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Parachutes, Stock Ownership and Stock Options**

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Abstract

This paper studies optimal managerial contracts applying both complete and incomplete contracting approaches. In a complete contracting environment where contracts can be based on earnings, an optimal contract is interpreted as a combination of base salary, golden parachute and bonus. When earnings are not verifiable, two types of optimal contracts are derived: a contract with restricted stock ownership, and a contract with stock options. These three types of optimal contracts are payoff-equivalent in a strong sense: agents' ex ante and ex post payoffs are the same under all three contracts. This suggests that the choice of contractual form is irrelevant in the environment studied in this paper. Comparative static analyses of optimal contracts generate several testable hypotheses.

KEY WORDS: Optimal contract, executive compensation, bonus, golden parachutes, stock ownership, stock options.

JEL CLASSIFICATION: D82, G32, J33.

1. Introduction

For some time, the magnitude of compensation for corporations' chief executive officers (CEOs) has spawned heated debate among academics and the public alike.⁽¹⁾ While public outcry regarding the astronomical figures may still exist, it seems that the debate has waned at least among academics. Academic interests in CEO compensation have taken different turns. Some of the major issues now are the discrepancy between theory and practice, and the way CEOs ought to be paid.

The main point regarding the first issue is how economic theory of contract fails to explain small pay-performance sensitivity of CEO compensation. While there is no consensus whether the empirical pay-performance sensitivity of executive compensation is as prescribed by the principal-agent theory⁽²⁾, there is convincing evidence that incentive effects of stock options or stock ownership far outweigh those of cash compensation. For example, Jensen and Murphy (1990) report that the pay-performance sensitivity for CEOs represented by stock options is more than 30 times than that by cash compensation. Hall and Liebman (1998) find that a strong positive relationship between firm performance and CEO compensation is mostly due to CEO holdings of stocks and stock options, with the incentive effects from stock and stock option revaluations being 53 times larger than those from salary and bonus changes. Nonetheless, incentive effects of stocks or stock options have not been put under rigorous theoretical scrutiny.

This paper is mainly concerned with the second issue. In particular, we address the incentive effects of various components that comprise CEO compensation. Typical CEO compensation for large US corporations is often a combination of cash salary and bonus, stock ownership, stock options and a provision for severance payment.⁽³⁾ Clearly these various

⁽¹⁾ See, for example, Milgrom and Roberts (1992), Ch. 13 and various references therein.

⁽²⁾ Initial debate started with a seminal article by Jensen and Murphy (1990). The low pay-performance sensitivity reported by Jensen and Murphy was explained by a parametrized principal-agent model by Haubrich (1994). Instead of using the level of executive compensation, Garen (1994), and Aggarwal and Samwick (1999) used the comparative static predictions of principal-agent model to explain the variations in pay-performance sensitivity across the cross section of firms. Hadlock and Lumer (1997), and Holderness et al. (1999) provide historical evidence on executive compensation. Using proxies for incentive effects of executive stock options, Hall and Liebman (1998), and Hall (1998) provide evidence for strong pay-performance sensitivity. For a survey, see Baker, Jensen and Murphy (1988) or Murphy (1998).

⁽³⁾ From a sample of 446 firms that appeared on the Forbes magazine list of the largest US firms in 1987,

components are interrelated in motivating CEOs to act in the interests of shareholders. For example, the severance payment, or golden parachutes, is intended to induce the CEO to make proper decisions based on available information and not to distort the running of the firm to fight takeover bids. The opportunity cost for the CEO in taking this course of action is the compensation from continuation of appointment that might be lost after takeover. It thus follows that golden parachutes should reflect this opportunity cost.

This paper studies a parsimonious model in which the components of CEO compensation package mentioned above can be introduced most naturally. The simple three-period model we study has two economic agents one of whom is called the owner and the other, the manager. The owner has an investment project and capital to finance it, but only the manager has the expertise to assess the profitability of the project. Initially, the owner hires a manager who then privately studies the profitability, which is modelled as the process of information gathering. In period 2, the manager decides whether or not to undertake the project, or equivalently, the owner decides based on the report by the manager. If the project is aborted, then the manager leaves at a severance payment. If the project is undertaken, then in period 3, the return is realized and publicly observed, based on which the manager is paid.

We study two environments and derive optimal contracts. First, if the return is verifiable also so that initial contract can be based on the return, then the optimal contract is interpreted as a combination of golden parachute (payment at period 2 to the leaving manager), base salary and bonus (payment at period 3). With this kind of complete contracting technology, there is no need to use stocks or stock options as part of optimal contract. In the second environment, we thus assume that the return is not verifiable, hence cannot be contracted upon. Nonetheless, it is publicly observable, and is reflected in the ‘price’ of project. In this case, we derive two types of optimal contracts: a contract with stock ownership that is restricted to be traded only at date 3, and a contract with stock options. These three types of optimal contracts are payoff-equivalent in a strong sense: managers’ ex ante and ex post payoffs are the same under all three contracts. The paper thus shows how different types of contracts can replicate the exact same incentives.

Agrawal and Knoeber (1998) find that the CEOs of 51 percent of these firms had golden parachutes (a severance agreement granting cash and other benefits if the CEO is fired, demoted, or resigns within a certain time period following the change in control).

At first sight, one might think that the result of this paper is more negative than positive. A strong message from the paper, for example, is the irrelevance of using different forms of contracts as long as they are designed optimally. Accordingly, the question of why a certain type of contract is used more often than another remains unanswered. In the spirit similar to Modigliani and Miller propositions, what the result of this paper is pointing at is not so much the irrelevance of different forms of contracts per se, but rather the conditions that would make the question of relevance meaningful. For example, special features of the simple model studied in this paper include risk neutrality of managers, dichotomous and bulky investment, absence of moral hazard from other employees, absence of earnings manipulation by managers, perfect observability of earnings by markets, and efficient stock markets where public information is reflected perfectly in stock prices. Thus, a message from this paper is that the question of relevance is meaningful when one or more of these conditions are relaxed. In the concluding section of this paper, we discuss how the irrelevance result of this paper is likely to change when these conditions are relaxed.

This paper overlaps with three strands of literature in accounting, economics and finance. The first of those, of course, is the literature on executive compensation. Setting aside studies reviewed before, a bulk of papers in accounting have been concerned with the incentive aspect of managerial contracts based on either reported accounting earnings or stock price. Some examples are Bushman and Indjejikian (1993), Kim and Suh (1993), Sloan (1993), and Baiman and Verrechia (1995) on the analysis of optimal contract, and Healy (1985) with numerous follow-up empirical studies on the possibility of earnings manipulation by managers when their bonus plan is based on accounting earnings. Depending on how private information is impounded in stock price, the first set of studies typically analyze optimal *linear* contract. The present paper differs from these studies in two ways. First, we do not impose a priori restrictions on contractual forms other than those given by informational constraints. Second, our paper provides a broad benchmark for the irrelevance of contractual forms, including contracts with stock options. As a consequence, we contend that elements such as information content of earnings or the possibility of earnings manipulation are but a few of many that would make the question of relevance meaningful.

The second strand of literature related to the present study is that on golden parachutes.

Positive explanations for the use of golden parachutes offered previously include incentive alignment effect by Lambert and Larcker (1985), deferred payment effect by Knoeber (1986), bargaining advantage effect by Harris (1990), and commitment effect by Cyert and Kumar (1996) and Choe (1998).⁽⁴⁾ While the explanation provided in this paper is similar to those in Lambert and Larcker, and Choe, an additional insight is offered as to how golden parachutes are related to other components of CEO compensation package. In a simplified model of this paper, the size of golden parachute is the same regardless of whether performance incentives are provided through bonus, stock ownership or stock options.

Finally, the second half of this paper can be viewed as an application of incomplete contract theory to executive compensation. The single most important focus of incomplete contract theory has been on the resolution of holdup problem: the problem of underinvestment due to incompleteness of contracts and specificity of investment (Williamson, 1985; Hart and Moore, 1988).⁽⁵⁾ There is now extensive literature concerned with overcoming the holdup problem by adding option-like features to the initial contract,⁽⁶⁾ or by allowing renegotiation.⁽⁷⁾ Incomplete contracting approach has also been applied to explain the use of financial contracts different from standard debt or equity (Aghion and Bolton, 1992), or the stage financing feature of venture capital contracts (Repullo and Suarez, 1999). In a sense, this paper is also concerned with the resolution of holdup problem: the manager can learn the profitability of project at private cost, which cannot be directly contracted upon. Apart from the applied nature of questions addressed, this paper offers another solution to the holdup problem different from option-like features or simple contract combined with renegotiation possibility. That is, when the ownership rights can be traded in a market which correctly reflects public information in the price of ownership, then ownership itself can solve the holdup problem.

The rest of this paper is organized as follows. Section 2 describes a basic model and

⁽⁴⁾ For empirical evidence on the relationships between the adoption of golden parachutes, stock price reactions, and the incidence of takeovers, see Walking and Long (1984), Lambert and Larcker (1985), Agrawal and Knoeber (1998), and Narayanan and Sundaram (1998).

⁽⁵⁾ The literature on legal remedies for breach of contracts predicts overinvestment in the presence of expectation damages remedy. See Edlin and Reichelstein (1998).

⁽⁶⁾ Some of these studies are Demski and Sappington (1991), Hermalin and Katz (1993), Nöldeke and Schmidt (1995, 1998), Bernheim and Whinston (1998), and Edlin and Hermalin (1998).

