism problem and permits the use of higher-powered incentives, can therefore only be optimal when “early” compensation is second-best optimal ( $\tau^* < T$ ) but not robust to short-termism. In turn, early compensation is second-best optimal when information asymmetries are outweighed by noise.<sup>30</sup> This analysis points to two possible corporate governance equilibria. When shareholders have effectively reduced information asymmetries, it is especially valuable for them to monitor the manager, to have relatively early stock-based compensation ( $\tau < T$ ), and to give high-powered incentives ( $b = b^*$ ). This tends to correspond to the corporate governance system typically observed in firms controlled by a private-equity fund (Jensen (1986, 1989), Leslie and Oyer (2009)). On the contrary, when information asymmetries between the manager and shareholders are strong, it is optimal to postpone the manager’s compensation or even to pay him based on the realized payoff of the project ( $\tau = T$ ), and it may be optimal to give low-powered incentives ( $b = 0$ ). In any of these cases ( $\tau = T$  or  $b = 0$ ), monitoring is unnecessary. This tends to correspond to the corporate governance system typically observed in publicly listed firms (Lowenstein (1988), Jensen (1989), Jensen and Murphy (1990)).<sup>31</sup> In support of this hypothesis, Leslie and Oyer (2009) find that any

---

<sup>30</sup>Edmans (2010) argues that blockholders have strong incentives to acquire information, while Parrino, Sias and Starks (2003) and Bushee and Goodman (2007) find that larger shareholders are indeed more informed. We therefore expect information asymmetries between managers and investors to be lower for these firms. This gives a joint prediction of the model and of the Edmans (2010) hypothesis: firms controlled by bigger shareholders tend to pay their managers earlier and to monitor them more, *ceteris paribus*. Given that the U.S. is the country with the most dispersed shareholder structure (La Porta, Lopez-de-Silanes, and Shleifer (1999)), this may explain why U.S. firms tend to heavily use deferred equity-based compensation (Fernandes, Ferreira, Matos, and Murphy (2009)). On the contrary, controlling shareholders in other countries may more easily resort to monitoring (see Kaplan (1994) for a comparison of the U.S. and Japan). They also tend to rely relatively more on bonus payments, which reward short-term performance, for incentive purposes (Fernandes, Ferreira, Matos, and Murphy (2008)).

<sup>31</sup>With a dispersed ownership structure, shareholders face a coordination problem in the acquisition of information. They may free-ride on price discovery. This potentially explains why publicly-listed firms with a dispersed ownership tend to fall in the corporate governance equilibrium with strong information asymmetries,



difference in compensation practices between private-equity-owned firms and publicly listed firms disappears shortly after the private-equity-owned firm goes public, which suggests that firm fixed effects do not explain these differences.

### III Conclusion

This paper adds a new dimension to the executive compensation problem, and formalizes the tradeoff which determines the timing of stock-based compensation. Whereas information asymmetries between the manager and investors suggest that contingent compensation should be delayed, the fact that noise progressively accumulates in the stock price suggests that it should not. The optimal timing of compensation balances these two conflicting forces. In particular, this analysis invalidates the common view that the timing of compensation should necessarily coincide with the realization of uncertainty.

If the second-best optimal timing thus derived is not robust to managerial short-termism, we show that the power of the incentive scheme should be lowered, and the compensation date should be postponed. Even though it is necessary to provide incentives for the manager to opt for a project with a high expected payoff, it may even be optimal not to provide any incentives when the short-termism problem is very severe. These results hold for both types of short-termism. Thus, our model can explain both low pay-performance sensitivities (Jensen and Murphy (1990)) and deferred compensation.

More generally, this paper improves our understanding of the complementarity between stock-based managerial compensation and monitoring. It also demonstrates how the degree of stock-market efficiency influences the efficient delivery of managerial incentives. We deliberately focused on the corporate governance aspect, and took the extent of information asymmetries between the manager and investors as given. Future research could adopt the other angle, notably by endogeneizing information acquisition by shareholders, as well as the shareholder structure.

---

while firms controlled by a venture capitalist, say, tend to fall in the corporate governance equilibrium with low information asymmetries.

## IV Bibliography

Bergstresser, Daniel, and Thomas Philippon, 2006, CEO incentives and earnings management, *Journal of Financial Economics* 80 (3), 511-529.

Bertrand, Marianne, and Sendhil Mullainathan, 2003, Enjoying the quiet life? Corporate governance and managerial preferences, *Journal of Political Economy* 111 (5), 1043-1075.

Bhattacharyya, Sugato, and Jonathan B. Cohn, 2008, The temporal structure of equity compensation, working paper.

Bizjak, John M., James A. Brickley, and Jeffrey L. Coles, 1993, Stock-based incentive compensation and investment behaviour, *Journal of Accounting and Economics* 16, 349-372.

Bolton, Patrick, Jose Scheinkman, Wei Xiong, 2006, Executive compensation and short-termist behavior in speculative markets, *Review of Economic Studies* 73, 577-610.

Brickley, James A., 2003, Empirical research on CEO turnover and firm-performance: a discussion, *Journal of Accounting and Economics* 36 (1-3), 227-233.

Burns, Natasha, and Simi Kedia, 2006, The impact of performance-based compensation on misreporting, *Journal of Financial Economics* 79 (1), 35-67.

Bushee, Brian and Theodore Goodman, 2007, Which institutional investors trade based on private information about earnings and returns? *Journal of Accounting Research* 45, 289-321.

Clinch, Greg, 1991, Employee compensation and firms' research and development activity, *Journal of Accounting Research* 29 (1), 59-78.

Coles, Jeffrey L., Naveen D. Daniel, and Lalitha Naveen, 2006, Managerial incentives and risk-taking, *Journal of Financial Economics* 79 (2), 431-468

Core, John, Guay, Wayne, 1999. The use of equity grants to manage optimal equity incentive levels, *Journal of Accounting and Economics* 28, 151-184.

de Marzo, Peter, and Yuliy Sannikov, 2006, Optimal security design and dynamic capital structure in a continuous-time agency model, *Journal of Finance* 61, 2681-2724.

Diamond, Douglas W., and Robert E. Verrecchia, 1982, Optimal managerial contracts and equilibrium security prices, *Journal of Finance* 37 (2), 275-287.

Goss, Betsy C., and James F. Waagelein, 2006, The influence of executive compensation

on the dispersion of security analyst forecasts, *Managerial and Decision Economics* 14 (6), 499-507.

Edmans, Alex, 2009, Blockholder trading, market efficiency, and managerial myopia, forthcoming, *Journal of Finance*.

Edmans, Alex, Xavier Gabaix, Tomasz Sadzik, Yuliy Sannikov, 2009, Dynamic incentive accounts, working paper.

Efendi, Jap, Anup Srivastava, and Edward P. Swanson, 2007, Why do corporate managers misstate financial statements? The role of option compensation and other factors, *Journal of Financial Economics* 85 (3), 667-708.

Fahlenbrach, Rudiger, 2009, Shareholder rights, boards, and CEO compensation, *Review of Finance* 13 (1), 81-113.

Fernandes, Nuno, Miguel A. Ferreira, Pedro Matos, and Kevin J. Murphy, 2009, The pay divide: (why) are U.S. top executives paid more?, ECGI Finance working paper 255.

Giannetti, Mariassunta, 2009, Serial CEO incentives and the structure of managerial contracts, working paper.

Goldman, Eitan, and Steve K. Slezak, 2006, An equilibrium model of incentive contracts in the presence of information manipulation, *Journal of Financial Economics* 80, 603-626.

Gomez-Mejia, Luis R., Henry Tosi, and Timothy Hinkin, 1987, Managerial control, performance, and executive compensation, *Academy of Management Journal* 30 (1), 51-70.

Graham, John R., Campbell R. Harvey, and Manju Puri, 2009, Managerial attitudes and corporate actions, working paper.

Hartzell, Jay C., and Laura T. Starks, 2003, Institutional investors and executive compensation, *Journal of Finance* 58, 2351-2374.

Holmstrom, Bengt, and Paul Milgrom, 1987, Aggregation and linearity in the provision of intertemporal incentives, *Econometrica* 55, 308-328.

Holmstrom, Bengt and Paul Milgrom, 1991, Multitask principal-agent analyses: incentive contracts, asset ownership, and job design, *Journal of Law, Economics, and Organization* 7 (0), 24-52.

- Holmstrom, Bengt, and Jean Tirole, 1993, Market liquidity and performance monitoring, *Journal of Political Economy* 101 (4) 678-709.
- Holmstrom, Bengt, 1999, Managerial incentive problems: a dynamic perspective, *Review of Economic Studies* 66 (1), 169-182.
- Jensen, Michael C., 1986, Agency costs of free cash flow, corporate finance, and takeovers, *American Economic Review* 76 (2), 323-29.
- Jensen, Michael C., 1989, Eclipse of the public corporation, *Harvard Business Review*, September-October, 61-74.
- Jensen, Michael C., and Kevin J. Murphy, 1990, Performance pay and top-management incentives, *Journal of Political Economy* 98(2), 225-64.
- Johnson, Shane, Harley Ryan, and Yisong Tian, 2009, Managerial incentives and corporate fraud: the source of incentives matter, *Review of Finance* 13 (1), 115-145.
- Kaplan, Steven N., 1989, The effects of management buyouts on operating performance and value, *Journal of Financial Economics* 24, 217-254.
- Kaplan, Steven N., 1994, Top executive rewards and firm performance: a comparison of Japan and the United States, *Journal of Political Economy* 102 (3), 510-546.
- Kaplan, Steven N., and Per Stromberg, 2001, Venture capitalists as principals: contracting, screening, and monitoring, *American Economic Review* 91 (2), 426-430.
- Kaplan, Steven N., and Bernadette A. Minton, 2006, How has CEO turnover changed? increasingly performance sensitive boards and increasingly uneasy CEOs, NBER Working Paper No. W12465.
- Kole, Stacey R., 1997, The complexity of compensation contracts, *Journal of Financial Economics* 43 (1), 79-104.
- Krugman, Paul, 2002, Greed is bad, *New York Times*, June 4.
- Kumar, Raman, and Parvez R. Sopariwala, 1992, The effect of adoption of long-term performance plans on stock prices and accounting numbers, *Journal of Financial and Quantitative Analysis* 27 (4), 561-573.
- Lacker, Jeffrey M., and John A. Weinberg, 1989, Optimal contracts under costly state

falsification, *Journal of Political Economy* 97 (6), 1345-1363.

Laffont, Jean-Jacques, and Jean Tirole, 1988, Repeated auctions of incentive contracts, investment, and bidding parity with an application to takeovers, *RAND Journal of Economics* 19 (4), 516-537.

La Porta, Rafael, Florencio Lopez-de-Silanes, and Andrei Shleifer, 1999, Corporate ownership around the world, *Journal of Finance* 54 (2), 471-517.

Larcker, David F., 1983, The association between performance plan adoption and corporate capital investment, *Journal of Accounting and Economics* 5, 3-30.

Leslie, Phillip, and Paul Oyer, 2009, Managerial incentives and value creation: evidence from private equity, working paper.

Lowenstein, Louis, 1988. *What's wrong with Wall Street? Short-term gain and the absentee shareholder* (Addison-Wesley).

Manso, Gustavo, 2007, Motivating innovation, Hudson Institute Research Paper no. 08-01.

Mehran, Hamid, 1995, Executive compensation structure, ownership, and firm performance, *Journal of Financial Economics* 38 (2), 163-184.

Murphy, Kevin J., 1999, Executive compensation, in Orley Ashenfelter and David E. Card, eds.: *Handbook of Labor Economics* (North Holland) .

