Optimal Compensation for Risk-Averse Executives with Career Concerns

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Abstract

This paper studies the problem of optimally compensating a risk-averse, career conscious manager who sets the investment strategy of a firm based on private information he possesses about project payoffs. Consistent with the marketplace, we focus on contracts that include cash, shares, and call options. We find that the optimal compensation contract consists of mostly cash, supplemented by a small amount of call options; shares are excluded. Furthermore, the options are struck at-the-money, consistent with the near uniform practice followed by compensation committees. The convexity of the option's payoff helps to overcome managerial risk aversion, though an optimal contract leaves the manager too conservative. The size of the optimal option grant is an increasing function of the manager's career concerns and project quality and a decreasing function of the manager's reservation utility. We also estimate the pay-for-performance sensitivities of second best contracts and find results consistent with earlier empirical work.

JEL Classification: G31, G34, J33, L22.

1. Introduction

The investment preferences of executives and shareholders may differ when corporate ownership and control are separated.[1] This conflict of interest is exacerbated if executives and shareholders have different risk tolerances, or if executives worry about their reputations or careers. Lacking the means to diversify their firm-specific human capital, managers show great aversion to firm-specific risk, while well diversified outside investors show little or no concern for it. Career concerns augment managerial risk aversion, prompting managers to eschew certain risky projects shareholders want them to pursue.[2] In this paper, we study how executive compensation can be structured to overcome these problems.

We model the compensation decision as an optimal contracting problem. We show that when risk-neutral investors hire a risk-averse manager with career concerns, a first-best contract fully insures the manager's reputation risk. However, such a contract is not incentive compatible. The second best contract pays the manager predominantly in cash, supplemented by a small amount of *at-the-money* call options on the firm's equity; shares are excluded. The convexity of the options' payoff helps to overcome managerial risk aversion, though a second best contract leaves the manager more conservative than shareholders prefer.

There is an established literature that examines how a manager chooses among mutually exclusive investment alternatives, based on the incentives provided by his compensation. Lambert (1986) studies executives who must expend effort to generate information about the profitability of projects. Managers and shareholders do not always agree which projects are best. This conflict of

1 See Jensen & Meckling (1976) and Fama (1980), among others.

2 Earlier papers that consider managerial career concerns as a source of agency conflict include Harris and Holmstrom (1982) and Holmstrom and Ricart I Costa (1986). In contrast, Gibbons and Murphy (1992) study career concerns that *help*

interest can lead (from the shareholders' perspective) to either under-investment or over-investment in risky projects. In contrast, Holmstrom and Ricart I Costa (1986) model the agency problem between managers and their superiors as stemming from managers' career concerns. Their main objective is to explain capital rationing for junior managers. They show that a junior manager is best compensated with a "downward rigid" wage, equivalent to a fixed salary plus a call option on the manager's human capital.

In practice, companies pay executives a mix of cash, shares, and call options on the firm's shares. The convexity of call option payoffs may encourage risk-averse managers to invest appropriately, if the option grant size and strike price are carefully chosen. Thus, Hall and Murphy (2000) and Nohel and Todd (2001) examine the incentive effects of various option strike price policies, assuming managers are paid in cash, shares, and options. Hall and Murphy (2000) show that managerial incentives to increase share prices are maximized by setting executives' option strike prices "within a range that typically includes the grant-date market price." In contrast, Nohel and Todd (2001) show that in-, at-, or out-of-the-money options can align incentives, provided the proportion of option and share-based pay is small. Both Hall and Murphy (2000) and Nohel and Todd (2001) assume that companies develop executive compensation plans by first fixing the dollar cost of the award, and then determining the specific mix of pay, an approach taken by firms in the marketplace (see Morgenson, 2000; and Hall, 1998).

In this paper, we derive the optimal mix of pay, including the optimal strike price policy, for a risk-averse manager with career concerns. We solve for the optimal compensation contract in an environment where awards are restricted to non-negative amounts of cash, shares, and call options, though we place no restrictions on option strike prices. Our model incorporates elements from each

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to align the incentives of shareholders and managers. A conflict of interest between managers and investors can also arise of the papers cited above. Like Lambert (1986), we assume the manager chooses between a safe and a risky project based on private information he possesses about project payoffs. In the spirit of Holmstrom and Ricart i Costa (1986), we assume the agency problem between managers and shareholders stems from managers' career concerns. Like Hall and Murphy (2000) and Nohel and Todd (2001), we examine the incentive properties of various strike price policies. However, we do so in an optimal contracting setting, where firm value is linked to managerial behavior.

Our model generates several interesting results. We find that the optimal strike price policy is to strike the manager's options *at-the-money*. This result gives a theoretical foundation for the near uniform practice of granting executives at-the-money stock options (see Murphy, 1998; Bryan, Hwang, and Lilien, 2000; and Perry and Zenner, 2001).