⁽⁷⁾ See Hart and Moore (1988), Chung (1991), MacLeod and Malcomson (1993), Aghion et al. (1994), and Edlin and Reichelstein (1996). With the possibility of renegotiation, Che and Hausch (1999) point out the difficulty of overcoming the holdup problem when specific investment is cooperative in nature.

derives an optimal contract in an environment where the return from project is verifiable. The identified optimal contract is interpreted as a combination of base salary, golden parachute, and bonus. Comparative statics of optimal contract generate several testable hypotheses. Section 3 is concerned with a contracting environment where the return from project is not verifiable. Two types of optimal contracts are derived: a contract with restricted stock ownership, and a contract with stock options. In addition to providing testable hypotheses, all three types of optimal contracts are shown to be payoff-equivalent both for the manager and for the owner. Section 4 summarizes the main results of the paper and discusses limitations of the model. Proofs not provided in the main text are all relegated to the appendix.

2. Optimal Contract When Return is Verifiable

2.1. Information Gathering and Optimal Investment Decision

There are two agents whom we call the owner and the manager. The owner is identified with a financier who is pondering over whether or not to undertake an investment project. However, only the manager has expertise to assess the profitability of the project, and if it is found positive, to implement the project.⁽⁸⁾ The project requires an outlay K , and returns π_g in a good state (G) to be called ‘success’, and π_b in a bad state (B) to be called ‘failure’, with $\pi_g > K > \pi_b \geq 0$. Common prior probability of success is $\gamma \in (0, 1)$. Net interest rate is assumed to be zero, and both agents’ reservation utilities are also normalized to zero. Finally, both agents are assumed to be risk neutral, interested only in maximizing expected payoffs. Assuming risk neutrality allows us to separate the risk-sharing aspect from the incentive aspect of optimal contracts. Relaxation of this assumption will be discussed in the concluding section of this paper.

Prior to making a decision whether to undertake the project, the manager alone can observe a signal $s \in (s_1, s_2) \subset \mathbb{R}^1$ which has a conditional density function $f(s|\theta)$ and a conditional distribution function $F(s|\theta)$ for $\theta = G, B$. This signal observation, or information

⁽⁸⁾ An alternative description would be that the manager has a project but no wealth, so should rely on the owner to finance the project. In this case, the result of the paper can be reinterpreted as a financial contract governing entrepreneur-investor relationships.

acquisition, is a primary task of the manager, which incurs private cost c to the manager.⁽⁹⁾ One can think of this cost as a monetary equivalent of the manager's time and effort in assessing the profitability of the project, which increases as the size of investment increases. That is, a larger K requires more time and effort of the manager in gathering information, managing requisite resources, and so on. Without information acquisition, the manager shares the same information as the owner, i.e., the prior probabilities. Given the signal observation, the marginal density function of signals is denoted by $f(s) = \gamma f(s|G) + (1-\gamma)f(s|B)$ and the distribution function by $F(s)$. Posterior probabilities are then $Pr(G|s) = \frac{\gamma f(s|G)}{f(s)} \equiv p(s)$, and $1-p(s) = \frac{(1-\gamma)f(s|B)}{f(s)}$. Thus, $p(s)$ is the posterior probability of success if the observed signal was s . All density functions are assumed to be differentiable and satisfy the following assumptions.

Assumption 1: $f(s|\theta)$ satisfies the monotone likelihood ratio condition, i.e., $\frac{f(s|G)}{f(s|B)}$ is increasing in s .

Assumption 2: $f'(s|G) > f'(s|B)$ for all s where the prime indicates a derivative with respect to s .

Assumption 3: There is an $s \in (s_1, s_2)$ such that $f(s|G) = f(s|B)$.

As usual, assumption 1 means that a higher value of signal is more indicative of success. In particular, it implies that the conditional distribution $F(\cdot|G)$ dominates $F(\cdot|B)$ in the sense of first-order stochastic dominance. Assumption 2 is analogous to the single-crossing property in adverse selection literature,⁽¹⁰⁾ implying that the increase in the value of observed signal increases the likelihood of success more than that of failure. This will turn out to be a sufficient condition for the incentive constraints for the manager's decision problem. Assumptions 2 and

⁽⁹⁾ We do not model the manager's or other employees' effort subsequent to the choice of project. This simplification is justified on two grounds. First, given other assumptions of our model, incorporating this type of moral hazard will not change the qualitative results of this paper. For instance, effort variable can be introduced in an additively, separable way to the return as, for example, in Rogerson (1997). Second, we view the main role of managers as that of setting directions based on superior information they possess. To quote Jensen and Murphy (1990, p. 251), "*Managers often have better information than shareholders and boards in identifying investment opportunities and assessing the profitability of potential projects; indeed, the expectation that managers will make superior investment decisions explains why shareholders relinquish decision rights over their assets by purchasing common stocks*".

⁽¹⁰⁾ If the space of states is also a real interval with a generic element $\theta \in \Theta = (\theta_1, \theta_2)$ and a larger value for the state representing a better state, then assumption 2 can be stated as $f_{s\theta}(s|\theta) > 0$ where the double subscript denotes a cross partial derivative.

3 then imply that there is a *unique* s such that $f(s|G) = f(s|B)$, which will be denoted by s^* . These assumptions lead to the following lemma.

Lemma 1: (a) The posterior probability of success is strictly increasing in s , i.e., $p'(s) > 0$; (b) $p(s^*) = \gamma$.

Proof: (a) follows directly from the monotone likelihood ratio condition, and (b) follows from the definition of s^* since $f(s^*) = \gamma f(s^*|G) + (1 - \gamma)f(s^*|B) = f(s^*|G)$. ■

It is assumed that the owner delegates the project choice decision to the manager. Insofar as the manager is the only party who can observe the signal, it does not matter whether the owner makes the project choice decision based on the report made by the manager (i.e., the owner has formal authority and the manager has real authority in the language of Aghion and Tirole (1997)), or the manager makes the decision (i.e., the manager has both formal and real authority).

Information structure for the model is as follows. The project choice decision ($d = 1$ if chosen, and $d = 0$ otherwise), and the return from the project ($r = \pi_g$ or $r = \pi_b$) are publicly observable, and can be contracted upon. All other aspects of the model (the manager's decision of information acquisition and the signals observed) are private and cannot be contracted upon. Given this, the time line for the model and the description of informationally feasible contracts are as in Figure 1.

— **Figure 1 goes about here.** —

Net present value from the project under the prior belief is $\gamma\pi_g + (1 - \gamma)\pi_b - K$ which is assumed to be zero. Thus the owner is not sure whether or not to go ahead with the project. Given the signal s , net present value from the project under the posterior belief is $p(s)\pi_g + (1 - p(s))\pi_b - K$. By Lemma 1, we have $p(s^*) - \gamma = 0$ and $p(s) - \gamma > 0$ for all $s > s^*$. In the first-best world, information acquisition should thus lead to a cutoff rule for optimal project choice decision of $d = 1$ if and only if $s \geq s^*$.

Then what is the value of information? In the event of information acquisition, expected net present value from the optimal project choice decision less the cost of information acquisition is

$$\begin{aligned}
& \int_{s^*}^{s_2} f(s)[p(s)\pi_g + (1-p(s))\pi_b - K]ds - c \\
& = \gamma[1 - F(s^*|G)]\pi_g + (1-\gamma)[1 - F(s^*|B)]\pi_b - K[1 - F(s^*)] - c.
\end{aligned} \tag{1}$$

Thus an optimal project choice decision with information acquisition leads to the revision of success probability from γ to $\frac{\gamma[1-F(s^*|G)]}{1-F(s^*)}$ which is larger than γ since $F(s^*) > F(s^*|G)$ due to the assumption that $F(\cdot|G)$ stochastically dominates $F(\cdot|B)$. We assume that the net present value in Eq. (1) is positive. Replacing K with $\gamma\pi_g + (1-\gamma)\pi_b$ and simplifying, this assumption can be stated as

$$\textit{Assumption 4: } \gamma[F(s^*) - F(s^*|G)]\pi_g + (1-\gamma)[F(s^*) - F(s^*|B)]\pi_b > c.$$

The (LHS) of the above inequality will be called the value of information, denoted by \mathcal{V} . Assumption 4 implies that information is valuable insofar as the manager follows the optimal project choice decision described above. The first-best optimum in this model thus consists of information acquisition and the optimal project choice decision by the manager. The question is to find an optimal contract which implements the first-best optimum given the information structure specified above.

2.2. Analysis of Optimal Contract

As mentioned before, the contract specifies the compensation to the manager based on two publicly observable variables: project choice decision ($d = 0, 1$) and the return from the project ($r = \pi_g, \pi_b$). Thus a contract can be denoted by a triple (t_1, t_2, t_3) where t_1 is the compensation if $d = 1, r = \pi_g$, t_2 is if $d = 1, r = \pi_b$ and t_3 is if $d = 0$.