Narayanan, M. P., 1985, Managerial incentives for short-term results, *Journal of Finance* 40, 1469-1484.

Parrino, Robert, Richard Sias and Laura Starks, 2003, Voting with their feet: institutional ownership changes around forced CEO turnover, *Journal of Financial Economics* 68, 3-46.

Peng, Lin, and Ailsa Roell, 2008, Executive pay and shareholder litigation, *Review of Finance* 12 (1), 141-184.

Radner, Roy, 1981, Monitoring cooperative agreements in a repeated principal-agent relationship, *Econometrica* 49 (5), 1127-1148.

Richardson, Vernon J., and James F. Waagelein, 2002, The influence of long-term performance plans on earnings management and firm performance, *Review of Quantitative Finance and Accounting* 18 (2), 161-183.

Richardson, Vernon J., and James F. Waagelein, 2003, Characteristics associated with the corporate decision to adopt long-term performance plans, *Journal of Business Finance and Accounting* 30 (3-4), 621-644.

Sannikov, Yuliy, 2008, A continuous-time version of the principal-agent problem, *Review of Economic Studies* 75, 957-984.

Shleifer, Andrei, and Robert W. Vishny, 1987, A survey of corporate governance, *Journal of Finance* 52 (2), 737-783.

Shleifer, Andrei, and Robert W. Vishny, 1990, Equilibrium short horizons of investors and firms, *American Economic Review* 80 (2) 148-153.

Smith, Clifford W., Jr., and Ross L. Watts, 1992, The investment opportunity set and corporate financing, dividend, and compensation policies, *Journal of Financial Economics* 32 (3), 263-292.

Stein, Jeremy C., 1988, Takeover threats and managerial myopia, *Journal of Political Economy*, 96 (1) 61-80.

Stein, Jeremy C., 1989, Efficient capital markets, inefficient firms: a model of myopic corporate behavior, *Quarterly Journal of Economics* 104, 655-669.

Tirole, Jean, 2006. *The Theory of Corporate Finance* (Princeton University Press).

von Thadden, Ernst-Ludwig, 1995, Long-term contracts, short-term investment and monitoring, *Review of Economic Studies* 62, 557-575.

Wang, Cheng, 1997, Incentives, CEO compensation, and shareholder wealth in a dynamic agency model, *Journal of Economic Theory* 76, 72-105.

Williams, Noah, 2004, On dynamic principal-agent problems in continuous time, working paper.

# The optimal timing of executive compensation

Pierre Chaigneau\*

HEC Montreal

`pierre.chaigneau@hec.ca`

August 13, 2010

## **Abstract**

We propose a new continuous-time principal-agent model to study the optimal timing of stock-based incentives, when the effects of managerial actions materialize with a lag and are only progressively understood by shareholders. On the one hand, early contingent compensation hedges the manager against the accumulation of exogenous shocks. On the other hand, the fact that initial information asymmetries between the manager and shareholders are progressively resolved suggests that contingent compensation should be postponed. We introduce two possible types of managerial short-termism, and show that they both result in lower-powered incentives and more deferred compensation.

---

\*I thank Sudipto Bhattacharya, Amil Dasgupta, Denis Gromb, Ian Jewitt, David Webb, and seminar participants at McGill, for useful comments and suggestions. I acknowledge financial support from Institut de Finance Mathématique de Montréal.

This paper introduces a new stylized principal-agent model through which the power and timing of stock-based incentive schemes are analysed. This model is unique as it combines three essential elements of executive pay: (i) a noisy output realized some time after the managerial action, (ii) time-varying information asymmetries between the manager and investors, and (iii) a stock price process continuously set by rational investors, on which the manager's pay may be contingent.<sup>1</sup> In this baseline model, we show that the optimal timing of stock-based compensation trades-off the accumulation of noise against the progressive elimination of information asymmetries. The paper then addresses the issue of managerial myopia, which is closely related to the timing of compensation. We show that the manager's ability to take short-termist actions affects the optimal corporate governance system: short-termism is exacerbated by a high-powered incentive scheme, but can be abated either with deferred compensation or with costly monitoring. Finally, we argue that the model's predictions are consistent with the empirical evidence, and conclude that it markedly improves our understanding of executive compensation.

The recent travails of major companies have reignited the debate on executive compensation, and in particular on the timing of variable pay. An emphasis on the maximization of short-term shareholder value, allegedly fostered by the current structure of executive pay, has been widely condemned in the wake of the 2008 crisis. There is growing concern that executives are remunerated before the full effects of their actions are revealed, which decouples their pay from their contribution and generates perverse incentives. The model we present formalizes this intuition. In the presence of market monitoring (Holmstrom and Tirole (1993)), it relates the power and timing of managerial incentive pay to the moral hazard problem between shareholders and the manager.

Uncertainty alone cannot explain the widespread practice of delaying the contingent compensation of managers. If noise makes the performance measure (possibly the stock price) less

---

<sup>1</sup>In most discrete time agency models (see the seminal papers of Mirrlees (1975), Holmstrom (1979), Grossman and Hart (1983)), the agent exerts effort at the beginning of the period, and a contractible output is realized at the end of the period. By contrast, in the more recent agency literature in continuous time (see for example Holmstrom and Milgrom (1987), Williams (2004), de Marzo and Sannikov (2006), Sannikov (2008)), the agent exerts effort continuously, and a contractible output is realized continuously and instantaneously.



informative about the manager's action as time passes, then a mechanism with delayed compensation cannot in general be optimal in a model in which the manager's action is observable. Indeed, setting up a mechanism which translates observability into contractibility, or simply renegotiating in the spirit of Hermalin and Katz (1991) would yield the first-best outcome. For example, the manager could be compensated based on the stock price established after he took his action, but before uncertainty is realized, which does not expose him to any risk.<sup>2</sup> As a consequence, this type of model cannot explain deferred managerial compensation.<sup>3</sup>

The main counterargument, first articulated by Narayanan (1985), states that managers have private information, so that their actions are not perfectly observable. This paper adopts the same premise, and introduces progressive learning by rational investors of the manager's private information through a signalling process. We show that this progressive diminution of information asymmetries can make deferred compensation optimal, and can therefore explain the fact that deferred compensation is the norm for CEOs: restricted stock grants typically vest after three years, while close to 90% of stock-options granted to S&P500 CEOs in 2006 had a maturity of 6 to 10 years.

We start with a standard moral hazard problem: a risk averse manager must be given incentives to undertake an efficient project rather than an inefficient project with a lower expected payoff, but which provides him with private benefits of control. To this end, his pay may depend on a stock price process established by a representative rational investor. This investor determines the stock price according to his information at a given time.<sup>4</sup> On the one hand, the conditional value of the payoff progressively diverges from its ex-ante value following the arrival of additive shocks, so that noise accumulates at a constant rate in the stock price as time passes. On the other hand, the investor progressively learns the conditional value of

---

<sup>2</sup>Bhattacharyya and Cohn (2008) reach a similar conclusion, but for a different reason: short-term equity compensation allows a risk averse manager to quickly reduce his exposure to the firm's risk, which enhances his willingness to undertake risky but valuable projects.

<sup>3</sup>Deferred compensation is sometimes justified as a retention tool. However, this hypothesis can only explain the progressive vesting of stocks and stock-options grants, not the fact that they are contingent upon the future, as opposed to the current, stock price.

<sup>4</sup>This paper considers a representative investor with rational expectations. By contrast, in Bolton, Scheinkman and Xiong (2006), a speculative component in the stock price results in an optimal compensation contract which encourages managerial short-termism. In Aghion and Stein (2008), short-term stock-based compensation may induce the manager to inefficiently cater to the stock market.

the final (noisy) payoff, by continuously receiving signals whose precision is increasing with time.<sup>5</sup> This captures the progressive diminution of information asymmetries. Our modelling of this process represents a significant methodological innovation, which could more generally be used in any model of learning in continuous time.

With a risk-neutral investor, we show that the optimal timing of compensation minimizes the variance of the manager's pay. This is achieved by paying him based on the stock price which is most informative about his project choice. Intuitively, the optimal timing of compensation balances the accumulation of noise, which grows with time, against the mispricing emanating from information asymmetries, which fades with time because of learning. While the first force degrades the informativeness of the stock price over time, the second one improves it.<sup>6</sup> We identify four possible cases. If information asymmetries outweigh noise, compensation should be contingent on the end-of-period stock price, in order for learning to be complete. If noise outweighs information asymmetries, compensation should be contingent on the initial date's stock price, so that the manager is thoroughly protected from noise. If information asymmetries are eliminated at an increasing rate, the manager should be compensated either based on the initial or the end-of-period stock price. If information asymmetries are eliminated at a decreasing rate, the manager should be compensated at the time when the rate in question is equal to the rate at which noise accumulates.

However, in practice, a manager's action is typically multi-dimensional. It often does not reduce to choosing the project with the mix of expected pay and private benefits of control which maximizes his expected utility. It is therefore important to take into account the potential perverse incentives that a compensation scheme, and especially the timing of compensation,

---

<sup>5</sup>We assume that the degree of information asymmetries is exogenous. However, in Holmstrom and Tirole (1993), the degree of liquidity in the secondary market for the firm's stocks determines the incentives of shareholders to gather information. In Edmans (2009), large blockholders have strong incentives to gather information on the firm's fundamental value, which reduces information asymmetries and mitigates managerial short-termism. Endogeneizing the degree of information asymmetries is a natural extension of the model.

<sup>6</sup>This result should be distinguished from the result of Bizjak, Brickley and Coles (1993) that higher information asymmetries translate into greater managerial opportunities for short-termism, which can in turn be tackled by postponing compensation. Although we address short-termism in the second part of the paper, our present argument that higher information asymmetries result in more delayed compensation is about the informativeness of the stock price, and the minimization of the agency cost of inducing the CEO to choose the efficient project.

may create on other dimensions. In particular, a risk averse manager may be tempted to artificially generate good signals of performance for long enough to benefit from a high stock price at the compensation date. In the words of Krugman (2002), “a system that lavishly rewards executives for success tempts those executives, who control much of the information available to outsiders, to fabricate the appearance of success.” We call that managerial short-termism of the first-type.<sup>7</sup> Note that inefficiently enhancing short-term payoffs at the expense of long-term payoffs can be viewed as short-termism of the first type.<sup>8</sup> Alternatively, the manager may prefer to opt for a less risky project with a shorter time horizon but a lower expected payoff so as to reduce the variability of his remuneration. We call that managerial short-termism of the second type. We expand the baseline model along these two dimensions, in order to examine their effects on the optimal compensation scheme.

Since the manager may now choose among a larger set of “inefficient projects” (in the sense that their expected payoffs are lower than the one of the efficient project), the compensation scheme derived in the baseline model may now lead him to select an inefficient project. Rational investors are not duped in equilibrium, and the manager does not derive any rent, but the outcome may still be inefficient. Consequently, it may be efficient to alter the compensation scheme derived in the baseline model.

Remarkably, the same remedies apply to both types of short-termism. First, we show that short-termism can be alleviated with lower-powered incentives, and that it is optimal to provide muted incentives when the short-termism problem is very severe.<sup>9</sup> Thus, there is a conflict between mitigating the effect of private benefits of control (or equivalently providing

---

<sup>7</sup>This could also be interpreted as “costly state falsification”, as in Lacker and Weinberg (1989). In his textbook on Corporate Finance, Tirole (2006) notes that “The management’s ability to garble signals received (...) adds an extra degree of moral hazard into the managerial incentive problem. Incentive schemes (...) that are meant to align managerial incentives with investors’ interests and thus induce high performance also tend to invite management to game the incentive system.”