The optimal contracts that we derive pay the manager predominantly in cash, supplemented by a small amount of call options; shares are excluded. The convexity of the option's payoff helps to overcome managerial risk aversion, but the second best contract leaves the manager more conservative than shareholders prefer, resulting in potentially significant losses for shareholders.

We find that the size of the optimal option grant is an increasing function of project quality. This is consistent with Core, Holthausen, and Larcker (1999) who find a positive relation between the value of a manager's incentive compensation and a firm's investment opportunities. It also complements Bernardo, Cai, and Luo (2001). Furthermore, we find that the size of the optimal option grant is an increasing function of the manager's career concerns, consistent with Kole (1997), who finds a positive relation between the value of a manager's incentive compensation and his firm's agency costs. Finally, we find that the size of the optimal option grant is a decreasing function of the manager's reservation utility.

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when managers are effort-averse and risk-averse, see Lambert (1986).

We estimate the pay-for-performance sensitivities (PFP) of our second best contracts. We find that PFP is small, similar in magnitude to the PFP estimates of Jensen and Murphy (1990a,b). Moreover, PFP is an increasing function of project quality and an increasing function of a manager's career concerns.

The remainder of this paper is organized as follows. We develop an optimal contracting model of executive compensation in Section 2. We present numerical solutions of our model in section 3 and analyze pay-for-performance in Section 4. Section 5 concludes.

2. A Model of Executive Compensation

2.1 *Set-up and Information Structure of the Model*

Consider a firm with I dollars in cash on its balance sheet at t = 0. The firm's investment opportunity set consists of two mutually exclusive projects. Each project requires an initial investment of I. One project is riskless and generates a zero return. The other project is risky and generates a payoff that is uniformly distributed on the interval, $[V_L, V_H]$, with $V_H \geq I \geq V_L$. V_L is known, but V_H is uniformly distributed on the interval, $[V_{H1}, V_{H2}]$. Finally, we assume the relationship among V_L, I, V_{H1}, and V_{H2} are such that $I = (V_L + (V_{H1} + V_{H2})/2)/2$.[3]

Our model has three types of participants, investors, a manager, and an intermediary. The investors put their capital at risk in the firm. They hire a manager to make the firm's investment decisions, and they select an intermediary to design the manager's compensation contract. Think of this intermediary as either a compensation consultant, or as the firm's board of directors. We assume the compensation designer acts in the interest of shareholders, and is otherwise passive.

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3 This means that, ex-ante, both the riskless and the risky projects have zero NPV. This assumption is not critical, but it simplifies the analysis.

At t = 0, investors know that the firm has I in cash on its balance sheet. Furthermore, investors are aware of the firm's investment opportunities (that have zero NPV), and they select a compensation designer (elect a board of directors) to hire a manager. At t = 0+, the manager is hired and the particulars of his contract are set. At t = 1, the manager receives a signal that identifies V_H.[4] Based on this signal, the manager chooses between the firm's two investment opportunities. The signal is never revealed and thus cannot be contracted on. The outcome of the investment decision is realized at t = 2 and the firm is liquidated at t = 3.

The investors and the manager differ in their appetites for risk. We assume investors are risk-neutral and the manager is risk-averse in wealth. This assumption is consistent with the idea that investors can easily diversify their portfolios, but the manager has undiversifiable firm-specific human capital tied to the firm that employs him. The manager derives his wealth from two sources: his compensation and the value of his reputation.

The manager's compensation consists of a cash payment, k, n shares, m options with an exercise price of X, and a state contingent bonus, B. Here n and m represent fractions of the firm's outstanding shares. We restrict n, m, and k, to be non-negative. Cash, shares, and options are paid to the manager at t = 0+, with shares and options vesting at t = 2.[5] The manager's bonus is linear in earnings (share price) and is paid to the manager at t = 3.

We assume the value of the manager's reputation is perfectly correlated with the firm's share price. Mathematically, we express the value of the manager's reputation as proportional to the change

4 The distribution of project outcomes and the information structure of our model are similar to Ross (1977). Note also that our model can easily be generalized so that the manager's choice is between two risky projects.

5 It is crucial that the options not vest immediately; otherwise the manager could sell his shares and/or options and undo all the incentives. We assume that there is no risk of the firm not having sufficient assets on hand to pay the manager's salary and bonus. This is reasonable as long as the manager's cash salary and bonus are less than V_L. Under these conditions, the firm could risklessly borrow funds to pay the manager's salary.

in firm value from the time when the manager is hired, t=0+, to the time when the firm is liquidated, t=3, i.e., $\alpha(V - V_{0+})$. In this expression, α is a non-negative constant, V is the firm's liquidation value, and V_{0+} is the value of the firm immediately after the manager is hired. The value of the manager's reputation represents the present value of all future gains (losses) that the manager receives due to his rising (falling) reputation.