We will focus on contracts that satisfy limited liability (LL), individual rationality for both agents ((IR-O) for the owner and (IR-M) for the manager), and can implement the first-best optimum which can be represented by incentive compatibility (IC).⁽¹¹⁾ Denoting ex ante

⁽¹¹⁾ Consider a general mechanism where the owner asks the manager to make a report regarding the observed signal based on which the owner wants to make the project choice decision. By the revelation principle, one can restrict attention to a direct mechanism and truth-telling by the manager if he observed a signal, which at the same time implements the cutoff rule for the project choice explained above. The conditions guaranteeing that the manager gathers information and truthfully reports the observed signals can be stated as incentive compatibility. A slight variation of the argument in Choe (1998) can be used to show that the revelation principle holds in the current setup.

expected payoffs for the owner and the manager by V_0 and U_0 respectively, we have the following limited liability and individual rationality constraints.

$$(LL) \quad 0 \leq t_i, \quad i = 1, 2, 3.$$

$$(IR-O) \quad V_0 \equiv \int_{s^*}^{s_2} f(s)[p(s)(\pi_g - t_1) + (1 - p(s))(\pi_b - t_2) - K]ds + \int_{s_1}^{s^*} f(s)(-t_3)ds \geq 0.$$

$$(IR-M) \quad U_0 \equiv \int_{s^*}^{s_2} f(s)[p(s)t_1 + (1 - p(s))t_2]ds + \int_{s_1}^{s^*} t_3 f(s)ds - c \geq 0.$$

For incentive compatibility, we need conditions that lead the manager to choose the first-best option over the following other alternatives: (i) always undertake the project without information acquisition; (ii) always abort the project without information acquisition; (iii) acquire information and make project choice decision other than the optimal one; (iv) randomize between (i) and (ii). As the alternative (iv) is dominated by either (i) or (ii), we need to consider only the first three. The alternative (iii) represents an (uncountably) infinite number of incentive constraints. But this can be simplified. Suppose the manager chose the project given a signal $s' \neq s^*$. Expected compensation from this decision must not be smaller than that from aborting the project, or $p(s')t_1 + (1 - p(s'))t_2 \geq t_3$. Since $p'(s) > 0$ by Lemma 1, any decision rule should thus include an interval $[s', s_2)$ as the range of signal values at which the project must be undertaken. Thus any decision should again follow a cutoff rule. Incentive compatibility constraints corresponding to the first three alternatives are formally stated below.

$$(IC-i) \quad U_0 \geq \gamma t_1 + (1 - \gamma)t_2.$$

$$(IC-ii) \quad U_0 \geq t_3.$$

$$(IC-iii) \quad U_0 \geq \int_s^{s_2} f(x)[p(x)t_1 + (1 - p(x))t_2]dx + \int_{s_1}^s t_3 f(x)dx - c \quad \text{for all } s.$$

An optimal contract is then (t_1, t_2, t_3) which maximizes the owner's expected utility subject to the above constraints. This can be stated as:

$$\text{Maximize}_{(0 \leq t_i, i=1,2,3)} V_0 \quad \text{subject to (IR-0), (IR-M), (IC-i), (IC-ii), (IC-iii).} \quad (2)$$

To solve problem (2), we will start by studying the incentive constraints more closely. (IC-iii) is equivalent to s^* being a global maximizer of $\int_s^{s^2} f(x)[p(x)t_1 + (1 - p(x))t_2]dx + \int_{s_1}^s t_3 f(x)dx - c$. Due to assumption 2, this constraint can be simplified by the first-order condition for the corresponding optimization problem.

Lemma 2: (IC-iii) is equivalent to $t_3 = \gamma t_1 + (1 - \gamma)t_2$ and $t_1 > t_2$.

That $t_3 = \gamma t_1 + (1 - \gamma)t_2$ along with $t_1 > t_2$ are necessary and sufficient for (IC-iii) is reminiscent of incentive compatibility constraints in adverse selection literature.⁽¹²⁾ While the conditions in Lemma 2 guarantee ex ante incentive compatibility, they also assure that interim incentive compatibility is satisfied for *each* observed signal. That is, the manager does not have incentives to undertake the project if $s < s^*$, for otherwise, expected compensation is $p(s)t_1 + (1 - p(s))t_2 < \gamma t_1 + (1 - \gamma)t_2 = t_3$, falling short of the compensation from aborting the project. Similarly, the manager does not have incentives to abort the project if $s \geq s^*$.

Substituting $t_3 = \gamma t_1 + (1 - \gamma)t_2$ into the expected payoffs for the owner and the manager, and arranging terms yields

$$V_0 = \gamma[1 - F(s^*|G)]\pi_g + (1 - \gamma)[1 - F(s^*|B)]\pi_b - K[1 - F(s^*)] - t_1\gamma[1 - F(s^*|G) + F(s^*)] - t_2(1 - \gamma)[1 - F(s^*|B) + F(s^*)], \quad (3)$$

$$U_0 = t_1\gamma[1 - F(s^*|G) + F(s^*)] + t_2(1 - \gamma)[1 - F(s^*|B) + F(s^*)] - c. \quad (4)$$

Also, given $t_3 = \gamma t_1 + (1 - \gamma)t_2$, (IC-i) and (IC-ii) are equivalent. Since the owner's problem is equivalent to minimizing the expected payment to the manager, (IC-i) will be binding at the solution to problem (2), or $t_1\gamma[F(s^*) - F(s^*|G)] + t_2(1 - \gamma)[F(s^*) - F(s^*|B)] - c = 0$. Note also that (IR-M) is satisfied whenever (IC-i) or (IC-ii) are since (LL) precludes negative compensation to the manager. Ignoring (IR-O) for a moment, the owner's problem in Eq. (2) is then to choose nonnegative values for (t_1, t_2) to minimize the expected compensation to the manager given by $t_1\gamma[1 - F(s^*|G) + F(s^*)] + t_2(1 - \gamma)[1 - F(s^*|B) + F(s^*)]$ subject

⁽¹²⁾ Given $t_3 = \gamma t_1 + (1 - \gamma)t_2$ and $t_1 > t_2$, the manager's expected compensation is increasing in observed signals if the manager follows the optimal project choice decision. Note the analogy with adverse selection literature where weak monotonicity of allocation in private types is necessary and sufficient for incentive compatibility under the single-crossing property.

to binding (IC-i), and $t_1 > t_2$. Once the solution to this problem is identified, t_3 can be calculated as $\gamma t_1 + (1 - \gamma)t_2$.

It is easy to see that, at the solution to the above problem, limited liability for t_2 is binding, i.e., $t_2 = 0$. The intuition is simple. As the manager is risk neutral and π_b is a sign of bad performance which is more likely to be observed if the manager made suboptimal project choice decisions, incentives for optimal project choice can be best provided by making the difference between t_1 and t_2 as larger as possible. In other words, an optimal contract entails the usual combination of carrot and stick. This, along with (IC-iii) and binding (IC-i), leads to $t_1 = \frac{c}{\gamma[F(s^*) - F(s^*|G)]}$, $t_2 = 0$, and $t_3 = \frac{c}{F(s^*) - F(s^*|G)}$. This contract satisfies (LL) since the stochastic dominance condition implies $F(s^*) > F(s^*|G)$.

One last thing to check is if the above contract satisfies (IR-O). Substituting the above contract to V_0 and setting $V_0 \geq 0$ leads to the inequality $c \leq \left(\frac{F(s^*) - F(s^*|G)}{1 - F(s^*|G) + F(s^*)} \right) \mathcal{V}$ where $\mathcal{V} \equiv \gamma[F(s^*) - F(s^*|G)]\pi_g + (1 - \gamma)[F(s^*) - F(s^*|B)]\pi_b$ was defined earlier in assumption 4 as the value of information. Note that assumption 4 is not enough to guarantee this inequality. What assumption 4 means is that information is valuable in the first-best world where the owner need not incur incentive costs to implement an optimum. In the second-best world where providing incentives to the manager is costly, the cost of information acquisition c should not be too large for (IR-O) to be satisfied. Even when assumption 4 is satisfied so that information is potentially valuable, if the owner has to pay too much to induce information acquisition by the manager, then there may not exist any contract satisfying (IR-O). The cost of providing such incentives to the manager increases as the private cost of information acquisition increases. For the set of contracts satisfying all the constraints to be nonempty, we thus need an upper bound on c smaller than the value of information.

Proposition 1: Suppose $c \leq \left(\frac{F(s^*) - F(s^*|G)}{1 - F(s^*|G) + F(s^*)} \right) \mathcal{V}$ so that the set of contracts satisfying the constraints is not empty. Then an optimal contract is given by $t_1^* = \frac{c}{\gamma[F(s^*) - F(s^*|G)]}$, $t_2^* = 0$, $t_3^* = \frac{c}{F(s^*) - F(s^*|G)}$.

At an optimal contract, the value of information (\mathcal{V}) less the cost of information acquisition (c) is shared between the owner and the manager: $V_0 = \mathcal{V} - \frac{c}{F(s^*) - F(s^*|G)} - c$, $U_0 = \frac{c}{F(s^*) - F(s^*|G)}$. In particular, the manager enjoys strictly positive information rent. The main

reason for this is limited liability, without which the owner can extract entire rent by setting t_2 a negative number such that $\gamma t_1 + (1 - \gamma)t_2 = t_3 = 0$. Such a contract will satisfy all the incentive constraints and make (IR-M) binding. In view of limited liability observed in actual contracts, this positive information rent for the manager could be regarded as a norm.

In the remainder of this section, we conduct some comparative statics of optimal contract, which will be useful in providing an interpretation of optimal contract in the following section. The first question is how various components of optimal contract are related to the size of investment, K . It was assumed earlier that the private cost of information acquisition by the manager (c) increases as K increases. An increase in K would also change π_g and π_b , which however do not affect managerial compensation. Thus, as long as various probabilities are independent of the size of investment, an immediate conclusion is that t_1^* , t_3^* and U_0 are all increasing in K .