<sup>8</sup>In some models, notably Narayanan (1985) and Stein (1989), the project’s payoff is divided into several components which are realized sequentially. They play the roles of early signals of performance based on which the manager may be paid. Such a compensation scheme could induce the manager to inefficiently produce early signals of high quality if his pay (or his tenure) depends on it, to the detriment of the final outcome – the discounted sum of all payoffs. This corresponds to short-termism of the first type.

<sup>9</sup>Thus, the paper is related to the multitask literature. Admittedly, the manager has only one task: selecting the firm’s project. However, when projects differ on dimensions other than their expected payoff and their private cost to the manager, we show that giving the manager strong incentives on one dimension only may be inefficient – a result reminiscent of Holmstrom and Milgrom (1991).

incentives for effort), which can be achieved with a rise in the pay-performance sensitivity, and preventing short-termism, which calls for a lessened pay-performance sensitivity. Second, we show that short-termism can be alleviated by postponing the evaluation and payment date. As discussed later, these results are consistent with empirical findings.<sup>10</sup> Finally, we postulate that a manager who is actively monitored cannot take short-termist actions, and we determine in which circumstances monitoring is valuable. We argue that our results contribute to the debate on the interaction between active monitoring and explicit incentives, and can explain why certain aspects of the corporate governance systems of publicly-listed corporations and firms controlled by a private-equity fund differ.

Since we assume that the manager has only one action (the project choice) and is paid only once, we do not consider the balance between short-term and long-term incentives (Holmstrom and Tirole (1993)), consumption smoothing (Wang (1997)), borrowing and saving, or conditioning the manager's current action on his past performances. These last three issues have been extensively studied in the dynamic moral hazard literature, notably in Fama (1980) and Holmstrom (1999). In these papers with repeated moral hazard, the passage of time enables a more precise assessment of the agent's talent, a result also obtained in Radner (1981).

In the theoretical literature on managerial short-termism, myopic behavior can be a response to early termination of projects with low short-term payoffs by uninformed financiers, as in von Thadden (1995). The manager is thus led to prefer a safer short-term project with a lower expected payoff. Short-termism can also emerge when managers can manipulate investors' expectations by increasing the short-term payoff at the expense of the long-term payoff, as in the signal-jamming models of Narayanan (1985) and Stein (1989). These papers show that short-termism may lead to inefficient investment decisions, but they do not take an optimal contracting perspective. Other papers show that managers may become overly concerned

---

<sup>10</sup>They are also in line with the existing theoretical literature. Goldman and Slezak (2006) reach a similar conclusion regarding the pay-performance sensitivity, in a model featuring what we would call short-termism of the first-type. Bizjak, Brickley and Coles (1993) show that for the manager not to be induced to undertake inefficient investments in order to "fool" the market and reap undeserved rewards in the short-run, his pay must be relatively more sensitive to long-run rather than short-run stock returns. However, these papers only consider one type of short-termism, and one instrument to discourage it. We consider both the pay-performance sensitivity and the timing of compensation. In a model of optimal contracting, we determine which one should be adjusted to discourage short-termism, depending on the parameters of the short-termism problem.

about short-term profits, whether because of takeover threats (Stein (1988)), or because the Principal may terminate them (Laffont and Tirole (1988), Manso (2007)). Giannetti (2009) shows that long-term compensation may be optimal to prevent managers from overinvesting in general skills, at the expense of firm-specific skills. Lastly, in Edmans, Gabaix, Sadzik and Sannikov (2009), a risk averse manager with stock-based pay may want to indulge in short-termism and shift stock returns from future periods to the current period because of consumption smoothing.

Section I presents the baseline model, derives the optimal timing of compensation at the second-best, and confronts the baseline model's predictions with empirical evidence. Section II introduces opportunities for two types of managerial short-termism, highlights how it could modify the second-best optimal power and timing of compensation, and confronts the model's predictions with empirical evidence. Section III concludes.

# I Optimal Timing of Compensation

## A. The Baseline Model

Consider a firm initially owned by a risk-neutral founder and run by a manager with CARA utility and coefficient of absolute risk aversion  $\gamma$ . The sequence of events is the following. At  $t = -2$ , the founder offers a compensation contract  $W$  to the manager. If he accepts, the manager then chooses between two projects and invests in the chosen project at  $t = -1$ . The efficient project has a publicly observed payoff of  $\bar{A} + \sigma^N B_T^N$  at time  $T$ , where  $B_t^N$  is an unobserved Brownian motion,<sup>11</sup> The inefficient project has a publicly observed payoff  $\underline{A} + \sigma^N B_T^N$  at time  $T$ , with  $\underline{A} < \bar{A}$ , and confers private benefits of control worth  $P$  to the manager. The parameters  $\sigma^N$  and  $P$  are common knowledge.

The founder is committed to selling the firm<sup>12</sup> at  $t = 0$  to a risk-neutral, unconstrained,

---

<sup>11</sup>It is therefore characterized by the standard properties of Brownian motions. In particular, it is equal to 0 at  $t = 0$ , and it writes as  $B_t^N = \int_0^t dB_s^N$ , for any  $t \geq 0$ . For any  $s > t$ , the term  $B_s^N - B_t^N$  is normally distributed with mean 0 and variance  $s - t$ .

<sup>12</sup>This assumption may be microfounded by assuming that the founder is an insider, and wants to protect himself against charges of insider trading. This can be achieved by placing at  $t = -1$  a sell order at the market price prevailing at  $t = 0$ .

and competitive representative investor, who is the only agent allowed to trade its stock. At any time  $t \in [0, T]$ , the stock price  $S_t$  is endogenously determined. At  $t = T$ , the firm's stock entitles its owner to the project's payoff. A liquidation of the firm at any time between  $t = 0$  and  $t = T$  is infinitely costly, so that investment is irreversible.<sup>13</sup> The objective of the founder is to maximize the expected (as of  $t = -2$ ) stock price of the firm at  $t = 0$ ,  $E_{-2}[S_0]$ , net of expected compensation costs  $E_{-2}[W]$ . For simplicity, the discount factor is zero.

### *Contracting*

For simplicity and tractability, we assume that the manager's contractual pay can depend linearly on the stock price at one predetermined point in time,  $\tau$ , where  $\tau \in [0, T]$ . The non-negative parameter  $b$  is the sensitivity of pay to performance at this time. Contract parameters are common knowledge. The manager's contingent pay writes as

$$W(S_\tau) = w + bS_\tau \tag{1}$$

where  $w$  is the fixed wage. Any compensation contract may therefore be described by the triplet  $\{w, \tau, b\}$ .

We assume that the manager has outside employment opportunities which give him a reservation utility of  $\bar{U}$ . He will therefore accept the contract if and only if his expected utility in equilibrium exceeds  $\bar{U}$ . Define his reservation wage as  $\bar{W}$ , where  $-exp\{-\gamma\bar{W}\} \equiv \bar{U}$ .

Since the manager is risk averse and the founder is risk-neutral, the first-best risk sharing rule consists in paying the manager a fixed wage, so that  $b = 0$  and  $w = \bar{W}$  if the efficient project is to be undertaken. Deviating from this rule by making the manager's pay variable for incentive reasons will be costly. For any given compensation contract  $\{w, \tau, b\}$ , we call the agency cost the difference between the manager's expected pay if he chooses  $A = \bar{A}$  in equilibrium, which is  $E_{-1}[w + bS_\tau | A = \bar{A}]$ , and his reservation wage  $\bar{W}$ .<sup>14</sup>

---

<sup>13</sup>It is possible that, ex-post, at  $t = 0$ , the stock price is lower than the expected payment to the manager, so that the firm is expected to operate at a loss. Since liquidation is infinitely costly, the firm must keep on operating from  $t = 0$  to  $t = T$ . This implies that no profitable renegotiation is possible, and any possible expected losses, as of  $t = 0$ , are incurred by the firm's founder.

<sup>14</sup> $E_{-1}$  denotes the conditional expectation operator at  $t = -1$ . The information of the founder is admittedly

### *The information structure*

From  $t = -2$ , only the manager and the founder know  $\underline{A}$  and  $\bar{A}$  (the representative investor never does). We assume that the founder cannot credibly communicate this information to the representative investor. We also assume that neither the founder nor the representative investor observe the manager's choice of  $A$  – although the founder may infer it from the parameters of the contract and his knowledge of  $\underline{A}$  and  $\bar{A}$ , as will be clear shortly. However, the representative investor progressively learns the value of the project's conditional expected payoff  $A + \sigma^N B_t^N$ : for all  $t \in [0, T]$ , he observes a noncontractible signal  $v_t$  at time  $t$ . His initial information is therefore crystallized in the signal  $v_0$ , which may be viewed as his prior.<sup>15</sup>

Assume that the time 0 signal,  $v_0$ , and the time  $t$  signal,  $v_t$ , are respectively

$$v_0 = A - \int_0^T \sigma_s^U dB_s^U \quad (2)$$

$$v_t = A + \sigma^N B_t^N - \int_t^T \sigma_s^U dB_s^U \quad (3)$$

where  $B_t^U$  is another Brownian motion, uncorrelated with  $B_t^N$ , with time-varying, deterministic, and common knowledge diffusion process  $\sigma_t^U$ . For simplicity and tractability, we assume that the diffusion process  $\sigma_t^U$  is either constant, or monotonically increasing or decreasing with  $t$ . The Brownian motion  $B_t^U$  is fully realized before  $t = 0$ , and never observed by any agent at any time (however, the signal  $v_t$  is observed by the representative investor at time  $t$ ).

The dynamics of the  $\sigma_t^U$  process determine whether information asymmetries are resolved at the beginning or at the end of the time interval  $[0, T]$ : they are mostly resolved at the beginning if  $\sigma_t^U$  is decreasing in  $t$ , and mainly towards the end if  $\sigma_t^U$  is increasing in  $t$ . The overall magnitude of  $\sigma_t^U$  is the extent of information asymmetries: the less private information the manager possesses relative to the investor, the smaller the overall magnitude of  $\sigma_t^U$ . If

---

the same at  $t = -2$  and  $t = -1$ : the manager chooses in which project to invest at  $t = -1$ , but the founder already knows whether or not he will invest in the efficient project, given the parameters of the contract that he offers at  $t = -2$ . There is no arrival of new information at  $t = -1$  in equilibrium.

<sup>15</sup>Since neither the manager nor the founder do anything after  $t = -1$ , it is inconsequential whether or not they observe the process  $v_t$  at any time  $t \in [0, T]$ . Likewise, since the representative investor only acts from  $t = 0$ , his information prior to  $t = 0$  is irrelevant.

$\sigma_t^U$  were identically zero, there would not be any information asymmetries, and the passage of time would only add noise to the signal process  $v_t$ , where noise is represented by the Brownian motion  $B_t^N$ .

This representation of the signal process has the advantage of being very tractable, and also has three desirable properties. First, the signal is an unbiased estimate of  $A$ , since its probability distribution is centered around  $A$ . Second, the variance between the signal  $v_t$  and the conditional expected payoff  $A + \sigma^N B_t^N$  is decreasing in  $t$ , which is consistent with the progressive attenuation of the mispricing due to information asymmetries. Third, at any time  $t$ ,  $v_t$  is a sufficient statistic for the project's payoff  $A + \sigma^N B_T^N$  (this result is proven in the Appendix). Thus,  $v_0$  may be viewed as an uninformative prior over the project's payoff.