Since the reputation effect is perfectly correlated with the firm's publicly observable stock price, the manager can quit his firm and capture the benefits of his reputation at another firm. If he quits before period 2, he loses his shares and options. However, in period 2, the manager's shares and options no longer provide an incentive for the manager to stay with the firm. At that point, the manager need only fear losing his bonus by changing jobs. Thus, as long as $\alpha > 0$, the first best contract is unattainable.

The manager's preferences on wealth are characterized by a utility function exhibiting constant relative risk aversion (CRRA) of the form:[6]

$$U(w) = \frac{1}{1-b} w^{(1-b)}, \; b \geq 0, \; b \neq 1 \tag{1}$$

Where w is the level of the manager's wealth (compensation value + reputation value). We assume that the manager maximizes the expected utility of the sum of his compensation and the impact on his reputation.

We now summarize the information structure and sequence of events. At time 0, investors know that the firm has cash worth I on its balance sheet and they are aware that the firm's investment opportunities consist of a risky and a riskless project. Investors select a compensation designer (elect

6 Our specification of the manager's utility function follows Lambert, Larcker, and Verrechia (1991) and Hall and Murphy (2000).

a board of directors) and the designer is told to hire a manager to determine the firm's investment strategy. At t = 0+, the designer hires the manager and announces the hiring of the manager, the nature of his contract, and the nature of the firm's investment opportunities under the manager's control. At time 1, the manager generates his signal, makes his investment decision, and announces it. At time 2, the outcome of the manager's investment choice is realized and the manager's shares and options vest. Finally, at time 3, the manager receives his bonus (if he is still employed by the firm) and the firm is liquidated, with the proceeds distributed to shareholders.[7] Below is a time line specifying critical events in our model:

Investors choose compensation designer	*Designer hires mgr., reveals contract & inv. opps*	*Manager gets private signal and invests*	*Project payoffs determined, shares & options vest*	*Bonus paid, firm liquidated*
t = 0	**t = 0+**	**t = 1**	**t = 2**	**t = 3**

Investors are rational so the firm's share price changes as new information is released. Starting at an initial value of I (at time 0), the firm's share value adjusts sequentially to reflect information about the hiring of the manager (time 0+), the manager's investment decision (time 1), and the final project outcome (time 2). The price adjustment from time 0 to time 0+ reflects investors' valuation of the marginal benefit (cost) of hiring the manager, consistent with investor reactions to awards of incentive pay, as in Defusco, Johnson, and Zorn (1990) and Yermack (1997).[8]

In our model, the manager sets the investment strategy for the firm based on information that investors are not privy to. Given that the manager is risk-averse and the value of his reputation is linear in firm value, the manager's indirect utility is *concave* in firm value, as long as his compensation

7 Note that it is the sequence of these events, rather than the length of the periods that is important. Moreover, the periods need not be of equal length.

8 Note that if the manager is able to capture the entire surplus that he creates then there would be no reaction when the manager is hired.

is also linear in firm value. In contrast, risk-neutral investors' indirect utility is *linear* in firm value. Thus, there is a conflict of interest between the manager and investors over the choice of investment strategy: the manager eschews certain risky projects that shareholders want him to take. This divergence of incentives relies critically on our assumptions that the manager cares about his reputation (career concerns) and is more risk-averse than investors.[9] Absent the manager's career concerns, shareholders need only compensate the manager in cash and ask the manager to follow their preferred investment strategy. In such a case, the manager has no qualms about following shareholders' preferred strategy, since his utility does not depend on the strategy chosen.

What is the investment strategy preferred by shareholders? To answer this question, we need to know how firm value varies with investment strategy. Under investment strategy, [$\tilde{V}_H$], where $V_{H2} \geq \tilde{V}_H \geq V_{H1}$, the manager chooses the risky project whenever he observes a signal $V_H \geq \tilde{V}_H$; otherwise he invests in the riskless project. Thus, when the manager follows the investment strategy, [$\tilde{V}_H$], he chooses the risky project with probability $(V_{H2}-\tilde{V}_H)/(V_{H2}-V_{H1})$, and he chooses the riskless project with probability $1-\frac{V_{H2}-\tilde{V}_H}{V_{H2}-V_{H1}}=\frac{\tilde{V}_H-V_{H1}}{V_{H2}-V_{H1}}$. Recall that the riskless project has zero NPV. In contrast, the risky project has NPV given by: NPV = $[(V_{H2}+\tilde{V}_H)/2 + V_L]/2 - I$. Therefore, if the manager follows investment strategy, [$\tilde{V}_H$], the value of the firm's equity after the manager is hired, V_{0+}, as a function of the manager's investment strategy, [$\tilde{V}_H$], is given by:

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9 An alternative approach would be to assume a disutility of effort on the part of the manager, as in Lambert (1986). However, Kaplan (1984) argues that effort-based models are highly inadequate for capturing the incentive issues that management faces.

$$V_{0+}(\tilde{V}_H) = I + \frac{(V_{H2} - \tilde{V}_H)}{(V_{H2} - V_{H1})}\left(\frac{\frac{V_{H2} + \tilde{V}_H}{2} + V_L}{2} - I\right) \qquad (2)$$

Note that equation (2) ignores the cost of the manager's compensation.