How does the degree of information asymmetry change the nature of optimal contract? In corporate finance, this question spawned a great deal of interest both theoretically and empirically. There is some evidence that, the severer information asymmetry is, the more likely financing pattern deviates from standard methods such as straight debt or equity. Nonetheless, our understanding of the issue is still at a rudimentary stage, which perhaps is due to the difficulty of finding a reasonable measure of information asymmetry, again both theoretically and empirically. We attempt to provide one such measure in the current context and show how the optimal contract in Proposition 1 changes in response to changes in the degree of information asymmetry.

The owner's assessment of the probability of success is given by γ . If the manager acquires information and follows the optimal project choice rule, then the ex ante cumulative probability of success is $\frac{\gamma[1-F(s^*|G)]}{1-F(s^*)}$. Therefore, the ratio of the two, $\frac{1-F(s^*|G)}{1-F(s^*)} > 1$ measures the degree by which the manager's information is better than the owner's in predicting success. Similarly, the ratio, $\frac{1-F(s^*|B)}{1-F(s^*)} < 1$ measures the degree by which the manager's information is better than the owner's in predicting failure. Ideally, one would hope to have a measure of information asymmetry which could reflect both of these two ratios. For example, the spread between the two given by $\frac{F(s^*|B)-F(s^*|G)}{1-F(s^*)}$ is one such measure with a larger spread reflecting more information asymmetry. An alternative would be to take the ratio of the two, $\frac{1-F(s^*|G)}{1-F(s^*|B)}$.

Unfortunately these two measures are not easily tractable.

We thus introduce a third measure of information asymmetry, which is inspired by the fact that larger information asymmetry should lead to a higher value of information. After some algebraic manipulation, the value of information can be restated as $\mathcal{V} = \gamma(1 - \gamma)(\pi_g - \pi_b)(F(s^*|B) - F(s^*|G))$, which increases in $F(s^*|B) - F(s^*|G)$. We thus use this as a proxy for information asymmetry. It is easy to check that both of the above two measures are positively related to $F(s^*|B) - F(s^*|G)$. With this and noting that $F(s^*) = \gamma F(s^*|G) + (1 - \gamma)F(s^*|B)$, it is immediate to see that t_3^* is a decreasing function of $F(s^*|B) - F(s^*|G)$, hence less information asymmetry should lead to a larger value for t_3^* . The intuition is as follows. t_3^* is essentially compensation for gathering information and correctly choosing not to undertake the project, should sufficiently adverse signals be observed. As $F(s^*|B) - F(s^*|G)$ decreases, the manager's information converges to that of the owner's.⁽¹³⁾ Thus the owner would want to give incentives to the manager not to pursue the project unduly, which can be done by making t_3^* larger. The effect of changes in $F(s^*|B) - F(s^*|G)$ on t_1^* is similar. Again, a decrease in information asymmetry needs to be accompanied by a larger payment for good performance to ensure that the manager makes efficient use of information in project choice decision. The discussions so far are summarized in Proposition 2.

Proposition 2: (a) Other things being equal, an increase in the size of project leads to an increase in t_1^* , t_3^* and U_0 ; (b) If the degree of information asymmetry can be proxied by $F(s^*|B) - F(s^*|G)$, then more information asymmetry leads to smaller t_3^* and t_1^* .

2.3. Interpretation of Optimal Contract

This section will provide an interpretation of optimal contract in Proposition 1. For this, we employ an alternative description of the model, which has essentially the same mathematical representation as in subsection 2.1. Also readers are referred to the time line in Figure 1.

Continue to assume that the owner has the investment project, but now there is a continuum of ex ante identical managers whose types are identified with signal s . At date 0, the owner randomly selects a manager to offer a contract. At date 1, the chosen manager decides

⁽¹³⁾ Or, the manager's information becomes gradually useless.

whether to learn his type at private cost of c . If the initial contract is incentive compatible, then the manager learns and truthfully reports his type. At date 2, the owner makes the project choice decision based on the report. An optimal project choice decision would imply that the project should be aborted if and only if the reported type is $s < s^*$. Thus if the chosen manager's type turns out to be $s < s^*$, then the owner fires him at severance payment of t_3 , and chooses another manager with whom the game starts again. If the reported type is $s \geq s^*$, then the project is chosen and the remaining terms of initial contract (t_1, t_2) are executed at date 3.⁽¹⁴⁾ It is easy to adapt this scenario to the model in subsection 2.1. In particular, an equivalent version of (IC-iii), $t_3 = \gamma t_1 + (1 - \gamma)t_2$ given in Lemma 2 ensures that interim incentive compatibility is satisfied for all types of managers. Thus, once the chosen manager decided to learn his type which is guaranteed by (IC-i) and (IC-ii), then he does not have incentive to misrepresent the type. Therefore, an incentive-compatible contract implementing the first-best optimum is precisely as in Proposition 1.

Given the above scenario, the contract in Proposition 1 can be interpreted as a compensation package consisting of base salary corresponding to t_2^* , a golden parachute represented by t_3^* , and the bonus for good performance given by $t_1^* - t_2^*$. That the base salary is $t_2^* = 0$ is due to risk neutrality and limited liability. For risk-averse managers, base salary would be generally positive. The interpretation of t_3^* as a golden parachute is justified by the fact that it is essentially payment for leaving managers whether the departure has been initiated by hostile takeover or by the existing board. Its main rationale is to give managers incentives not to distort the running of the firm, or the investment decision in the current context, for fear of replacement by (potentially) better managers. For future reference, we also note that, while ex ante expected compensation (at date 0) for managers is the same for all types, interim expected compensation (at date 2) is nondecreasing in the type of managers. That is, interim expected compensation for all managers with type $s < s^*$ is t_3^* and that for managers with type $s \geq s^*$ is $p(s)t_1^*$ which is an increasing function of s .

With this interpretation, Proposition 2 provides testable hypotheses: (a) the size of golden

⁽¹⁴⁾ Under this scenario, there is an additional piece of information observable by the owner, namely the reported type. We assume that the reported type is not verifiable, hence cannot be contracted upon. This can be justified on two grounds. First, as in incomplete contracting literature, what is observable by insiders may not be easy to verify in the court of law. Second, if the optimal decision can be made without having to make contracts contingent on this information, then there is no need to consider such contracts. In any case, the space of contracts is restricted to the one in subsection 2.2.

parachute is positively related to the size of firm; (b) salary plus bonus is positively related to the size of firm; (c) the size of golden parachute is negatively related to the degree of information asymmetry; (d) the size of bonus is negatively related to the degree of information asymmetry. Except for hypothesis (b), we do not know of any empirical studies either rejecting or supporting any of these hypotheses.⁽¹⁵⁾ As a practical matter, the degree of information asymmetry could be empirically proxied by such measures as the dispersion in analysts' earnings forecasts for each firm (Atiase and Bamber, 1994; Ajinkya et al., 1991), or the residual volatility in a firm's stock returns (Dierkens, 1991; Krishnaswami et al., 1999).

Increasing size of managerial compensation is largely due to stock options or stocks held by managers (Hall, 1998; Hall and Liebman, 1998). To have a richer theory of optimal managerial contract, it thus seems imperative to have a model that could explain the use of these instruments. One obvious rationale for using stocks and stock options to motivate managers is that contracts need not be explicitly based on performance signals. For example, as possible explanations for small pay-performance sensitivity of managerial compensation, Jensen and Murphy (1990) contend that performance signals such as accounting earnings can be manipulated while stock price may be too noisy a signal for manager's effort. The possibility of earnings manipulation by managers seems to have support by many empirical studies in accounting as well. In the next section, we make an extreme assumption that the return from project is not verifiable, hence cannot be contracted upon. While this assumption needs justification, we leave it to readers to resort either to Jensen and Murphy's explanations, or to the rationale given in incomplete contracting literature.⁽¹⁶⁾

3. Optimal Contract When Return Is Not Verifiable

3.1. *Inefficiency of Simple Contract*

⁽¹⁵⁾ Regarding hypothesis (b), there is evidence that CEO salary and bonus has a significant and positive relationship with the size of sales. For example, Baker et al. (1988) report that the best documented empirical regularity in this regard is an elasticity of compensation with respect to firm sales of about 0.3.

⁽¹⁶⁾ There are two ways incomplete contracting literature justifies the use of incomplete contracts. The first simply assumes intrinsic incompleteness in contracting technology either due to bounded rationality or due to transactions costs (for example, Williamson, 1985; Hart, 1995). The second approach endogenizes incomplete contracts based on strategic ambiguity that, if some aspects of environment cannot be written into contracts, then there may be gains in leaving some other aspects out of contracts as well (Bernheim and Whinston, 1998). See also Maskin and Tirole (1999), and Hart and Moore (1999) in the special issue of the *Review of Economic Studies* on contracts.

For ready interpretations of optimal contract, this section follows the second scenario described in subsection 2.3, except that return is not verifiable. Nonetheless, we assume that return is publicly observable. Note that reported types by managers were also assumed not to be verifiable. Then a contract can be represented by a triple (B_0, P, S) where B_0 is fixed base salary, P is compensation when the project is aborted, or a golden parachute, and S is compensation when the project is undertaken. Regardless of this change in contracting environment, the first-best optimum still consists of information gathering by the manager and the optimal project choice decision.