### *Profitability*

We make two assumptions on ex-ante profitability, from the founder's perspective. First, as of  $t = -2$ , the expected payoff net of the expected payment to the manager in equilibrium is assumed to be nonnegative with the inefficient project with private benefits of control. Second, as of  $t = -2$ , the expected payoff net of the expected payment to the manager in equilibrium is assumed to be larger with the efficient project at the second-best than with the inefficient project with private benefits of control. Formally, and as will be clearer later, this reduces to assuming the following:

$$\bar{A} - \bar{W} - \frac{\gamma}{2} \left( \frac{P}{\bar{A} - \underline{A}} \right)^2 \left( \sigma^{N^2} \tau^\star + \int_{\tau^\star}^T \sigma_t^{U^2} dt \right) > \underline{A} - \bar{W} + P \geq 0 \quad (4)$$

where  $\tau^\star$  is defined in Proposition 1. When the contract  $\{w, \tau, b\}$  is such that the manager optimally chooses the efficient project, the objective function of the founder is

$$E_{-1}[S_0 - (w + bS_\tau) | A = \bar{A}] \quad (5)$$



### *The stock price*

The discount factor is zero, the representative investor is competitive and risk-neutral, and a sufficient statistic for his information at time  $t$  is  $v_t$ . For any  $t \in [0, T]$  and  $j \in [t, T]$ , we therefore have in equilibrium:

$$S_t = E_t[S_j|v_t] \quad (6)$$

At  $t = T$ , the payoff  $A + \sigma^N B_T^N$  of the stock is known, so

$$S_T = A + \sigma^N B_T^N \quad (7)$$

Setting  $j = T$  in (6) and substituting,

$$S_t = E_t[A + \sigma^N B_T^N | v_t] \quad (8)$$

At any time  $t \in [0, T]$ , the market clearing price  $S_t$ , at which the net demand from the representative investor equals the net supply of the stock, is equal to the conditional expectation of the project's payoff.<sup>16</sup> Using (3),

$$S_t = E_t \left[ v_t + \int_t^T \sigma_s^U dB_s^U | v_t \right] = v_t \quad (9)$$

Applying this equality to (2) and (3) respectively yields the time 0 and time  $t$  stock prices:

$$S_0 = A - \int_0^T \sigma_s^U dB_s^U \quad (10)$$

$$S_t = A + \sigma^N B_t^N - \int_t^T \sigma_s^U dB_s^U \quad (11)$$

---

<sup>16</sup>Since we work with one representative investor, there would admittedly not be any trading in the model, for any  $t \in (0, T]$ . This being said, we could imagine a mechanism in which a market-maker receives orders from this representative investor, which he must balance against a net supply of the stock of zero. The stock price announced by the market-maker will therefore be the market clearing price, which ensures that the net demand from the representative investor is zero.

Combining (10) and (11) gives another expression for  $S_t$ :

$$S_t = S_0 + \sigma^N B_t^N + \int_0^t \sigma_s^U dB_s^U \quad (12)$$

For  $t = T$ ,

$$S_T = S_0 + \sigma^N B_T^N + \int_0^T \sigma_s^U dB_s^U \quad (13)$$

Finally, the dynamics of  $S_t$  may be derived from either (11) or (12):

$$dS_t = \sigma^N dB_t^N + \sigma_t^U dB_t^U \quad (14)$$

This deserves clarification. The investor does not know the value of  $A$ , and at time  $t$  he does not observe any of the different terms on the right-hand-side of (11). Instead, at any time  $t$  he observes  $v_t$ , and sets the stock price  $S_t$  according to this information. Equation (11) shows how information asymmetries fade away as  $t$  approaches  $T$ . Loosely speaking, this method of unwinding a Brownian motion allows to use the Brownian motion  $B_t^U$  to *reduce* uncertainty, from the investor's perspective.

As is apparent in (11), a manager compensated at  $t = \tau$  is exposed to two sources of risk: the accumulated noise from  $t = 0$  to  $t = \tau$  on the one hand, and the remaining information asymmetries at  $t = \tau$  on the other hand (the higher  $\tau$  is, the less information asymmetries remain). A higher  $\tau$  results in more noise in the stock price used for managerial compensation, but less information asymmetries. In addition, the longer the time horizon  $T$  of the project, the more the manager is exposed to risk. In this sense, longer-term projects are more costly in terms of agency costs.<sup>17</sup> This will be crucial in the next section.

## B. The Optimal Contract

Because of (4), we know that it is optimal for the founder to design the compensation contract  $\{w, \tau, b\}$  so as to maximize his objective function in (5) conditional on the manager

---

<sup>17</sup>Shleifer and Vishny (1990) provide another reason, related to financial arbitrage, as to why long-term projects are prone to greater mispricing than short-term projects.

accepting the contract and choosing the efficient project. If this is the case, using (10) and (11), the objective function of the founder rewrites as

$$E_{-1}[S_0 - (w + bS_\tau)|A = \bar{A}] = (1 - b)\bar{A} - w \quad (15)$$

The value of  $\bar{A}$  being given, the objective of the founder reduces to minimizing the expected cost of the manager's pay, subject to the participation constraint and the incentive constraint defined below. We begin by setting  $b$  and  $w$  so as to bind these two constraints. Then we optimize over the compensation date,  $\tau$ .

In a CARA-normal framework with a contract linear in the outcome, the expected utility of pay is fully described by the expected pay and the variance of pay. The variance of the manager's pay given his information at  $t = -1$ , which includes the value of  $A$  and contract parameters, is obtained from (11):

$$var_{-1}[w + bS_\tau|A] = b^2 \left( \sigma^{N^2} \tau + \int_\tau^T \sigma_t^{U^2} dt \right) \quad (16)$$

This expression is independent of  $A$ .

The manager will therefore opt for the efficient project if and only if his expected pay (including private benefits of control) is higher with the efficient project than with the inefficient project. The incentive constraint, which ensures that this is the case, is

$$w + b\bar{A} \geq w + b\underline{A} + P \quad (17)$$

Or, since it is binding in equilibrium,<sup>18</sup> it gives the second-best optimal pay-performance sensitivity, denoted by  $b^*$ :

$$b^* = \frac{P}{\bar{A} - \underline{A}} \quad (18)$$

---

<sup>18</sup>The standard argument applies. If it is not binding, decrease  $b$  until the point where it is binding, and adjust  $w$  so that the manager's expected pay is unchanged. The founder is therefore indifferent between these two schemes since they are characterized by the same expected cost. But the variance of the manager's pay in (16) is lower with the new scheme, since  $b$  is lower. It follows that  $w$  can be reduced until the manager reaches his reservation utility, which reduces the expected cost of the scheme. This shows that a nonbinding incentive constraint cannot be optimal.

The fixed wage  $w$  is set to bind the participation constraint. Using the certainty equivalent approach with a given contract  $\{w, \tau, b\}$ , the participation constraint with  $A = \bar{A}$  and no private benefits of control is

$$w + bE_{-1}[S_\tau|A = \bar{A}] - \frac{\gamma}{2}b^2var_{-1}[S_\tau|A = \bar{A}] \geq \bar{W} \quad (19)$$

This gives the equilibrium value of the fixed wage at the second-best, denoted by  $w^*$ :

$$w^* = \bar{W} - b^*\bar{A} + \frac{\gamma}{2}b^2\left(\sigma^{N^2}\tau + \int_\tau^T \sigma_t^{U^2} dt\right) \quad (20)$$

In equilibrium, the expected cost of the contract  $\{w^*, \tau, b^*\}$  is equal to

$$w^* + E_{-1}[b^*S_\tau|A = \bar{A}] \quad (21)$$

Substituting for the value of  $w^*$  from (20), the expected cost of compensation at the second-best is

$$\bar{W} + \frac{\gamma}{2}b^{*2}\left(\sigma^{N^2}\tau + \int_\tau^T \sigma_t^{U^2} dt\right) \quad (22)$$

It decomposes as the reservation wage plus the agency cost, which is proportional to the variance of the manager's pay. As already discussed, the objective of the founder reduces to minimizing the expected cost of compensation. Since the pay-performance sensitivity  $b^*$  is already set in (18), (22) shows that this is achieved by paying the manager at the time  $t = \tau$  which minimizes the ex-ante variance of the stock price  $S_t$ , for  $t \in [0, T]$ .

The agency cost can be eliminated in three special cases. If there are no information asymmetries ( $\sigma_t^U \equiv 0$ ), full hedging against the accumulation of noise is possible: compensation is then contingent on  $S_0$  ( $\tau = 0$ ), and the manager does not face any risk. In the absence of noise ( $\sigma^N = 0$ ), it is costless to wait for information asymmetries to unwind: compensation is then contingent on  $S_T$  ( $\tau = T$ ), and the manager does not face any risk either. Lastly, if the manager is risk-neutral ( $\gamma = 0$ ), the timing of payments does not matter. If one of these three cases does not apply, the problem is nontrivial.

In view of (22), the problem of the founder can be written as<sup>19</sup>

$$\min_{\tau} \frac{\gamma}{2} b^{\star 2} \left( \sigma^{N^2} \tau + \int_{\tau}^T \sigma_t^{U^2} dt \right) \quad \text{where} \quad b^{\star} = \frac{P}{\bar{A} - \underline{A}} \quad (23)$$

Then we have the following result:

**Proposition 1:** The second-best optimal timing of compensation,  $\tau^{\star}$ , is as follows:

- If  $\sigma_t^U \geq \sigma^N$  for all  $t$ , then  $\tau^{\star} = T$ .
- If  $\sigma_t^U \leq \sigma^N$  for all  $t$ , then  $\tau^{\star} = 0$ .
- If none of the above applies and  $\sigma_t^U$  is increasing in  $t$ ,  $\tau^{\star} = 0$  if  $\int_0^T \sigma_t^{U^2} dt < \sigma^{N^2} T$ , and  $\tau^{\star} = T$  if  $\int_0^T \sigma_t^{U^2} dt > \sigma^{N^2} T$ .
- If none of the above applies and  $\sigma_t^U$  is decreasing in  $t$ , then  $\tau^{\star}$  is implicitly defined by  $\sigma_{\tau^{\star}}^U = \sigma^N$ .

The proof is in the Appendix. We call  $\{w^{\star}, \tau^{\star}, b^{\star}\}$  the second-best optimal contract parameters. Given the complexity of the model, it is remarkable that the rate at which noise accumulates and the rate at which information asymmetries are resolved fully determine the optimal timing of compensation. Paying the manager early hedges him against the noise which accumulates in the stock price. Paying the manager late ensures that most of his private information has been incorporated in the stock price, and so reduces his exposure to mispricing attributable to information asymmetries. As a rule, the stronger the noise is relative to information asymmetries, the earlier the manager should be paid. In view of (7), it is noteworthy that paying the manager at time  $T$  is equivalent to using an accounting-based measure of performance, the payoff of the project, rather a stock-market-based measure of performance. In

---

<sup>19</sup>Although we omit a thorough discussion, it should be clear that, given this agency cost of implementing the efficient project, undertaking this project at the second-best rather than the inefficient project with private benefits of control maximizes the objective function of the founder, because of (4).