Risk-neutral shareholders strictly prefer the risky project as long as it offers an expected return that exceeds the risk-free rate of zero. This implies that their preferred investment strategy is given by [$\tilde{V}_H = \hat{V}_H$], where $\hat{V}_H = 2I - V_L$.

However, if the manager is risk-averse and has career concerns, he will ignore investors' preferences on investment strategy and maximize his own utility. Herein lies the agency problem. Compensate the manager in cash and he is too conservative, because a risky project entails reputation risk without sufficient reward in some states. Substituting shares for cash makes matters worse. In fact, in our model, the reputation effect is equivalent to forcing the manager to hold some shares. Thus, the combination of the manager's risk aversion and career concerns pushes him to follow an overly conservative investment strategy, [$\tilde{V}_H > \hat{V}_H$], if his compensation is linear in firm value. The compensation designer's problem is then to overcome the manager's excessive conservatism in the most cost-efficient way.

2.2 *The Shareholder's Optimization Problem*

The shareholders' optimization problem is to choose the manager's compensation award and the investment rule (implicitly or explicitly) that maximizes firm value net of compensation costs. The ex-ante cost of the manager's compensation is given by:

$$Cost(m, X, n, k, B, \tilde{V}_H) = nV_{0+}(\tilde{V}_H) + mC_{0+}(\tilde{V}_H) + k + B_{0+}(\tilde{V}_H) \quad (3)$$

Where $V_{0+}(\tilde{V}_H)$ is as given in Equation (2), $C_{0+}(\tilde{V}_H)$ is the ex-ante value of the manager's call options, and $B_{0+}(\tilde{V}_H)$ is the ex-ante value of the manager's state-contingent bonus. Additionally, the contract offered to the manager must be individually rational and incentive compatible. Therefore, shareholders solve the following maximization problem:

$$\underset{\tilde{V}_H, m, X, n, k, B}{Max} \left(V_{0+}(\tilde{V}_H) - Cost(m, X, n, k, B, \tilde{V}_H)\right)$$

$$\begin{aligned}
Subject\ to: &\ i)\ EU(m, X, n, k, B, \tilde{V}_H) \geq \overline{U} && (P) \\
&\ ii)\ EU(w(V_H) \mid V_H,\ g = 1) \geq EU(w(V_H) \mid V_H,\ g = 0), V_H \geq \tilde{V}_H && (IC1) \\
&\quad\ \ EU(w(V_H) \mid V_H,\ g = 0) \geq EU(w(V_H) \mid V_H,\ g = 1), V_H \leq \tilde{V}_H && \\
&\ iii)\ B(V) \geq 0\ \ \forall V \in [V_L, V_H] && (IC2)
\end{aligned} \quad (4)$$

Where EU(m, X, n, k, $\tilde{V}_H$, B) is the manager's expected utility of the sum of the value of his compensation and the value of his reputation, U(.) is the utility function given in (1), and Cost (m, X, n, k, $\tilde{V}_H$, B) is the ex-ante cost of the manager's compensation, as defined in (3). The expectation, EU(m, X, n, k, $\tilde{V}_H$, B), is taken over all possible signals, V_H, and all possible liquidation values, V. The symbol γ represents the manager's investment decision, with $\gamma = 0$ corresponding to an investment in the riskless project and $\gamma = 1$ corresponding to an investment in the risky project. $EU(w(V_H) \mid V_H, \gamma = 1)$ is the manager's expected utility of wealth from investing in the risky project, given that he has observed the signal, V_H, and $EU(w(V_H) \mid V_H, \gamma = 0)$ is the manager's expected utility of wealth from investing in the riskless project, given that he has observed the signal, V_H (arguments other than the value of the manager's signal, V_H, have been suppressed). Both of these expected utilities are computed for a fixed compensation award of n shares, m options at strike price of X, k in cash, and a bonus of B, and are taken over all possible liquidation values of the firm. Note that (P) is an ex-ante constraint, while IC1 solves for an investment strategy, assuming a private signal has already been observed.