We start this section by showing that a ‘simple’ contract cannot implement the first-best optimum when return is not verifiable. By a simple contract, we mean a contract for which P and S also represent fixed payment. Limited liability imposes nonnegativity constraints on all these components. For a simple contract to implement the first-best optimum, we would need the manager to learn and truthfully report his type instead of (i) not learning his type and reporting $s < s^*$, (ii) not learning his type and reporting $s \geq s^*$, and (iii) learning his type but reporting a type different from what was learned.⁽¹⁷⁾ Given that the owner follows the optimal investment decision based on reported types, the first two incentive compatibility constraints can be expressed as

$$\text{(IC-i)} \quad U_0 \equiv P[1 - F(s^*|B)] + S[1 - F(s^*|G)] + B_0 - c \geq B_0 + S,$$

$$\text{(IC-ii)} \quad U_0 \geq B_0 + P.$$

The third incentive compatibility constraints are now essentially interim incentive compatibility constraints. Since P and S are fixed regardless of reported types, we need only consider two cases: the manager with type $s < s^*$ should not have incentives to report $s' \geq s^*$; the manager with type $s \geq s^*$ should not have incentives to report $s' < s^*$. From these two, we obtain

$$\text{(IC-iii)} \quad P = S.$$

It is immediate to see that (IC-iii) leads to the violation of (IC-i) and (IC-ii). Simply put, if managers receive the same payment regardless of reported types (because of (IC-iii)), then

⁽¹⁷⁾ Again there is no need to consider randomization over the options (i) and (ii).

they do not have incentives to learn their types at private cost. Since P is paid if and only if the project is aborted with the current manager, the only remedy for this inefficiency would be to make the payment represented by S dependent on subsequent return from the project. However, nonverifiability of return precludes the possibility of linking S directly to return. Indirect ways to link S to return are various arrangements whereby part of the right to return is transferred to the manager with whom the project is undertaken. In what follows, we will explore into these possibilities.

3.2. Optimal Contract with Restricted Stock Ownership

This section studies a contract (B_0, P, S) where B_0 is fixed base salary,⁽¹⁸⁾ P is a golden parachute, and S represents a fraction of the value of project awarded to the manager with whom the project is undertaken, i.e., stock ownership. In accordance with usual practice, the stock ownership is subject to limited liability. We will consider cases where this ownership share can be traded either at date 2 or at date 3.

If the ownership share can be traded at and after date 2, what will be the market value of project? Consider first date 3 when the return from the project is realized and publicly observed. Out of this return, B_0 has to be paid to the manager, and K has to be paid to the owner whenever possible. Since the ownership share represents residual claim, the value of project will be equal to the value of residual if it is nonnegative, and zero if it is negative. We are thus led to date 3 values of project, $V_3(r) \equiv \max\{r - B_0 - K, 0\}$ for $r = \pi_g, \pi_b$. Since $\pi_b < K$, the value of project is equal to zero in case of failure, and so we will simply denote the value of project in case of success as V_3 . Moreover, at any contract satisfying the owner's individual rationality constraint, V_3 has to be positive, or $B_0 < \pi_g - K$, since the owner receives positive payoff only when return is π_g . Therefore we can write the value of project at date 3 as

$$V_3 \equiv \pi_g - B_0 - K. \quad (5)$$

The value of project at date 2 can be recursively defined. At date 2, the announcement of

⁽¹⁸⁾ As there is no discounting, we assume, without loss of generality, that B_0 is paid at date 2 to departing managers, and at date 3 to managers with whom the project is undertaken.

project choice leads the market to update the probability of success. If the contract (B_0, P, S) is incentive-compatible, then the market correctly updates the probability of s conditional on the announcement $d = 1$ using Bayes' rule: $Pr(s|d = 1) = \frac{f(s)}{\int_{s^*}^{s_2} f(s)ds} = \frac{f(s)}{1-F(s^*)}$ if $s \geq s^*$, and $Pr(s|d = 1) = 0$, otherwise. As the value of project at date 2 should be equal to the expected value of project at date 3, the announcement of $d = 1$ will lead to date 2 value of project equal to

$$V_2 \equiv \int_{s^*}^{s_2} \frac{f(s)}{1-F(s^*)} p(s) V_3 ds = \frac{\gamma[1-F(s^*|G)]}{1-F(s^*)} V_3. \quad (6)$$

Finally, the initial value of project can be calculated. The announcement of $d = 0$ at date 2 leads to the value of project equal to zero, while incentive-compatible contracts will imply the value of project equal to V_2 upon the announcement of $d = 1$ at date 2. Again, incentive compatibility implies that the probability of $d = 1$ is $1 - F(s^*)$. Thus the initial value of project is

$$V_1 \equiv [1 - F(s^*)]V_2 = \gamma[1 - F(s^*|G)]V_3. \quad (7)$$

Consider first a case where there is no restriction on when to trade ownership share. Unless the size of golden parachute is sufficiently large, there is a possibility for managers with types $s < s^*$ to misrepresent their types to sell their ownership share at date 2. This puts a lower bound on the size of golden parachute. On the other hand, the golden parachute cannot be too large. For otherwise, managers with types $s \geq s^*$ may have incentives to deliberately abort the project. As the next lemma shows, these two restrictions on the size of golden parachute lead to the inefficiency of contracts with unrestricted stock ownership.

Lemma 3: A contract (B_0, P, S) where S is the ownership share tradable either at date 2 or at date 3 is not incentive compatible, hence cannot implement the first-best optimum.

As unrestricted stock ownership as in Lemma 3 cannot implement the first-best optimum, it seems natural to consider some form of restriction on when managers can trade their ownership share. Suppose the ownership share can be traded only at date 2. Intuitively, this should

not improve on the simple contract examined in the previous subsection. If the ownership share can be traded only at date 2 and if the contract is to be incentive compatible for all types, then the expected compensation at date 2 has to be the same for all types of managers when they truthfully report their types. This is precisely as in the case of simple contract where the main reason for inefficiency is the inability of owner to reward ‘better’ managers more favorably. Thus a contract with share ownership which is restricted to be traded before the realization of return, namely date 2, cannot implement the first-best optimum.

Lemma 4: A contract (B_0, P, S) where S is the ownership share tradable only at date 2 is not incentive compatible, hence cannot implement the first-best optimum.

What causes the inefficiency in Lemmas 3 and 4? Essentially it stems from stringent interim incentive compatibility constraints, mainly due to the incentives of managers with types $s < s^*$ to misrepresent their types for immediate sale of their stock ownership at date 2. A logical remedy for this inefficiency would then be a restriction on managers’ share trade at date 2. The final case to study is thus contracts for which ownership share can be traded only at date 3. At date 3, the return from project is publicly observed and correctly reflected in the value of project, implying that ‘better’ managers will expect higher expected compensation at date 2. Indeed, a contract with stock ownership that is restricted to be traded only at date 3 can implement the first-best optimum, as will be shown below.

Suppose (B_0, P, S) is a contract where S represents the manager’s stock ownership restricted to be traded only at date 3. For this contract to implement the first-best optimum, it has to be incentive compatible. If managers gather information and truthfully report their types based on which the optimal project choice decision is made, then the manager’s ex ante expected payoff is given by

$$\begin{aligned}\hat{U}_0 &\equiv S \int_{s^*}^{s_2} f(s)p(s)V_3 ds + P \int_{s_1}^{s^*} f(s)ds + B_0 - c \\ &= S\gamma[1 - F(s^*|G)]V_3 + PF(s^*) + B_0 - c.\end{aligned}\tag{8}$$

For ex ante incentive compatibility to be satisfied, \hat{U}_0 should not be smaller than $P + B_0$, the expected payoff from not learning his type and reporting $s < s^*$, and $S\gamma V_3 + B_0$, the expected payoff from not learning his type and reporting $s \geq s^*$.

Consider now interim incentive compatibility constraints: managers with type $s < s^*$ should not have incentives to report $s' \geq s^*$; managers with type $s \geq s^*$ should not have incentives to report $s' < s^*$. The first leads to $P + B_0 \geq S\gamma V_3 + B_0$. The second interim incentive compatibility constraints are equivalent to $S p(s) V_3 + B_0 \geq P + B_0$ for all $s \geq s^*$. As the (LHS) of this inequality increases in s , it is sufficient to have the inequality hold when $s = s^*$, which leads to $S\gamma V_3 + B_0 \geq P + B_0$. Thus interim incentive compatibility boils down to $S\gamma V_3 + B_0 = P + B_0$, or $P = S\gamma V_3$. Replacing this into the ex ante incentive compatibility constraints and simplifying, we have $S \geq \frac{c}{\gamma V_3 [F(s^*) - F(s^*|G)]}$.

We now turn to the owner's optimization problem. The owner provides K for the project at date 2 if $d = 1$, and pays $B_0 + P$ to the manager if $d = 0$. At date 3, if the return is π_g , then the owner recovers K , pays B_0 to the manager, and receives the residual $(1 - S)V_3$. If the return is π_b , then K cannot be recovered, and so the owner receives π_b and pays B_0 to the manager. Thus the owner's ex ante expected payoff at the first-best optimum can be written as

$$\begin{aligned} \hat{V}_0 &\equiv \int_{s^*}^{s_2} f(s) [p(s)(1 - S)V_3 + (1 - p(s))(\pi_b - K)] ds - P \int_{s_1}^{s^*} f(s) ds - B_0 \\ &= \gamma [1 - F(s^*|G)](1 - S)V_3 + (1 - \gamma)[1 - F(s^*|B)](\pi_b - K) - PF(s^*) - B_0. \end{aligned} \quad (9)$$

The owner's problem is then to choose $(B_0 \geq 0, P \geq 0, S \in [0, 1])$ to maximize \hat{V}_0 subject to $P = S\gamma V_3$ and $S \geq \frac{c}{\gamma V_3 [F(s^*) - F(s^*|G)]}$. Substituting $P = S\gamma V_3$ into \hat{V}_0 and differentiating with respect to B_0 leads to $-\gamma(1 - S)[1 - F(s^*|G)] - 1$ which is negative for all $S \in [0, 1]$. Thus $B_0 = 0$ and so $V_3 = \pi_g - K$. The derivative of \hat{V}_0 with respect to S is also negative, implying that the constraint $S \geq \frac{c}{\gamma V_3 [F(s^*) - F(s^*|G)]}$ has to be binding at the solution. Finally, P is found by replacing $S = \frac{c}{\gamma(\pi_g - K)[F(s^*) - F(s^*|G)]}$ and $B_0 = 0$ into $P = S\gamma V_3$ yielding $P = \frac{c}{F(s^*) - F(s^*|G)}$. This leads us to the following proposition.