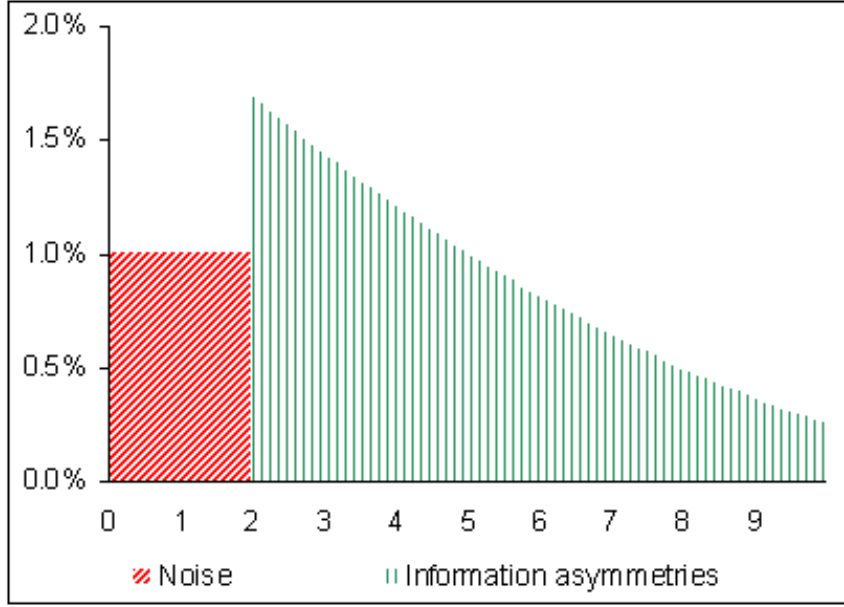


Figure 1: Suboptimal timing: the manager is paid at time 2. The agency cost of compensation is proportional to the sum of the two areas.

general, however, using the stock price as a measure of performance reduces the agency cost of the contract, thereby improving the efficiency of managerial compensation.

Figures 1 and 2 illustrate these arguments. Suppose that  $\sigma^N = 10\%$ , and the process  $\sigma_t^U$  decreases linearly from a level of 15% at  $t = 0$ , to a level of 5% at  $t = 10$ . In Figure 1, the manager is paid based on the stock price at  $t = 2$ . The sum of the two areas in Figure 1 gives its variance, from the manager's ex-ante perspective. This is precisely the criterion which is minimized at the optimum, as can be seen in (23). The diagonally hashed area is the part of the stock price variance attributable to noise, which accumulates from  $t = 0$  to  $t = 2$ , while the vertically hashed area is the part of the stock price variance due to information asymmetries which are not resolved yet at  $t = 2$ . Clearly, it is possible to reduce the variance of the manager's pay by paying him based on the stock price at  $t = 5$  rather than the stock price at  $t = 2$ , as shown in Figure 2. More noise will then accumulate, which increases the variance of his pay, and more information asymmetries will be resolved, which decreases the variance of his pay. But the second effect will dominate, since  $\sigma_t^U > \sigma^N$  from  $t = 2$  to  $t = 5$ .

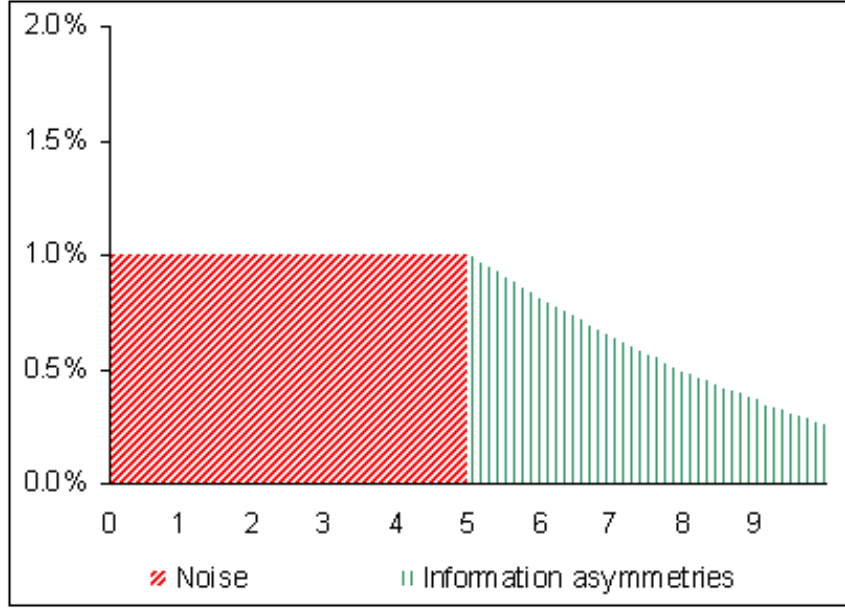


Figure 2: Optimal timing: the manager is paid at time 5. The agency cost of compensation is proportional to the sum of the two areas.

### C. Predictions and Empirical Evidence: the Baseline Model

The baseline model predicts that the level of information asymmetries relative to the level of noise determines the optimal timing of compensation. First, firms which manage to produce an almost noise-free performance measure, whether because their profits are not significantly affected by noise, or because they can filter it out, will delay compensation more, *ceteris paribus*. This will mainly depend on the industrial sector of the firm. Second, for a given level of noise, firms whose managers do not have a lot of private information (think about firms with recurring investments, or firms in traditional industries that investors easily comprehend) will pay managers early. Firms where information asymmetries are strong (think about firms with new projects, investment banks with opaque strategies, and firms in ascending industries that investors do not fully understand yet) will delay compensation more.<sup>20</sup>

<sup>20</sup>The banking industry provides a good case study. Prior to 2007, banks tended to make relatively steady profits, but their strategies left observers perplex. The financial crisis of 2007-2008 had three effects. It made bank profits much more volatile, it shed light on the strategies they use, and it prompted some of them to scale back rocket-science banking and go back to basics. In this context, the baseline model makes two predictions – or recommendations. First, the stock-based compensation of banks' top managers should have been tilted toward the long-term prior to 2007. Second, the financial crisis should have shortened the time horizon of their compensation. To the extent that the financial crisis exacerbated their opportunities for short-termism,

Kole (1997) finds that chemicals, machinery and producer firms have higher mean minimum and average waits to exercise stock-options award. Furthermore, this group of firms imposes a longer vesting period on restricted stock grants (50 months) than metals, foods, and consumer firms (20 months). Kole describes the former group of firms as belonging to highly innovative industries which require specialized knowledge. These are precisely the characteristics we would associate with a higher degree of information asymmetries between the management and shareholders. Our model's prediction that more information asymmetries result in a more delayed compensation concurs with this finding.

Besides the industrial sector, another good measure of information asymmetries is the growth rate of the firm. For example, Smith and Watts (1992) assume that information asymmetries are greater in high-growth firms, whereas managerial effort is more easily observable in low-growth firms. In line with our model's predictions, Bizjak, Brickley and Coles (1993) present evidence that "high-growth firms place less emphasis on current performance relative to future performance in managerial compensation plans than low-growth firms".

## II Optimal Timing of Compensation with Short-Termism

The model is now extended to allow for managerial short-termism. We expand the action set of the manager, to allow him to take (second-best) inefficient actions. We analyze two possible types of short-termism in turn, and we emphasize how the second-best outcome of the previous section is generally not robust to enlarging the action set of the manager. We then show how the optimal timing and power of compensation should be altered under third-best efficiency, which allows for short-termism. In a separate sub-section, we put forward monitoring as a solution to the short-termism problem. Finally, we review empirical evidence in light of these results.

---

however, the next section will show that it could instead have been optimal to defer their compensation even more from 2007.



### A. Short-Termism of the First Type

Assume that, at  $t = -1$ , the manager can either invest in one of the two projects already described, or in an inefficient short-term project, whose time  $T$  payoff is  $\underline{A} + \sigma^N B_T^N$ . A manager who selects this project must choose  $s \in [0, T)$ , which is unobservable to other agents. On the one hand, he then incurs a monetary cost  $\frac{c}{2}(s + \epsilon)^2$ , where  $c > 0$  and  $\epsilon \geq 0$  are common knowledge. On the other hand, the signal process  $v_t$  then has an unconditional mean of  $\hat{A} > \bar{A}$  from  $t = 0$  to  $t = s$ , and of  $\underline{A}$  from  $t = s$  to  $t = T$ :

$$v_t = \hat{A} + \sigma^N B_t^N - \int_t^T \sigma_z^U dB_z^U \quad (24)$$

for  $t \leq s$ , and

$$v_t = \underline{A} + \sigma^N B_t^N - \int_t^T \sigma_z^U dB_z^U \quad (25)$$

for  $t > s$ . We assume that the difference  $\hat{A} - \bar{A}$  is common knowledge, in order for the investor to be able to assess ex-ante whether it is in the manager's interests to invest in the inefficient short-term project rather than the efficient project, given contract parameters.<sup>21</sup>

A natural interpretation is that the manager can manipulate the signal process at a cost, so that it (misleadingly) indicates that he has invested in a project with a high expected payoff ( $\hat{A}$ ). In turn, manipulating the signal process until the time when he is paid enables him to enjoy the high pay associated with a high expected payoff.

Our approach is the following. First of all, we note that it is never optimal for the founder to induce the manager to invest in the short-term inefficient project at the third-best (see the Proof of Proposition 2 for a formal demonstration). Indeed, it is always better to induce him to invest in the inefficient project with private benefits of control instead: the final payoffs of these two projects have the same distribution, but the latter provides private benefits of control to the manager, which relaxes the participation constraint and enables a diminution of the fixed wage. We therefore know that the equilibrium contract will be such that it is optimal

---

<sup>21</sup>The investor will therefore not be misled in equilibrium, as we make clear below. But should it be in the manager's interests to manipulate the signal process, he will do it, which will be anticipated by investors. The manager will therefore not derive any rent in equilibrium, but the outcome will be inefficient. This is a typical signal-jamming equilibrium.

for the manager not to invest in the inefficient short-term project. Thus, we take as given the representative investor's belief that the manager invests either in the efficient project or in the inefficient project with private benefits of control in equilibrium. Then we verify that the representative investor cannot be misled in that regard, and we show in Proposition 2 that this belief is verified in equilibrium (when the stock price is determined in accordance with this belief, and the manager acts optimally conditional on this stock price process and on his contract).

We begin by determining the manager's optimal behavior regarding the inefficient short-term project:

**Claim 1:** If  $\tau = T$ , then it is suboptimal for the manager to select the inefficient short-term project. If  $\tau < T$ , and if the manager selects the inefficient short-term project in equilibrium, then he chooses  $s = \tau$ .

If the investor believes that the manager does not invest in the inefficient short-term project in equilibrium, then the stock price is determined as in the previous section, so that

$$S_t = v_t \tag{26}$$

for any  $t \in [0, T]$ .

If the manager is compensated at time  $\tau = T$ , then we know from Claim 1 that he will not invest in the inefficient short-term project, so that we know from the previous section and the incentive constraint in (17) that he selects the efficient project if and only if  $b \geq b^*$ . If the manager is compensated at time  $\tau < T$ , then the condition that must be satisfied for the investor's belief that he will invest in the efficient project rather than in the inefficient short-term project to be verified in equilibrium is, given Claim 1, the signal processes described in (3) and (24) respectively, the stock price process described in (26) and contract parameters:

$$w + b\bar{A} \geq w + b\hat{A} - \frac{c}{2}(\tau + \epsilon)^2 \tag{27}$$

The left-hand side of (27) is the expected pay of a manager who invests in the efficient project, while the right-hand side is the expected pay net of costs of a manager who invests in the inefficient short-term project and manipulates the signal process up to the time  $\tau$  when he is compensated (since both projects are associated with the same variance of pay, it was omitted). The parameters  $c$  and  $\epsilon$ , the difference  $\hat{A} - \bar{A}$  and contract parameters being common knowledge, the representative investor knows whether it is the interests of the manager to invest in the inefficient short-term project, given his compensation contract: the representative investor cannot be misled.