2.3 The First-Best Contract

A first-best solution to the contracting problem posed in (4) satisfies the participation constraint but ignores the incentive compatibility constraints. It solves:

$$\underset{\tilde{V}_H, m, X, n, k, B}{Max} \left(V_{0+}(\tilde{V}_H) - Cost(m, X, n, k, B, \tilde{V}_H) \right)$$

$$Subject\ to: \quad i)\ EU(m, X, n, k, B, \tilde{V}_H) \geq \overline{U} \qquad (P) \tag{4a}$$

Where all variables and functions are as defined in (4).

Recall that we are assuming that shareholders are risk-neutral and the manager is risk-averse. This implies that any component of the manager's compensation that has stochastic payoffs, such as shares, options, or a bonus, will be valued more highly by shareholders than by the manager. Therefore, cash is the cheapest form of compensation from shareholders' point of view. Furthermore, it is clear that a first-best contract will offer the manager full reputation insurance by having risk-neutral shareholders bear all of the manager's reputation risk. This insurance uses the state contingent bonus to engineer a short forward contract on the manager's reputation, perfectly hedging the manager's reputation risk. Naturally, as with any forward contract, the bonus will have zero cost ex-ante. These observations lead us to Proposition 1 that deals with a first-best contract.

Proposition 1: A first-best contract pays the manager a fixed cash wage, $U^{-1}(\overline{U})$, and a bonus, $B(\tilde{V}_H) = -a(V - V_{0+}(\tilde{V}_H))$, that exactly offsets the impact of a change in his reputation. Moreover, the manager will be asked to follow the investment strategy, $[\tilde{V}_H = \hat{V}_H]$.

Proof: *Based on the discussion above, the cheapest way of meeting the manager's expected utility is to pay the manager entirely in cash. Additionally, shareholders will choose to insure the manager's reputation risk. This is accomplished by paying the manager a state contingent bonus that exactly offsets any change in the value of his reputation. This is analogous to a short forward contract on the manager's reputation. Finally, we know that the investment strategy,* $[\hat{V}_H]$, *is the policy that maximizes ex-ante share value. QED.*

Under the first-best contract, the manager is indifferent among all investment strategies, since he receives a fixed salary that is unaffected by investment outcomes and his reputation is fully insured. In particular, he should be happy to implement $[\tilde{V}_H = \hat{V}_H]$. Clearly, the first-best contract will not obtain once incentives are factored in. Fully insuring the manager's reputation will involve making a compensating payment to the manager when his reputation falls and asking the manager to return money to shareholders when his reputation improves. Obviously, the manager will never choose to return money to the firm, when he can pick up and leave in period 2 and capture the value of his reputation elsewhere. What then will be the nature of the second-best contract?

2.4 The Second-Best Contract

The first-best contract pays the manager a cash salary and a bonus that insures the manager's reputation risk; no shares or options are included. However, in practice, we see executive pay in the form of cash, shares, and call options on the firms shares.[10] Our goal is to establish the optimal policy for choosing the proportions of cash, share, and option pay, as well as the optimal choice of strike price, X, in the presence of agency costs.

What will the manager's participation constraint look like if his compensation contains non-cash elements with contingent payoffs? The constraint requires that the manager earn an expected utility of $\overline{U}$. If the manager receives n shares, m options with exercise price of X and k in cash (with bonus B = 0), and follows investment strategy, [$\tilde{V}_H$], his ex-ante expected utility of wealth is given by:

$$EU(m,X,n,k,\tilde{V}_H) = \frac{1}{(1-b)(V_{H2}-V_{H1})}\left(\int_{V_{H1}}^{\tilde{V}_H}(nI + mMax(0,I-X) + k + a(I - V_{0+}(\tilde{V}_H))^{(1-b)})dV + \right.$$
$$\left.\int_{\tilde{V}_H}^{V_{H2}}\left(\frac{1}{(V_H - V_L)}\right)\left[\int_{V_L}^{V_H}(nV + mMax(0,V-X) + k + a(V - V_{0+}(\tilde{V}_H))^{(1-b)})dV\right]dV_H\right), b \neq 1$$

(5)

Where the first integral represents the manager's expected payoff from the riskless project and the second set of integrals represent the manager's expected payoff from the risky project, under investment strategy, $\tilde{V}_H$. The term, $\alpha(I\text{-}V_{0+}(\tilde{V}_H))$, represents the effect on the manager's reputation if he takes the riskless project and the term, $\alpha(V\text{-}V_{0+}(\tilde{V}_H))$, represents the effect on the manager's reputation if he takes the risky project. The manager's participation constraint, (P),

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10 In practice, we also see bonuses paid based on earnings or other measures of cash flow. However, given that, in our model, cash flows are perfectly reflected in share (and option) prices, such a bonus would be redundant here.

requires that the value of (4) equal or exceed $\overline{U}$. We now consider the *incentives* provided by the manager's compensation contract.