Proposition 3: The first-best optimum can be implemented by a contract (B_0, P, S) given by $B_0 = 0$, $P = \frac{c}{F(s^*) - F(s^*|G)}$, $S = \frac{c}{\gamma(\pi_g - K)[F(s^*) - F(s^*|G)]}$ where S represents the manager's stock ownership restricted to be traded only at date 3.

The contract in Proposition 3 will be called a contract with restricted stock ownership, in contrast to the contract in section 2, which will be called a bonus contract. Note that the

size of golden parachute is the same under both contracts. As both contracts implement the first-best optimum, they are not Pareto-comparable. Indeed, it is easy to show that the sum of ex ante expected payoffs for the manager and the owner is equal to the value of information (\mathcal{V}) less the cost of information gathering (c) in both contracts. Then which contract should be preferred by the owner, or by the manager? One might wonder if the contract with restricted stock ownership should be disadvantageous to the owner because of her inability to condition managerial compensation on return. However, this turns out not to be the case.

Proposition 4: The optimal bonus contract and the optimal contract with restricted stock ownership are payoff-equivalent. That is, the distribution of managers' (owner's, resp.) ex post payoffs under the bonus contract is the same as the distribution of managers' (owner's, resp.) ex post payoffs under the contract with restricted stock ownership.

The proof of Proposition 4 is straightforward upon comparing the two optimal contracts. First, straightforward algebra shows that the sum of ex ante expected payoffs for the manager and the owner under the contract with restricted stock ownership is equal to the net value of information: $\hat{U}_0 + \hat{V}_0 = \mathcal{V} - c$. This was also the case with the bonus contract. Second, the size of golden parachute is the same in both contracts. Finally, it is easy to see that the ex post value of manager's stock ownership given by SV_3 is equal to the ex post value of manager's bonus given by t_2^* .

Proposition 4 points to an important direction in designing optimal managerial contract. For reasons to favor one form of contract over another, managers' risk aversion is not a good place to look at. As long as the owner knows the distribution of return, and as long as the set of incentive-compatible contracts is not empty, the owner can replicate exactly the same payoff structure for the manager using either bonus or restricted stock ownership. Suppose for example that the manager's utility function is given by $u(y) - c$, $u' > 0$, $u'' < 0$ where y is monetary compensation. Then the manager's ex ante expected utility under bonus contract is given by $u(t_1)\gamma[1 - F(s^*|G)] + u(t_2)(1 - \gamma)[1 - F(s^*|B)] + u(t_3)F(s^*) - c$, and that under contract with restricted stock ownership by $u(SV_3 + B_0)\gamma[1 - F(s^*|G)] + u(B_0)(1 - \gamma)[1 - F(s^*|B)] + u(P + B_0)F(s^*) - c$. If the owner is risk-neutral, then all that matters from the owner's standpoint is whether total compensation is the same. These two contracts lead to exactly the

same ex ante payoff for the manager if $t_1 = SV_3 + B_0$, $t_2 = B_0$, and $t_3 = P + B_0$. Of course, an optimal contract in this case will generally have $t_2 = B_0 > 0$. However, managers' risk aversion combined with other elements such as the possibility of earnings manipulation or the information content of earnings could change the payoff-equivalence result. As discussed in the introduction, this has been a focus of numerous studies in accounting.

Comparative statics of Proposition 3 can provide testable hypotheses. Note first that the size of golden parachute is the same as in Proposition 1, hence the same comparative statics results for this component. For the stock ownership, replacing $F(s^*)$ with $\gamma F(s^*|G) + (1 - \gamma)F(s^*|B)$ leads to $S = \frac{c}{\gamma(1-\gamma)(\pi_g - K)[F(s^*|B) - F(s^*|G)]}$. Thus an increase in information asymmetry as proxied by $F(s^*|B) - F(s^*|G)$ unambiguously leads to smaller S . A change in the size of project has two effects on S . On one hand, an increase in K increases the private cost of information gathering, thereby necessitating a larger fraction of stock ownership to be awarded to the manager. On the other hand, an increase in K changes $V_3 = \pi_g - K$ which may have either sign. Since $\gamma\pi_g + (1 - \gamma)\pi_b = K$ and so $\gamma \frac{d\pi_g}{dK} + (1 - \gamma) \frac{d\pi_b}{dK} = 1$, $\frac{d\pi_g}{dK}$ could be larger or smaller than 1, implying that V_3 may or may not increase as K increases. In fact, straightforward algebra shows that

$$\text{sign}\left(\frac{\partial S}{\partial K}\right) = \text{sign}\left(\frac{\frac{dc}{dK}}{c} - \frac{\frac{dV_3}{dK}}{V_3}\right). \quad (10)$$

The (RHS) of Eq. (10) is the difference between the percentage changes in c and V_3 as K changes. To derive a testable hypothesis from Eq. (10), it would seem reasonable to relate $\frac{dV_3}{dK} = \frac{d\pi_g}{dK} - 1$ to a characteristic of an industry in which the project is undertaken. For example, in mature industries where growth opportunities are not plenty, one might expect the return from investment not to vary too much over different circumstances, which can be taken to imply $\frac{d\pi_g}{dK} \leq 1$, and so $\frac{\partial S}{\partial K} > 0$. This implies that the size of stock ownership for managers increases in the size of firm in mature industries.

However, the absolute size of stock ownership itself is not as meaningful as the value of stock ownership in motivating managers. For managers, what matters is the expected value of stocks when they are able to trade them, which is given by SV_3 . But this is precisely equal to the value of bonus under bonus contract. Thus hypotheses regarding the value of stock ownership is the same as those for bonus.

The discussions so far lead to hypotheses regarding the restricted stock ownership for managers: (a) the size of restricted stock ownership for managers is negatively related to the degree of information asymmetry, and positively related to the size of firm in mature industries; (b) the value of stock ownership for managers is negatively related to the degree of information asymmetry, and positively related to the size of firm.

3.3. Optimal Contract with Stock Options

When return is not verifiable, yet another way of linking executive compensation to performance is using stock options, which is the focus of this section. Specifically, we study a contract (B_0, P, σ, X) where B_0 and P are the same as before, and σ is the fraction of the value of project which the manager can buy either at date 2 or at date 3 at an exercise price given by X . In other words, σ represents (American-type) call options on stocks awarded to the manager at date 0. In view of discussions in the previous section, it should be clear that restricting the exercise of options to date 2 cannot be incentive compatible.

To derive an optimal contract with stock options, we start by analyzing the interim incentive compatibility constraints. At date 2, managers with types $s > s^*$ face three alternatives: report types truthfully and receive $B_0 + P$; report $s' \geq s^*$ and exercise options at date 2, receiving $\sigma(V_2 - X) + B_0$; report $s' \geq s^*$ and wait until date 3 for exercise of options, with expected payoff of $p(s)\sigma(V_3 - X) + B_0$. Note that exercising a fraction of σ at date 2 and the rest at date 3 is dominated by either of the second or third alternatives. Thus interim incentive compatibility constraints for managers with types $s < s^*$ can be written as

$$\begin{aligned} P + B_0 &\geq \max \{ \sigma(V_2 - X) + B_0, p(s)\sigma(V_3 - X) + B_0 : s < s^* \} \\ &= \max \{ \sigma(V_2 - X) + B_0, \gamma\sigma(V_3 - X) + B_0 \}. \end{aligned} \tag{11}$$

Similarly, interim incentive compatibility constraints for managers with types $s \geq s^*$ can be written as

$$\begin{aligned} P + B_0 &\leq \min \{ \sigma(V_2 - X) + B_0, p(s)\sigma(V_3 - X) + B_0 : s \geq s^* \} \\ &= \min \{ \sigma(V_2 - X) + B_0, \gamma\sigma(V_3 - X) + B_0 \}. \end{aligned} \tag{12}$$

From Eqs. (11) and (12), it is clear that the only way interim incentive compatibility can be satisfied for all types of managers is $\sigma(V_2 - X) = \gamma\sigma(V_3 - X)$ which leads to a unique exercise price given by $X = \frac{V_2 - \gamma V_3}{1 - \gamma}$. Replacing V_2 and V_3 using Eqs. (5) and (6) leads us to the following lemma.

Lemma 5: A contract (B_0, P, σ, X) satisfies interim incentive compatibility constraints for all types of managers if and only if (a) $X = \frac{\gamma[F(s^*) - F(s^*|G)]}{(1 - \gamma)[1 - F(s^*)]}(\pi_g - K - B_0)$ and (b) $P = \sigma(V_2 - X) = \gamma\sigma(V_3 - X)$.