We know from the previous section that for  $b \geq b^*$ , the manager had rather invest in the efficient project than in the inefficient project with private benefits of control. Therefore, if  $b \geq b^*$ , then the manager invests in the efficient project, and the investor knows that he does, if and only if condition (27) is satisfied. With second-best optimal contract parameters (notably given the value of  $b^*$  in (18)) and  $\tau^* \neq T$ , this condition is rewritten as

$$\tau^* \geq \sqrt{2b^* \frac{\hat{A} - \bar{A}}{c}} - \epsilon = \sqrt{2 \frac{P}{c} \frac{\hat{A} - \bar{A}}{\bar{A} - \underline{A}}} - \epsilon \equiv \underline{\tau} \quad (28)$$

Should the second-best optimal timing of compensation  $\tau^* \neq T$  defined in Proposition 1 be lower than  $\underline{\tau}$ , a manager compensated at time  $\tau^*$  will select the inefficient short-term project rather than the efficient project: the second-best outcome described in the previous section is then not feasible anymore. In this case, the inequality in (28) highlights the three possible ways to ensure that the manager still selects the efficient project rather than the inefficient short-term project. First and foremost, this can be achieved by postponing the compensation date and choosing  $\tau = \min\{\underline{\tau}, T\}$ , at the cost of a deviation from the second-best optimal timing  $\tau^*$  and the resulting increase in the agency cost. A second response consists in making it more costly to manipulate the signal process, by raising  $c$  or  $\epsilon$ . Auditing, or scrutiny from independent equity research analysts, could help. Third, the pay-performance sensitivity  $b$ , which fuels short-termism, could be reduced. However, with  $b < b^*$ , the manager would not invest in the efficient project, since he would then rather invest in the inefficient project with private benefits of control. Hence this important conclusion: the higher the power  $b^*$  of incentives needed to

prevent investment in the inefficient project with private benefits of control, the smaller the set of parameter values for which the second-best outcome (the second-best optimal contract parameters  $\{w^*, \tau^*, b^*\}$  and the manager opting for the efficient project) is feasible.

Given the founder's maximizing behavior, the next Proposition shows for which set of parameter values the efficient project is implemented, and for which set of parameter values the inefficient project with private benefits of control is implemented.

**Proposition 2:** If

$$\bar{A} - \underline{A} > \frac{\gamma}{2} \left( \frac{P}{\bar{A} - \underline{A}} \right)^2 \left( \sigma^{N^2} h + \int_h^T \sigma_t^{U^2} dt \right) + P \quad (29)$$

where  $h = T$  if  $\sigma_t^U$  is increasing in  $t$ ,  $\sigma^{N^2} T > \int_0^T \sigma_t^{U^2} dt$ ,  $0 < \underline{\tau} < T$ , and  $\int_{\underline{\tau}}^T \sigma_t^{U^2} dt > \sigma^{N^2} (T - \underline{\tau})$ , and  $h = \max\{\tau^*, \min\{\underline{\tau}, T\}\}$  otherwise, then the optimal contract parameters are  $b = b^*$  and  $\tau = h$ , and the manager selects the efficient project. Otherwise, it is optimal to set  $b = 0$ , and the manager selects the inefficient project with private benefits of control.

In summary, with short-termism of the first-type, either no explicit incentives are provided ( $b = 0$ ), or the timing of compensation is postponed relative to the second-best optimal timing ( $\tau \geq \tau^*$ ).

Even though the short-term inefficient project is never implemented in equilibrium, its mere existence may make it too costly to provide incentives for the manager to pick the efficient project. When  $\hat{A}$  is high and  $c$  and  $\epsilon$  are low,  $\underline{\tau}$  is high, so that a deviation from the second-best optimal contract parameters may be needed if the efficient project is to be implemented (since we then need to have  $\tau \geq \min\{\underline{\tau}, T\}$ , by definition of  $\underline{\tau}$ ). Should this deviation be too costly in terms of agency cost, it may then become more efficient to implement the inefficient project with private benefits of control.<sup>22</sup> This is achieved by giving only a fixed wage to the manager

---

<sup>22</sup>This is how condition (29) should be interpreted: the first-term on the right-hand side is the agency cost of inducing the manager to invest in the efficient project. Setting  $b = b^*$  ensures that the manager chooses the efficient project rather than the inefficient project with private benefits of control;  $h$  is the timing of pay which minimizes the agency cost under the constraint that the manager chooses the efficient project rather than the inefficient short-term project.

( $b = 0$ ), which ensures that he will prefer this project to the inefficient short-term project.

## B. Short-Termism of the Second Type

Now assume that, at  $t = -1$ , the manager can either invest in the inefficient project with private benefits of control already described in the baseline model, or invest in a project with a “time horizon” of  $r$ ,  $0 \leq r \leq T$  and expected payoff  $\bar{A}_r$ . As we explain below, the time horizon only denotes the time at which information asymmetries are fully resolved – the payoff is still realized at  $t = T$ , exactly as before. As in the baseline model, the manager choice is unobservable.

To introduce a potential conflict of interest between the founder and the manager, we need two elements. First, we assume that the expected payoff  $\bar{A}_r$  is increasing in the time horizon  $r$  (the inefficient project with private benefits of control is still characterized by an expected payoff of  $\underline{A}$ ). For simplicity, assume a linear relationship: for a given  $\mu > 0$  and any  $r \in [0, T]$ ,

$$\bar{A}_r = \bar{A} - \mu(T - r) \quad (30)$$

Second, from the manager’s ex-ante perspective, the variability of the stock price due to information asymmetries is increasing in the time horizon  $r$  of the project. Formally, if the manager chooses a project with time horizon  $r$  and expected payoff  $\bar{A}_r$ , we assume that the signal process is described by:

$$v_t = \bar{A}_r + \sigma^N B_t^N - \int_t^r \sigma_s^U dB_s^U \quad (31)$$

for  $t \leq r$ , and

$$v_t = \bar{A}_r + \sigma^N B_t^N \quad (32)$$

for  $t > r$  (if the manager opts for the inefficient project with private benefits of control, the signal process is still described in (2) and (3), as in the preceding section<sup>23</sup>). The manager

---

<sup>23</sup>Equivalently, the signal he receives in this case is described by the signal process described in (31) and (32), except that  $\bar{A}_r$  is replaced by  $\underline{A}$  and  $r$  is replaced by  $T$ .

effectively chooses when information asymmetries vanish. Notice that the project with  $r = T$  is the efficient project of the baseline model. Following the same steps as in section I, we get

$$S_t = v_t \tag{33}$$

for any  $t \in [0, T]$ .

In the baseline model, the only alternative to the inefficient project with private benefits of control is the efficient project. Now, as an alternative to the inefficient project with private benefits of control, the manager may choose among a set of projects with different expected returns and time horizons – where the time horizon determines the time at which information asymmetries are fully resolved. At one end of the spectrum (a low  $r$ ), some projects have relatively low expected returns but are less plagued by information asymmetries. One example is for the manager to reinvest in existing lines of business. At the other end of the spectrum (a high  $r$ ), some projects have higher expected returns but are characterized by strong information asymmetries. One example is for the manager to launch a brand new project involving lots of changes which are hard to apprehend for outside investors.

We are now going to analyze the manager's problem, given a compensation contract. First, we show in the Appendix that, conditional on the manager not choosing the inefficient project with private benefits of control,  $r \geq \tau$  at the optimum: the manager optimally chooses a time horizon  $r$  higher than the time  $\tau$  at which he is paid. Intuitively, as long as  $r < \tau$ , the manager's expected compensation is an increasing function of  $r$ , while his exposure to noise is independent of  $r$ , and he is not exposed at all to any variance of pay emanating from information asymmetries. Second, given parameters  $\{w, \tau, b\}$  of the compensation contract, the manager's certainty equivalent wealth of choosing the project with a time horizon of  $r \geq \tau$  is

$$CE(r) = w + b\bar{A}_r - \frac{\gamma}{2}b^2\left(\sigma^{N^2}\tau + \int_{\tau}^r \sigma_s^{U^2}ds\right) \tag{34}$$

where  $\bar{A}_r$  is defined in (30). The manager clearly faces a tradeoff. On the one hand, shortening the project's time horizon  $r$  diminishes the expected payoff of the project, which diminishes

his expected pay. On the other hand, shortening the project's time horizon  $r$  reduces the variability of the signal process, which reduces the variance of his stock-based pay.

The problem of the manager is solved in the Appendix. For the manager to select a project with a long time horizon  $r$ , superior expected returns must adequately compensate him for the extra risk borne. More precisely, the manager tends to optimally select a time horizon lower than  $T$  when  $\mu$  is low, and when his risk aversion  $\gamma$  and the pay-performance sensitivity  $b$  are high. The higher  $\mu$  is, the more a longer time horizon project is valuable in terms of expected payoffs; the higher the manager's risk aversion  $\gamma$ , the more expected pay he is willing to forgo to reduce the variance of his pay; the higher the pay-performance sensitivity  $b$  is, the larger the weight he assigns to the variance of his pay relative to his expected pay. As  $b$  approaches zero, the manager only cares about his expected pay, so that the value of  $b$  which maximizes (34) is  $r = T$ . As with short-termism of the first-type, the higher the power  $b^*$  of incentives needed to prevent investment in the inefficient project with private benefits of control, the smaller the set of parameter values for which the second-best outcome (the second-best optimal contract parameters  $\{w^*, \tau^*, b^*\}$  and the manager opting for the project with  $r = T$ ) is feasible.

Short-termism of the second-type is not an issue if, given the second-best optimal contract parameters  $\{w^*, \tau^*, b^*\}$ , the manager chooses  $r = T$ . Contract parameters are then as in the previous section. In particular, this is always the case when the second-best optimal timing is  $\tau^* = T$ , since we know that  $r \geq \tau$ .

However, just as with short-termism of the first-type, implementing the efficient project is so costly for certain parameter values that it is then optimal not to provide any incentives to the manager:

**Proposition 3:** When  $\mu > \frac{\bar{A}-A}{T}$ ,  $\sigma^N > \sigma_t^U$  for all  $t$ , and  $\gamma$  is sufficiently high, then it is optimal to set  $b = 0$ .

First, a sufficiently risk averse manager will opt for  $r = \tau$ . Second, for a sufficiently high  $\gamma$ , the agency cost of setting  $\tau > \tau^* = 0$  is too large. Third, when  $\mu > \frac{\bar{A}-A}{T}$  (short-termism of the

second-type greatly lowers the firm's expected value), the expected payoff of a project with a time horizon of  $r = 0$  is even lower than  $\underline{A}$ . It is then more efficient to induce the manager to pick the inefficient project with private benefits of control, whose expected payoff is  $\underline{A}$ . This is achieved by giving him only a fixed wage.

We now address the effect of short-termism of the second-type on the optimal timing of compensation:

**Proposition 4:** If the manager does not choose  $r = T$  when  $\tau = \tau^*$ , then the value of  $\tau$  which results in  $r = T$  is larger than  $\tau^*$ .

If the second-best optimal contract parameters are not robust to short-termism of the second-type, then a preservation of the manager's incentives to invest in the efficient project ( $r = T$ ) requires that he be paid later than at the second-best. This result is all the more remarkable that it applies to all four cases distinguished in Proposition 1.