Of paramount interest to shareholders is how the manager's compensation affects his incentives to choose projects. A contract is incentive compatible if the manager is asked (chooses) to invest in the risky project when it offers him greater expected utility than the utility he earns from the risk-free project and vice-versa. More precisely, the manager's utility if he takes the riskless project, given the signal, V_H, is:

$$U(m,X,n,k) = \frac{1}{1-b}[nI + mMax(0,I-X) + a(I-V_{0+}) + k]^{1-b}, \ b \neq 1 \tag{6}$$

The utility he expects from the risky project, given the signal V_H, is:

$$E[U(m,X,n,k,V_H)] = \frac{1}{1-b}\left(\frac{1}{(V_H - V_L)}\right)\left(\int_{V_L}^{Min(X,V_H)} (nV + K + a(V-V_{0+}))^{(1-b)} dV + \right.$$
$$\left.\int_{Min(X,V_H)}^{V_H} (nV + m(V-X) + K + a(V-V_{0+}))^{(1-b)} dV\right), b \neq 1 \tag{7}$$

The manager's investment decision rule [$\tilde{V}_H$] will be considered incentive compatible if and only if it satisfies [$\tilde{V}_H = V_H^*$], where V_H^* solves the following:

$$1 = \frac{(nI + mMax(0,I-X) + a(I-V_{0+}) + k)^{b-1}}{(V_H^* - V_L)(2-b)}\left[\frac{1}{n+a}(((n+a)Min(X,V_H^*) + k - aV_{0+})^{2-b}\right.$$
$$-((n+a)V_L + k - aV_{0+})^{2-b}) + \frac{1}{n+m+a}(((nV_H^* + m(V_H^* - X) + a(V_H^* - V_{0+}) + k)^{2-b}$$
$$\left.-((n+a)Min(X,V_H^*) + m(Min(X,V_H^*) - X) + k - aV_{0+})^{2-b}\right] \tag{8}$$

Equation (8) is derived by setting equation (6) equal to equation (7), solving the integrals, and rearranging terms. V_H^* is the signal that renders the manager indifferent between the riskless and risky projects.

Now we are able to state the maximization problem that solves for the second-best solution to the problem of optimally compensating the manager. The shareholders' optimization problem is to choose the manager's compensation package and the investment rule (implicitly or explicitly) that maximizes firm value net of the cost of compensating the manager subject to the participation constraint (P) and the incentive compatibility constraints (IC1) and (IC2):

$$\underset{V_H^*, m, X, n, k, B}{Max} \left(V_{0+}(V_H^*) - Cost(m, X, n, k, B, V_H^*) \right)$$

$$\begin{aligned}
&Subject\, to: \; i) \;\; EU(m, X, n, k, B, V_H^*) \geq \overline{U} && (P) \\
&\qquad\qquad\quad where\, V_H^* \; satisfies\, (8) && \\
&\qquad\qquad ii) \; The\, manager\, follows\, investment && \\
&\qquad\qquad\quad strategy[\tilde{V}_H = V_H^*], V_H^* \; satisfies\, (8) && (IC1) \\
&\qquad\qquad iii) \; B(V) \geq 0 \;\; \forall V \in [V_L, V_H] && (IC2)
\end{aligned} \qquad (9)$$

where EU(m, X, n, k, B, V_H^*) is the manager's expected utility given by (5).

The constrained non-linear optimization problem in (9) is quite complex, making an analytical solution intractable. Therefore, in Section 3, we present numerical solutions for specific sets of parameter values that are consistent with the marketplace.

3. Estimation and Properties of 2^{nd} Best Solutions

In this section, we solve the optimal contracting problem presented in (9) for several sets of parameters that we believe are consistent with the marketplace. Our solution algorithm is based on the generalized reduced gradient (GRG2) non-linear optimization method developed in Lasdon and Smith (1992).

We assume a manager's coefficient of relative risk aversion, b = 3, consistent with studies by Friend and Blume (1975), Litzenberger and Ronn (1986), Lambert, Larcker and Verrechia (1991) and Hall and Murphy (2000). For convenience, we set the investment amount, I = $100, and consider three levels of managerial reservation utility: U($1 cash), U($3 cash), and U($5 cash). We can think of these as representing a variety of ways of dividing the surplus created by the manager. These reservation utility levels, representing between 1% and 5% of the firm's value at time zero, are also consistent with the value of compensation awards paid in aggregate to managers with investment decision responsibilities at U.S. firms. As reported in the Economist (1999), during the year through June 1998, the 200 largest American companies granted employees shares and options amounting to 2% of their outstanding equity.