Before we examine ex ante incentive compatibility constraints, we digress a bit to see how the implication of Lemma 5 can be compared to usual practice in granting stock options to executives. For example, Hall (1998) reports that virtually all options are granted at the money, i.e., the exercise price is equal to the stock price on the grant date, a smaller portion in the money, i.e., the exercise price is less than the stock price on the grant date, and rarely out of the money, i.e., the exercise price is higher than the stock price on the grant date. An explanation for this practice can be provided in view of Lemma 5. Manipulating the expression for X in Lemma 5 leads us to

Lemma 6: $X \gtrless V_1$ if and only if $F(s^*) \gtrless \frac{1 - F(s^*|B)}{1 - F(s^*|G)}$.

In the above, $F(s^*)$ represents the probability that the project will be aborted, and $\frac{1 - F(s^*|B)}{1 - F(s^*|G)}$ is the relative likelihood of failure to success conditional on undertaking the project. Thus one could argue that options are granted out of the money ($X > V_1$) if future prospects are optimistic ($F(s^*) > \frac{1 - F(s^*|B)}{1 - F(s^*|G)}$), and in the money ($X < V_1$) if future prospects are pessimistic ($F(s^*) < \frac{1 - F(s^*|B)}{1 - F(s^*|G)}$).⁽¹⁹⁾ The usual practice of granting options at the money thus can be interpreted as reflecting more or less neutral prospects for the future.

Given that interim incentive compatibility is satisfied, all options are exercised at date 3. Thus the manager's ex ante expected payoff can be written as

⁽¹⁹⁾ This interpretation can be better justified if we approximate $\frac{1}{F(s^*)}$ by $1 - F(s^*)$. Then Lemma 6 can be restated as $X \gtrless V_1$ if and only if $1 - F(s^*) \lesseqgtr \frac{1 - F(s^*|G)}{1 - F(s^*|B)}$ where $1 - F(s^*)$ represents the probability the project will be undertaken, and $\frac{1 - F(s^*|G)}{1 - F(s^*|B)}$ is the relative likelihood of success to failure conditional on undertaking the project.

$$\begin{aligned}
\tilde{U}_0 &\equiv S \int_{s^*}^{s_2} f(s)p(s)\sigma(V_3 - X)ds + P \int_{s_1}^{s^*} f(s)ds + B_0 - c \\
&= \gamma[1 - F(s^*|G)]\sigma(V_3 - X) + PF(s^*) + B_0 - c.
\end{aligned} \tag{13}$$

Ex ante incentive compatibility requires $\tilde{U}_0 \geq P + B_0$. Replacing P with $\gamma\sigma(V_3 - X)$ using Lemma 5, this constraint becomes $\sigma \geq \frac{c}{\gamma(V_3 - X)[F(s^*) - F(s^*|G)]}$ where X is as in Lemma 5.

Consider now the owner's optimization problem. The owner provides K for the project at date 2 if $d = 1$, and pays $B_0 + P$ to the manager if $d = 0$. In case of success at date 3, the owner receives π_g , and pays $\sigma(V_3 - X) + B_0$ to the manager as options will be exercised against her. If the return is π_b , then the owner receives π_b and pays only B_0 to the manager as options will then be under water. Thus the owner's ex ante expected payoff at the first-best optimum can be written as

$$\begin{aligned}
\tilde{V}_0 &\equiv \int_{s^*}^{s_2} f(s) \left[p(s)(\pi_g - K - \sigma(V_3 - X)) + (1 - p(s))(\pi_b - K) \right] ds - P \int_{s_1}^{s^*} f(s) ds - B_0 \\
&= \gamma[1 - F(s^*|G)][\pi_g - K - \sigma(V_3 - X)] + (1 - \gamma)[1 - F(s^*|B)](\pi_b - K) - PF(s^*) - B_0.
\end{aligned} \tag{14}$$

Substituting P and X into \tilde{V}_0 using Lemma 5, the owner's problem is then to choose $(B_0 \geq 0, \sigma \in [0, 1])$ to maximize \hat{V}_0 subject to $\sigma \geq \frac{c}{\gamma(V_3 - X)[F(s^*) - F(s^*|G)]}$. As in the case of stock ownership, it is easy to see that both constraints are binding at the solution. To see this, observe $\frac{\partial \hat{V}_0}{\partial \sigma} = -\gamma(V_3 - X)[1 - F(s^*|G) + F(s^*)] < 0$ and $\frac{\partial \hat{V}_0}{\partial B_0} = \sigma[\gamma(1 - F(s^*|G)) + F(s^*)] - 1 < 0$ for all $\sigma \in [0, 1]$ since $\gamma(1 - F(s^*|G)) + F(s^*) < 1$. Therefore we must have $B_0 = 0$ and $\sigma = \frac{c}{\gamma(V_3 - X)[F(s^*) - F(s^*|G)]}$. Finally, using Lemma 5 again gives us the following proposition.

Proposition 5: The first-best optimum can be implemented by a contract (B_0, P, σ, X) given by $B_0 = 0$, $P = \frac{c}{F(s^*) - F(s^*|G)}$, $X = \frac{\gamma[F(s^*) - F(s^*|G)]}{(1 - \gamma)[1 - F(s^*)]}(\pi_g - K)$, and $\sigma = \frac{c}{\gamma(\pi_g - K)[F(s^*) - F(s^*|G)]} \left[\frac{(1 - \gamma)(1 - F(s^*))}{(1 - \gamma)(1 - F(s^*)) - \gamma(F(s^*) - F(s^*|G))} \right]$ where σ represents the manager's stock option with the exercise price X .

Let us compare the contract with stock options (Proposition 5) with the contract with restricted stock ownership (Proposition 3). First, as both contracts implement the first-best

optimum, they are not Pareto-comparable. In fact, it is a matter of simple calculation to show that the contract with stock options again leads to the sum of ex ante expected payoffs for the manager and the owner equal to the net value of information: $\tilde{U}_0 + \tilde{V}_0 = \mathcal{V} - c$. Second, note that the size of golden parachute is the same in both contracts. Moreover, it is easy to see that the ex post value of manager's stock ownership given by SV_3 is equal to the ex post value of manager's stock options given by $\sigma(V_3 - X)$. This again establishes the payoff-equivalence of the two contractual forms.

Proposition 6: The optimal contract with stock options and the optimal contract with restricted stock ownership are payoff-equivalent. That is, the distribution of managers' (owner's, resp.) ex post payoffs under the contract with stock options is the same as the distribution of managers' (owner's, resp.) ex post payoffs under the contract with restricted stock ownership.

As in contracts with restricted stock ownership, what matters in motivating managers is the value of stock options rather than the absolute size of options awarded. The value of stock options when they are exercised is equal to $\sigma(V_3 - X)$ which, as shown above, is equal to the value of stocks under the optimal contract with restricted stock ownership. Thus we are led to hypotheses regarding the value of stock options awarded to managers: the value of stock options awarded to managers is negatively related to the degree of information asymmetry, and positively related to the size of firm.

4. Summary and Discussions

This paper has studied an optimal contract for executives applying both complete and incomplete contracting approaches. In a complete contracting environment where contracts can be based on earnings, an optimal contract is shown to be a combination of base salary, golden parachute and bonus. In an incomplete contracting environment where earnings are not verifiable, two types of optimal contracts were derived: a contract with restricted stock ownership, and a contract with stock options. Three main conclusions could be drawn. First, various components comprising a compensation package are interdependent. Second, the size

of golden parachute is the same regardless of different contractual forms. Third and most importantly, these three types of optimal contracts are all payoff-equivalent in a strong sense: managers' ex ante and ex post payoffs are exactly the same under all three contracts.

At times, it has been discussed how the nature of contracts will change if there are possibilities of earnings manipulation by managers. The change, of course, will depend on the extent to which the information content of earnings report is reflected in stock prices. For example, if there is significant room for earnings manipulation and if markets do not take earnings information fully into account, then compensation based on stocks or stock options would be a better alternative than earnings-based bonus. The cost of using stock-based incentives is that of risk-bearing by managers when they are risk-averse. While we admit that earnings manipulation is not driven simply by managers' individual motives, such a possibility together with information content of earnings report do seem to be an important element to take into account when asking the question about the relevance of contractual forms.

Other elements that need mentioning are managers' risk aversion, concern for reputation, private benefits of control, and the complexity of corporate hierarchy where good performance is often the result of consonant efforts by all those involved including the whim of nature. Risk aversion alone has been shown not to be a good explanation for the use of different forms of contracts since all three types of optimal contracts derived in this paper are payoff-equivalent in a strong sense. The next two do not seem to cause significant changes to the main conclusion of this paper. For example, suppose the manager enjoys some private benefits of control when the project is undertaken under his tenure, which leaving managers at date 2 will lose. Such private benefits of control increase the incentives of managers to stay in the office by making, if necessary, untruthful report. All that is needed to defeat these incentives is to increase the size of severance payment. The simplest, albeit ad hoc, way of thinking about managers' concern for reputation would be similar to how private benefits of control are introduced - leaving managers at date 2 incur private costs from loss of reputation. This again makes the departure more costly than otherwise, necessitating larger severance compensation. Neither of these are likely to change the other components of contracts.⁽²⁰⁾

⁽²⁰⁾ For example, consider a modification to the model in section 2 that the managers under whom the project is undertaken enjoy some private benefits equal to ϕ . It can be shown that, at an optimal contract, only t_3^* (as well as P) changes to $\phi + \frac{c}{F(s^*) - F(s^*|G)}$. Therefore the irrelevance result of the paper remains intact. If

The complexity of corporate hierarchy does seem to be an important element that could bring about changes to the irrelevance result of this paper. Two of the most important roles executives of corporation are expected to play are setting directions - which was the main focus of this paper - and supervising employees on behalf of shareholders, the latter including the design of employment contracts for, and monitoring of employees. The more complex corporate hierarchy becomes, the more onerous it is to perform the second role, and the more difficult it gets to predict performance. Again, risk aversion may then be an important factor to consider, which may call for the need to protect executives from risk and to motivate them to specialize in the role of direction setting while delegating supervisory role down the corporate hierarchy. In this case, compensation based on stock options could be a more attractive alternative than that based on stocks or earnings information.