Information asymmetries are directly responsible for short-termism of the second type. However, the best cure against both moral hazard and short-termism may paradoxically be to reduce the amount of noise which accumulates in the stock price. Indeed, in the baseline model with moral hazard, more information asymmetries result in a more delayed compensation (a higher  $\tau^*$ ), while more noise results in earlier compensation. The latter is more problematic because it renders the prevention of short-termism more difficult. If there were no noise, the second-best optimal timing of compensation would be  $\tau^* = T$ , and short-termism, whether of the first or the second type, would not occur under the second-best optimal contract parameters. Diminishing  $\sigma^N$  is therefore doubly worthwhile in the presence of potential short-termism: not only does it lower the agency cost, but it also mitigates the short-termism problem. The best remedy for short-termism could thus consist in filtering the noise out of the stock price process, so as to obtain a precise performance measure (relative to the manager's choice of  $A$ ) at time  $T$ . This could be achieved with relative performance evaluation and the hedging of risks at the corporate level.



## C. Monitoring

In this section on short-termism, we have assumed that the manager has some leeway to take inefficient actions such as manipulating the signal process or investing in a short-term project with lower expected returns. In reality, some firms set up monitoring mechanisms to deal with these problems. Von Thadden (1995) argues that monitoring by investors could decrease information asymmetries and be the remedy to what we would call short-termism of the second-type. Likewise, Goldman and Slezak (2006) postulate that monitoring can limit earnings manipulation, and therefore short-termism of the first-type.

We now assume that, at  $t = -2$ , the founder decides whether to monitor the manager, at a given fixed cost, or not.<sup>24</sup> A manager who is monitored can neither invest in an inefficient short-term project nor set  $r \neq T$ .<sup>25</sup> Thus, monitoring prevents the manager from taking second-best-inefficient actions. With monitoring, as in the baseline model, the manager therefore only makes choices along one dimension: he trades off the expected payoff of a project against the private benefits of control it yields. In this setting, incentives can be high-powered ( $b = b^*$ ) without perverse effects.

Monitoring will be valuable whenever its cost is lower than the difference between the objective function of the founder at the second-best (i.e., in the baseline model) and at the third-best (with short-termism of either the first or second type). Since these two values coincide for  $\tau^* = T$ , costly monitoring is suboptimal when the manager is compensated at time  $T$ , i.e., based on the realized payoff of the project.

In the subsection below, we discuss which form monitoring could take in practice.

---

<sup>24</sup>Monitoring could also be performed by the representative investor or by a third-party, as long as the founder incurs its cost in fine.

<sup>25</sup>This assumption is standard in the literature. For example, in his textbook on corporate finance, Tirole (2006) “[assumes] that the active monitor could reduce the extent of moral hazard by ruling out some egregious forms of managerial misbehavior.”

#### **D. Predictions and Empirical Evidence: Short-Termism and the Timing of Pay**

The model first predicts that the more the pay of managers is sensitive to their performance, the more they will adopt short-termist behaviors.<sup>26</sup> With regards to the first type of short-termism, this is consistent with the positive correlation between the propensity to misreport or “manage” earnings and the level of the pay-performance sensitivity empirically identified in Bergstresser and Philippon (2005), Burns and Kedia (2006), Efendi, Srivastava and Swanson (2007), and Johnson, Ryan and Tian (2009). With regards to the second type of short-termism, Coles, Daniel and Naveen (2006) find that a higher pay-performance sensitivity results in lower R&D expenditures, while Francis, Hasan, and Sharma (2009) find that the pay-performance sensitivity is negatively related to patents and citations to patents. These results are consistent with our prediction that managers with higher-powered incentives have a stronger propensity to avoid projects for which the time  $r$  to wait until information asymmetries are fully resolved is long (this includes innovative projects), since these projects are more risky from a manager’s perspective.

A stronger prediction is that firms which are particularly vulnerable to managerial short-termism should have lower pay-performance sensitivities. If we consider that risk-taking and short-termism of the second type are bigger issues in small, rapidly growing firms rather than big firms, then the evidence presented in Graham, Harvey, and Puri (2009) and in the Figure 3 in Murphy (1999) is consistent with this prediction: the larger the firm, the larger is the proportion of CEO pay which takes the form of stocks and stock-options. Conversely, the smaller the firm, the larger is the contribution of the base salary to total CEO pay. In the same vein, Bizjak, Brickley and Coles (1993) find that pay-performance sensitivities tend to be lower in high-growth firms, a result they describe as “surprising given the conventional arguments”. Graham, Harvey, and Puri (2009) also find that the fixed salary component is proportionally lower in public companies. This finding may appear counterintuitive, but could be explained by a less acute short-termism problem in public companies. Finally, as already discussed, monitors can detect short-termism or at least increase its cost. Hartzell and Starks

---

<sup>26</sup>All else equal, a higher value of  $b$  expands the set of parameter values for which short-termism of either the first or the second type is optimal, from the manager’s perspective.

(2003) argue that institutional investors serve as monitors, and find a positive correlation between the pay-performance sensitivity of executives and institutional ownership. This is what the model would lead us to expect.

The model also predicts that postponing compensation should mitigate short-termist behaviors.<sup>27</sup> Regarding the first type of short-termism, this explains the fact that long-term performance plans are associated with lower levels of manipulation of short-term earnings, as documented in Richardson and Waagelein (2002). Moreover, Johnson, Ryan, and Tian (2009) and Peng and Roell (2008) respectively find that unrestricted stockholdings (which can be sold immediately) and vested options (which can be exercised immediately) encourage earnings manipulation. Regarding the second type of short-termism, the model explains the finding of Richardson and Waagelein (2003) that investment in R&D is increased following the adoption of long-term performance plans. Similarly, Francis, Hasan, and Sharma (2009) find that long-term equity incentives are positively related to patents and citations to patents. In addition, Kumar and Sopariwala (1992) document a positive association between the adoption of a long-term performance plan and long-term growth in profitability (in our model, short-term projects have lower payoffs). Larcker (1983) also finds that firms which adopt long-term performance plans exhibit a stronger growth in capital expenditures than other similar firms – which suggests that their managers are more willing to depress short-term cash-flows in order to boost long-term cash-flows.

A stronger prediction is that firms which are particularly vulnerable to managerial short-termism should postpone compensation more. Kole (1997) finds that the minimum and average wait times until stock-options are exercised are longer in R&D intensive firms, although the minimum vesting period for restricted stocks is shorter. Richardson and Waagelein (2003) find that these firms are more likely to adopt long-term performance plans. Lastly, Bizjak, Brickley and Coles (1993) show that the higher the growth rate of the firm, the more compensation is postponed.

More controversially, the model shows that when the short-termism problem is acute, it is

---

<sup>27</sup>All else equal, a later compensation date  $\tau$  shrinks the set of parameter values for which short-termism of either the first or the second type is optimal, from the manager's perspective.

optimal not to provide any significant incentives to the manager, and let him enjoy private benefits of control instead. This contributes to explaining low pay-performance sensitivities (Jensen and Murphy (1990)), the fact that poorly performing CEOs bear little risk of being dismissed (Jensen and Murphy (1990), Kaplan (1994)),<sup>28</sup> and the fact that some managers seem to “enjoy the quiet life” (Bertrand and Mullainathan (2003)). In our model, all this is third-best optimal when the short-termism problem, either of the first or the second type, is very severe (see Propositions 2 and 3).

In such a case, mitigating the short-termism problem, for instance with increased monitoring, would make it possible to provide stronger incentives to the manager. Thus, our model predicts that stock-based monetary incentives and monitoring are complements rather than substitutes when the manager may take short-termist actions.<sup>29</sup> This is because these two mechanisms perform different functions: while monetary incentives ensure that the manager invests in high payoff projects rather than projects associated with private benefits of control, monitoring ensures that he does not indulge in short-termism. This prediction is in line with the empirical findings of Mehran (1995) and Hartzell and Starks (2003) in the case of publicly-held companies, Gomez-Mejia, Tosi and Hinkin (1987) in the case of big manufacturers, Leslie and Oyer (2009) in the case of private-equity-owned companies, Kaplan (1989) in the case of management buyouts, and Kaplan and Stromberg (2001) in the case of companies financed by venture capitalists, although it is not consistent with Fahlenbrach (2009). Interestingly, leveraged buyouts and private equity transactions (including venture capital) involve a change of ownership, with a strong hands-on monitor, *and* high-powered managerial incentives (Kaplan (1989), Shleifer and Vishny (1997), Leslie and Oyer (2009)). In the perspective of our model, the latter may only be optimal because the monitor prevents management from indulging in short-termism (if providing higher-powered managerial incentives created value per se, publicly listed firms could do it as well). Similarly, takeovers may solve the short-termism problem

---

<sup>28</sup>More recent studies, for example Kaplan and Minton (2005) find a stronger relation between firm performance and CEO turnover. However, Brickley (2003) asserts that “firm performance continues to explain very little of the variation in CEO turnover.”

<sup>29</sup>To use the terminology of Tirole (2006), active and passive monitoring (the latter involves an assessment of past managerial decisions on profits) are complements. In his words, “This question is central to the design of the financial system (...) and yet it has not been investigated in detail in the literature.”

with an organizational change. If these conjectures are correct, then these three types of deals notably create value by solving the short-termism problem, thereby unlocking the target firm’s potential.

To the extent that monitoring is costly, we would finally like to determine in which circumstances it is most valuable. We have already seen that monitoring is worthless when  $\tau^* = T$ , which happens when information asymmetries are strong relative to noise. Monitoring, which addresses the short-termism problem and permits the use of higher-powered incentives, can therefore only be optimal when “early” compensation is second-best optimal ( $\tau^* < T$ ) but not robust to short-termism. In turn, early compensation is second-best optimal when information asymmetries are outweighed by noise.<sup>30</sup> This analysis points to two possible corporate governance equilibria. When shareholders have effectively reduced information asymmetries, it is especially valuable for them to monitor the manager, to have relatively early stock-based compensation ( $\tau < T$ ), and to give high-powered incentives ( $b = b^*$ ). This tends to correspond to the corporate governance system typically observed in firms controlled by a private-equity fund (Jensen (1986, 1989), Leslie and Oyer (2009)). On the contrary, when information asymmetries between the manager and shareholders are strong, it is optimal to postpone the manager’s compensation or even to pay him based on the realized payoff of the project ( $\tau = T$ ), and it may be optimal to give low-powered incentives ( $b = 0$ ). In any of these cases ( $\tau = T$  or  $b = 0$ ), monitoring is unnecessary. This tends to correspond to the corporate governance system typically observed in publicly listed firms (Lowenstein (1988), Jensen (1989), Jensen and Murphy (1990)).<sup>31</sup> In support of this hypothesis, Leslie and Oyer (2009) find that any

---

<sup>30</sup>Edmans (2010) argues that blockholders have strong incentives to acquire information, while Parrino, Sias and Starks (2003) and Bushee and Goodman (2007) find that larger shareholders are indeed more informed. We therefore expect information asymmetries between managers and investors to be lower for these firms. This gives a joint prediction of the model and of the Edmans (2010) hypothesis: firms controlled by bigger shareholders tend to pay their managers earlier and to monitor them more, *ceteris paribus*. Given that the U.S. is the country with the most dispersed shareholder structure (La Porta, Lopez-de-Silanes, and Shleifer (1999)), this may explain why U.S. firms tend to heavily use deferred equity-based compensation (Fernandes, Ferreira, Matos, and Murphy (2009)). On the contrary, controlling shareholders in other countries may more easily resort to monitoring (see Kaplan (1994) for a comparison of the U.S. and Japan). They also tend to rely relatively more on bonus payments, which reward short-term performance, for incentive purposes (Fernandes, Ferreira, Matos, and Murphy (2008)).