We consider three risky investments: a low-risk project with a volatility of 14.4% of invested capital, a medium risk project with a volatility of 28.9% of invested capital, and a high-risk project with a volatility of 43.3% of invested capital. These projects have net present values equal to 3.125%, 6.25%, and 9.375% of invested capital, respectively. We believe these projects are representative of the projects available to typical U.S. firms. In particular, Dimson and Marsh (2001) estimate a geometric equity risk premium of 6.2% for U.S. firms for the period 1955- 1999.

Tables 1 – 3 summarize the second-best solutions to (8). In Table 1, reservation utility is $\overline{U}$ = U($1.00 cash); in Table 2, reservation utility is $\overline{U}$ = U($3.00 cash); in Table 3, reservation utility is $\overline{U}$ = U($5.00 cash). The tables report the range of risky project cash flows (V_L, V_{H1}, V_{H2}), the manager's reputation parameter, α, the optimal option grant size, m (as a fraction of the firm's outstanding shares), the optimal option strike price, the manager's investment strategy, [V_H^*], total compensation cost, and the value of the firm net of compensation costs.

Several observations merit discussion. First, in all of the second best solutions, X = I = $100. In other words, the options are struck "at-the-money", since the firm's share price equals $100 before the manager is hired. This result is consistent with the marketplace and may explain the near uniform practice of striking executive stock options at-the-money.[11] In a setting similar to ours, Nohel and Todd (2001) show that risk-taking incentives are strongest when options are struck at-the-money. Similarly here, at-the-money options are the most efficient means of overcoming managerial risk-aversion.

Second, the size of the optimal option grant is an increasing function of the project's quality (as measured by NPV) and risk. For example, for the upper utility level (Table 3), when alpha = .02, as we move from the low to the medium to the high risk/quality project, m increases from 0.43% to 1.09% to 2.18%. This is consistent with empirical studies that find a positive relation between the value of executive incentive compensation awards and a firm's investment opportunities (e.g., Core, Holthausen and Larcker, 1999). It is also consistent with Bernardo, Cai, and Luo (2001) who find that managers of higher quality projects require more incentive pay.

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11 It is well documented that more than 95% of all executive stock options are awarded at-the-money (see Murphy, 1998; and Bryan, Hwang and Lilien, 2000).

Third, all of the second-best solutions involve under-investment. For example, for the low risk/quality project, shareholders want the manager to follow the investment strategy, [$\tilde{V}_H = \hat{V}_H$ = 125], but the manager sets his cutoff too high, from 125.09 (Table 3) to 134.15 (Table 1). Intuitively, incentive pay is less valuable to risk- averse managers than to risk neutral investors. Thus, inducing a first-best level of investment is costly. The tradeoff between the increased cost of incentive pay and the benefit of greater risk-taking is resolved at a point that leaves the manager too conservative, resulting in losses for shareholders.

Setting [$\tilde{V}_H$ = 125.09] results in a loss of 0.006%, while setting [$\tilde{V}_H$ = 134.15] results in a loss of 2.554% of invested capital, relative to firm value under the first-best. Alternatively, when the manager follows the investment strategy, [$\tilde{V}_H$ = 134.15], he is setting the hurdle rate at 4.575%, rather than the first-best level of zero.[12] This hurdle rate differential is an order of magnitude larger than the typical increase in hurdle rates due to shareholder-bondholder conflicts reported in Parrino and Weisbach (1999).

Fourth, the size of the optimal option grant is an increasing function of the manager's career concerns. For example, for the middle utility level (table 2) and the medium risk project, as α increases from .02 to .03, m increases from 2.71% to 6.14%. This is consistent with Kole (1997) who finds a positive relation between the value of a manager's incentive compensation and the magnitude of his firm's agency costs. As α rises, career concerns induce greater risk avoidance on the part of the manager. This implies that he will require additional incentive pay to overcome his risk aversion.

12 Other situations lead to losses as high as 9.065% of invested capital, and hurdle rates as high as 13.73%. Clearly, in those cases where firm value less compensation costs falls below $100, the firm is better off with no manager and an automatic riskless investment strategy.

Fifth, all of the second best solutions exclude shares. Shares promote greater risk avoidance. Consistent with this result, Ofek and Yermack (2000) find that managers seek to curtail their positions in their own firms' shares when they receive new stock options. Moreover, when executives exercise stock options, they sell most of the shares they receive, regardless of prior ownership.

Finally, the size of the optimal option grant is a decreasing function of the manager's reservation utility. For example, for the low risk project, when alpha = .04, as we move from the lower utility level (table 1) to the middle utility level (table 2), m declines from 7.90% to 4.12%. At higher utility levels, the manager's utility function is less concave, thus fewer convex options are needed to overcome the manager's risk aversion.