Appendix

Proof of Lemma 2: The first-order condition for s^* being the global maximizer of $U(s) \equiv \int_s^{s_2} f(x)[p(x)t_1 + (1-p(x))t_2]dx + \int_{s_1}^s t_3 f(x)dx - c$ is $U'(s) = -t_1\gamma f(s^*|G) - t_2(1-\gamma) f(s^*|B) + t_3 f(s^*) = 0$, or $t_3 = \frac{\gamma f(s^*|G)}{f(s^*)}t_1 + \frac{(1-\gamma)f(s^*|B)}{f(s^*)}t_2 = \gamma t_1 + (1-\gamma)t_2$ where the second equality follows from $f(s^*) = f(s^*|G) = f(s^*|B)$. Given $t_3 = \gamma t_1 + (1-\gamma)t_2$, the second derivative of the objective function becomes

$$\begin{aligned} U''(s) &= -t_1\gamma f'(s|G) - t_2(1-\gamma)f'(s|B) + t_3 f'(s) \\ &= -t_1\gamma f'(s|G) - t_2(1-\gamma)f'(s|B) + [\gamma t_1 + (1-\gamma)t_2]f'(s) \\ &= \gamma t_1[f'(s) - f'(s|G)] + (1-\gamma)t_2[f'(s) - f'(s|B)] \\ &= \gamma(1-\gamma)(t_1 - t_2)[f'(s|B) - f'(s|G)]. \end{aligned}$$

By assumption 2, the above derivative is strictly negative if and only if $t_1 > t_2$. Thus any contract satisfying $t_3 = \gamma t_1 + (1-\gamma)t_2$ and $t_1 > t_2$ defines the manager's project choice decision a strictly concave problem, hence (IC-iii) is equivalent to $t_1 > t_2$ and the first-order condition given by $t_3 = \gamma t_1 + (1-\gamma)t_2$. ■

ϕ is positively related to the size of firm, as Demsetz (1997, p. 112) argues it is, then the comparative statics results for golden parachute with respect to size will be more strengthened.

Proof of Lemma 3: The proof is by contradiction. Suppose (B_0, P, S) implements the first-best optimum, hence incentive compatible. Then the value of project evolves to V_2 and V_3 . Consider interim incentive compatibility constraints. Managers with types $s < s^*$ face three options: report their types truthfully and receive $P + B_0$; report $s' \geq s^*$ and trade their shares at date 2, receiving $SV_2 + B_0$; report $s' \geq s^*$ and trade their shares at date 3, receiving $Sp(s)V_3 + B_0$. Note that selling a fraction of S at date 2 and the rest at date 3 is dominated by either of the second or third options. Thus interim incentive compatibility for managers with types $s < s^*$ can be written as

$$P + B_0 \geq \max \{SV_2 + B_0, Sp(s)V_3 + B_0 : s < s^*\} = SV_2 + B_0$$

where the second equality is from $V_2 = \left(\frac{1-F(s^*|G)}{1-F(s^*)}\right)\gamma V_3 > \gamma V_3 > p(s)V_3$ for all $s < s^*$. Therefore we have $P \geq SV_2$.

Managers with types $s \geq s^*$ also face three options: report $s' < s^*$ and receive $P + B_0$; report their types truthfully and trade their shares at date 2, receiving $SV_2 + B_0$; report their types truthfully and trade their shares at date 3, receiving $Sp(s)V_3 + B_0$. Again it is not necessary to consider fractional share trade. Thus interim incentive compatibility for managers with types $s \geq s^*$ can be written as

$$P + B_0 \leq \min \{SV_2 + B_0, Sp(s)V_3 + B_0 : s \geq s^*\} = S\gamma V_3 + B_0$$

leading to $P \leq S\gamma V_3$. But $V_2 > \gamma V_3$ implying that there does not exist a contract which satisfies interim incentive compatibility constraints for all types of managers. ■

Proof of Lemma 4: The proof is by contradiction. Suppose (B_0, P, S) implements the first-best optimum, hence incentive compatible. Then the value of project is revised at date 2 as V_2 . Thus if the manager learns and truthfully reports his type, his ex ante expected payoff is given by $U_0 \equiv SV_2[1 - F(s^*)] + PF(s^*) + B_0 - c$. For ex ante incentive compatibility to be satisfied, U_0 should not be smaller than $P + B_0$, the expected payoff from not learning his type and reporting $s < s^*$, and $SV_2 + B_0$, the expected payoff from not learning his type and reporting $s \geq s^*$. Consider now interim incentive compatibility: managers with type

$s < s^*$ should not have incentives to report $s' \geq s^*$; managers with type $s \geq s^*$ should not have incentives to report $s' < s^*$. It is easy to see that interim incentive compatibility boils down to $SV_2 + B_0 = P + B_0$, which leads to the violation of ex ante incentive compatibility constraints. ■

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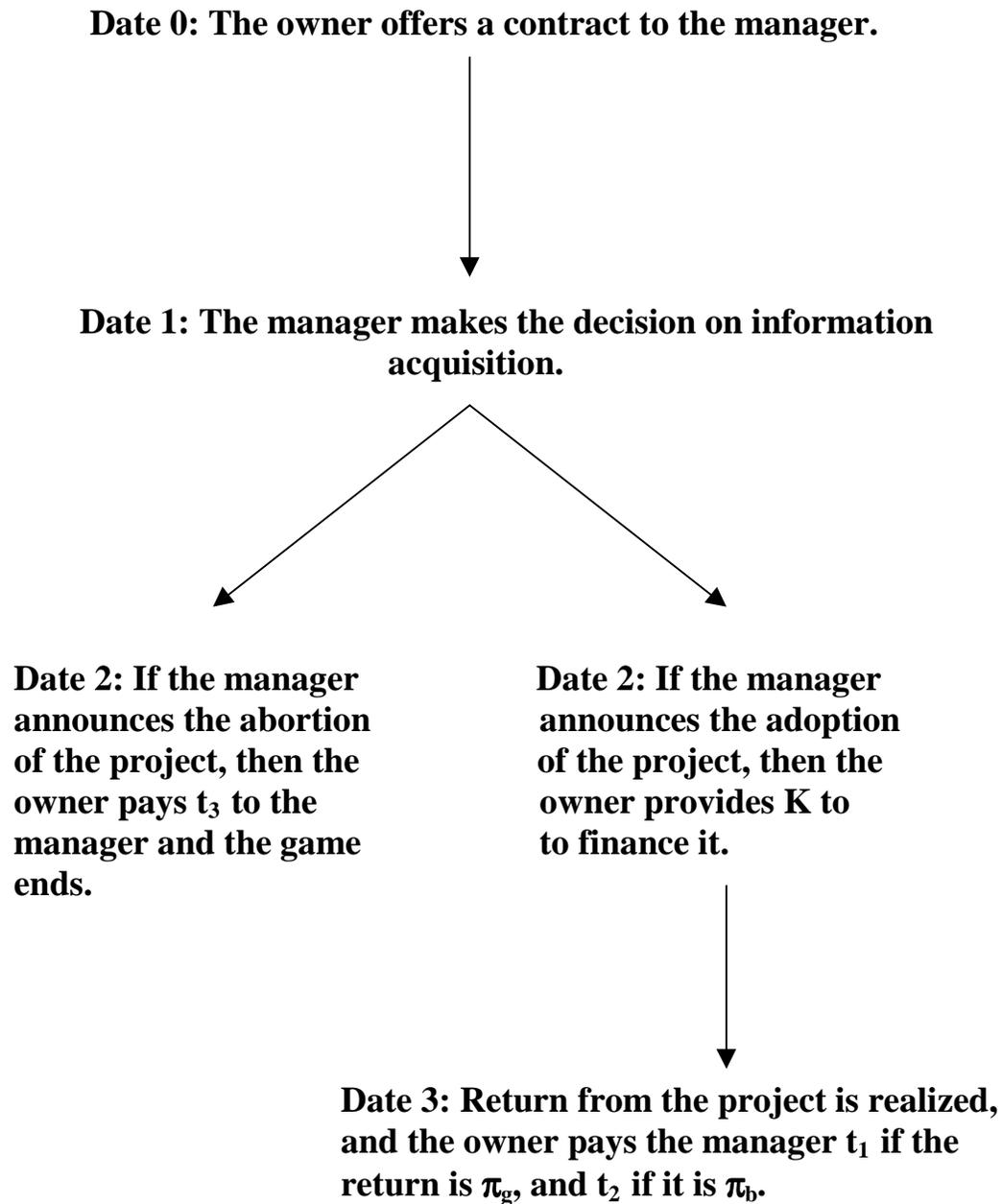


Figure 1: Time Line and the Description of Contract