<sup>31</sup>With a dispersed ownership structure, shareholders face a coordination problem in the acquisition of information. They may free-ride on price discovery. This potentially explains why publicly-listed firms with a dispersed ownership tend to fall in the corporate governance equilibrium with strong information asymmetries,

difference in compensation practices between private-equity-owned firms and publicly listed firms disappears shortly after the private-equity-owned firm goes public, which suggests that firm fixed effects do not explain these differences.

### III Conclusion

This paper adds a new dimension to the executive compensation problem, and formalizes the tradeoff which determines the timing of stock-based compensation. Whereas information asymmetries between the manager and investors suggest that contingent compensation should be delayed, the fact that noise progressively accumulates in the stock price suggests that it should not. The optimal timing of compensation balances these two conflicting forces. In particular, this analysis invalidates the common view that the timing of compensation should necessarily coincide with the realization of uncertainty.

If the second-best optimal timing thus derived is not robust to managerial short-termism, we show that the power of the incentive scheme should be lowered, and the compensation date should be postponed. Even though it is necessary to provide incentives for the manager to opt for a project with a high expected payoff, it may even be optimal not to provide any incentives when the short-termism problem is very severe. These results hold for both types of short-termism. Thus, our model can explain both low pay-performance sensitivities (Jensen and Murphy (1990)) and deferred compensation.

More generally, this paper improves our understanding of the complementarity between stock-based managerial compensation and monitoring. It also demonstrates how the degree of stock-market efficiency influences the efficient delivery of managerial incentives. We deliberately focused on the corporate governance aspect, and took the extent of information asymmetries between the manager and investors as given. Future research could adopt the other angle, notably by endogeneizing information acquisition by shareholders, as well as the shareholder structure.

---

while firms controlled by a venture capitalist, say, tend to fall in the corporate governance equilibrium with low information asymmetries.

## IV Bibliography

Bergstresser, Daniel, and Thomas Philippon, 2006, CEO incentives and earnings management, *Journal of Financial Economics* 80 (3), 511-529.

Bertrand, Marianne, and Sendhil Mullainathan, 2003, Enjoying the quiet life? Corporate governance and managerial preferences, *Journal of Political Economy* 111 (5), 1043-1075.

Bhattacharyya, Sugato, and Jonathan B. Cohn, 2008, The temporal structure of equity compensation, working paper.

Bizjak, John M., James A. Brickley, and Jeffrey L. Coles, 1993, Stock-based incentive compensation and investment behaviour, *Journal of Accounting and Economics* 16, 349-372.

Bolton, Patrick, Jose Scheinkman, Wei Xiong, 2006, Executive compensation and short-termist behavior in speculative markets, *Review of Economic Studies* 73, 577-610.

Brickley, James A., 2003, Empirical research on CEO turnover and firm-performance: a discussion, *Journal of Accounting and Economics* 36 (1-3), 227-233.

Burns, Natasha, and Simi Kedia, 2006, The impact of performance-based compensation on misreporting, *Journal of Financial Economics* 79 (1), 35-67.

Bushee, Brian and Theodore Goodman, 2007, Which institutional investors trade based on private information about earnings and returns? *Journal of Accounting Research* 45, 289-321.

Clinch, Greg, 1991, Employee compensation and firms' research and development activity, *Journal of Accounting Research* 29 (1), 59-78.

Coles, Jeffrey L., Naveen D. Daniel, and Lalitha Naveen, 2006, Managerial incentives and risk-taking, *Journal of Financial Economics* 79 (2), 431-468

Core, John, Guay, Wayne, 1999. The use of equity grants to manage optimal equity incentive levels, *Journal of Accounting and Economics* 28, 151-184.

de Marzo, Peter, and Yuliy Sannikov, 2006, Optimal security design and dynamic capital structure in a continuous-time agency model, *Journal of Finance* 61, 2681-2724.

Diamond, Douglas W., and Robert E. Verrecchia, 1982, Optimal managerial contracts and equilibrium security prices, *Journal of Finance* 37 (2), 275-287.

Goss, Betsy C., and James F. Waagelein, 2006, The influence of executive compensation

on the dispersion of security analyst forecasts, *Managerial and Decision Economics* 14 (6), 499-507.

Edmans, Alex, 2009, Blockholder trading, market efficiency, and managerial myopia, forthcoming, *Journal of Finance*.

Edmans, Alex, Xavier Gabaix, Tomasz Sadzik, Yuliy Sannikov, 2009, Dynamic incentive accounts, working paper.

Efendi, Jap, Anup Srivastava, and Edward P. Swanson, 2007, Why do corporate managers misstate financial statements? The role of option compensation and other factors, *Journal of Financial Economics* 85 (3), 667-708.

Fahlenbrach, Rudiger, 2009, Shareholder rights, boards, and CEO compensation, *Review of Finance* 13 (1), 81-113.

Fernandes, Nuno, Miguel A. Ferreira, Pedro Matos, and Kevin J. Murphy, 2009, The pay divide: (why) are U.S. top executives paid more?, ECGI Finance working paper 255.

Giannetti, Mariassunta, 2009, Serial CEO incentives and the structure of managerial contracts, working paper.

Goldman, Eitan, and Steve K. Slezak, 2006, An equilibrium model of incentive contracts in the presence of information manipulation, *Journal of Financial Economics* 80, 603-626.

Gomez-Mejia, Luis R., Henry Tosi, and Timothy Hinkin, 1987, Managerial control, performance, and executive compensation, *Academy of Management Journal* 30 (1), 51-70.

Graham, John R., Campbell R. Harvey, and Manju Puri, 2009, Managerial attitudes and corporate actions, working paper.

Hartzell, Jay C., and Laura T. Starks, 2003, Institutional investors and executive compensation, *Journal of Finance* 58, 2351-2374.

Holmstrom, Bengt, and Paul Milgrom, 1987, Aggregation and linearity in the provision of intertemporal incentives, *Econometrica* 55, 308-328.

Holmstrom, Bengt and Paul Milgrom, 1991, Multitask principal-agent analyses: incentive contracts, asset ownership, and job design, *Journal of Law, Economics, and Organization* 7 (0), 24-52.



- Holmstrom, Bengt, and Jean Tirole, 1993, Market liquidity and performance monitoring, *Journal of Political Economy* 101 (4) 678-709.
- Holmstrom, Bengt, 1999, Managerial incentive problems: a dynamic perspective, *Review of Economic Studies* 66 (1), 169-182.
- Jensen, Michael C., 1986, Agency costs of free cash flow, corporate finance, and takeovers, *American Economic Review* 76 (2), 323-29.
- Jensen, Michael C., 1989, Eclipse of the public corporation, *Harvard Business Review*, September-October, 61-74.
- Jensen, Michael C., and Kevin J. Murphy, 1990, Performance pay and top-management incentives, *Journal of Political Economy* 98(2), 225-64.
- Johnson, Shane, Harley Ryan, and Yisong Tian, 2009, Managerial incentives and corporate fraud: the source of incentives matter, *Review of Finance* 13 (1), 115-145.
- Kaplan, Steven N., 1989, The effects of management buyouts on operating performance and value, *Journal of Financial Economics* 24, 217-254.
- Kaplan, Steven N., 1994, Top executive rewards and firm performance: a comparison of Japan and the United States, *Journal of Political Economy* 102 (3), 510-546.
- Kaplan, Steven N., and Per Stromberg, 2001, Venture capitalists as principals: contracting, screening, and monitoring, *American Economic Review* 91 (2), 426-430.
- Kaplan, Steven N., and Bernadette A. Minton, 2006, How has CEO turnover changed? increasingly performance sensitive boards and increasingly uneasy CEOs, NBER Working Paper No. W12465.
- Kole, Stacey R., 1997, The complexity of compensation contracts, *Journal of Financial Economics* 43 (1), 79-104.
- Krugman, Paul, 2002, Greed is bad, *New York Times*, June 4.
- Kumar, Raman, and Parvez R. Sopariwala, 1992, The effect of adoption of long-term performance plans on stock prices and accounting numbers, *Journal of Financial and Quantitative Analysis* 27 (4), 561-573.
- Lacker, Jeffrey M., and John A. Weinberg, 1989, Optimal contracts under costly state

falsification, *Journal of Political Economy* 97 (6), 1345-1363.

Laffont, Jean-Jacques, and Jean Tirole, 1988, Repeated auctions of incentive contracts, investment, and bidding parity with an application to takeovers, *RAND Journal of Economics* 19 (4), 516-537.

La Porta, Rafael, Florencio Lopez-de-Silanes, and Andrei Shleifer, 1999, Corporate ownership around the world, *Journal of Finance* 54 (2), 471-517.

Larcker, David F., 1983, The association between performance plan adoption and corporate capital investment, *Journal of Accounting and Economics* 5, 3-30.

Leslie, Phillip, and Paul Oyer, 2009, Managerial incentives and value creation: evidence from private equity, working paper.

Lowenstein, Louis, 1988. *What's wrong with Wall Street? Short-term gain and the absentee shareholder* (Addison-Wesley).

Manso, Gustavo, 2007, Motivating innovation, Hudson Institute Research Paper no. 08-01.

Mehran, Hamid, 1995, Executive compensation structure, ownership, and firm performance, *Journal of Financial Economics* 38 (2), 163-184.

Murphy, Kevin J., 1999, Executive compensation, in Orley Ashenfelter and David E. Card, eds.: *Handbook of Labor Economics* (North Holland) .

Narayanan, M. P., 1985, Managerial incentives for short-term results, *Journal of Finance* 40, 1469-1484.

Parrino, Robert, Richard Sias and Laura Starks, 2003, Voting with their feet: institutional ownership changes around forced CEO turnover, *Journal of Financial Economics* 68, 3-46.

Peng, Lin, and Ailsa Roell, 2008, Executive pay and shareholder litigation, *Review of Finance* 12 (1), 141-184.

Radner, Roy, 1981, Monitoring cooperative agreements in a repeated principal-agent relationship, *Econometrica* 49 (5), 1127-1148.

Richardson, Vernon J., and James F. Waagelein, 2002, The influence of long-term performance plans on earnings management and firm performance, *Review of Quantitative Finance and Accounting* 18 (2), 161-183.

Richardson, Vernon J., and James F. Waagelein, 2003, Characteristics associated with the corporate decision to adopt long-term performance plans, *Journal of Business Finance and Accounting* 30 (3-4), 621-644.

Sannikov, Yuliy, 2008, A continuous-time version of the principal-agent problem, *Review of Economic Studies* 75, 957-984.

Shleifer, Andrei, and Robert W. Vishny, 1987, A survey of corporate governance, *Journal of Finance* 52 (2), 737-783.

Shleifer, Andrei, and Robert W. Vishny, 1990, Equilibrium short horizons of investors and firms, *American Economic Review* 80 (2) 148-153.

Smith, Clifford W., Jr., and Ross L. Watts, 1992, The investment opportunity set and corporate financing, dividend, and compensation policies, *Journal of Financial Economics* 32 (3), 263-292.

Stein, Jeremy C., 1988, Takeover threats and managerial myopia, *Journal of Political Economy*, 96 (1) 61-80.

Stein, Jeremy C., 1989, Efficient capital markets, inefficient firms: a model of myopic corporate behavior, *Quarterly Journal of Economics* 104, 655-669.

Tirole, Jean, 2006. *The Theory of Corporate Finance* (Princeton University Press).

von Thadden, Ernst-Ludwig, 1995, Long-term contracts, short-term investment and monitoring, *Review of Economic Studies* 62, 557-575.

Wang, Cheng, 1997, Incentives, CEO compensation, and shareholder wealth in a dynamic agency model, *Journal of Economic Theory* 76, 72-105.

Williams, Noah, 2004, On dynamic principal-agent problems in continuous time, working paper.