In Tables 1 -3, the size of the optimal option grant never exceeds 17% of total compensation. In contrast, Perry and Zenner (2000a) find that for the average CEO of an S&P 500 firm, option compensation represents nearly 38% of total compensation. Furthermore, the size of the optimal option grant never exceeds 10% of the firm's outstanding shares. In contrast, the top employees of large American firms have a claim on about 13% of their firms' equity (The Economist, 1999).[13]

4. Pay-For-Performance

Following Jensen and Murphy (1990a, b), we define pay-for-performance sensitivity (PFP) as the change in compensation value associated with a unit change in firm value. PFP is zero for cash compensation and positive for share and option compensation. Recall that the firm's value is V_{0+} once

13 A possible explanation for our smaller optimal option grants is that our model does not account for tax or accounting costs that may encourage firms to use larger amounts of incentive pay (see Perry and Zenner, 2000b). Nor does our model incorporate possible cash constraints faced by "new economy" and other start-up firms.

the manager is hired. As firm value moves from V_{0+} to V (its liquidation value), the value of the manager's incentive compensation changes by:

$$\Delta Pay = \begin{cases} m(V_{0+} - X - C_{0+}) + (n+m)\Delta Value, & V > X \\ -mC_{0+} + n\Delta Value, & V \le X \end{cases} \tag{10}$$

We define PFP as the slope coefficient in (9), as in Jensen and Murphy (1990a,b). All of our second best contracts exclude shares and set X = I. Thus, in our second best contracts, PFP depends on *m* only. It is straightforward to show that PFP is defined as:

$$PFP = m * prob(risky) * prob(V > X \mid risky) \tag{11}$$

where m denotes the fraction of the firm's shares underlying the manager's option grant, Prob(risky) is the probability the manager pursues the risky project, and Prob(V>X|risky) is the probability the risky project payoff exceeds the option strike price, given the risky project is selected.

Tables 4 - 6 report pay-for-performance measures. In Table 4, reservation utility is $\overline{U}$ = U($1.00 cash); in Table 5, reservation utility is $\overline{U}$ = U($3.00 cash); in Table 6, reservation utility is $\overline{U}$ = U($5.00 cash). The tables report project cash flows (V_L, V_{H1}, V_{H2}), the manager's reputation parameter, α, the probability the manager chooses the risky project, the probability the risky project payoff exceeds the strike price on the manager's call options, and the PFP measure.

Several observations merit discussion. First, PFP is an increasing function of the manager's career concerns. For example, for the middle utility level (Table 5) and the medium risk project, as alpha increases from .02 to .03, PFP increases from 0.73% to 1.38%. Second, PFP is an increasing function of the project's risk. For example, for the upper utility level (Table 6), when alpha = .02, as we move from the low to the medium to the high risk project, PFP increases from 0.13% to 0.32% to 0.61%. Third, PFP is a decreasing function of the manager's reservation utility. For example, for the low risk project, when alpha = .04, as we move from the lower utility level (Table 4) to the middle utility level (Table 5), PFP declines from 1.69% to 1.06%.

Our pay-for-performance measures range from .0003 (Table 6) to .0188 (Table 4), or 30 cents per thousand to $18.80 per thousand. Jensen and Murphy (1990a, b) estimate PFP at $2.59 or $3.25 per $1,000. We obtain PFP estimates similar to Jensen and Murphy (1990a, b) when alpha is between .01 and .04 for the least risky project, and when alpha is between .01 and .02 for the medium and high risk projects.

5. Conclusion

This paper solves an optimal contracting problem for a risk-averse, career conscious manager who sets the investment strategy of a firm based on private information he possesses about project payoffs. Consistent with the marketplace, we focus on contracts consisting of cash, shares, and call options on the firm's shares. We find that the optimal contract consists of mostly cash, supplemented by a small amount of *at-the-money* call options; shares are excluded. Thus, our model can explain the near uniform practice of granting executive stock options *at-the money*. Moreover, recent evidence that managers "dump" their firms' shares when they have the chance is also consistent with our model. Shares promote risk avoidance. In contrast, the convexity of an option's payoff helps to overcome managerial risk aversion. This effect is strongest if the options are struck at-the-money. These results do not entirely depend on our assumption that managerial career concerns are responsible for the agency problem between managers and shareholders. Similar results will obtain as long as the manager's indirect utility function is concave in the firm's value.

Though the convexity of the options' payoff helps to overcome managerial risk aversion, firms under-invest, since the second best contract leaves the manager more conservative than shareholders prefer. This under-investment can result in significant losses for shareholders relative to firm value under the first-best investment strategy. These losses appear to be much larger than the losses due to shareholder-bondholder conflicts reported in Parrino and Weisbach (1999). Consistent with empirical findings, we find that the size of the optimal option grant is an increasing function of project quality and managerial career concerns. In contrast, the size of the optimal option grant is a decreasing function of the manager's reservation utility. Finally, the size of the optimal option grant is relatively small.

We estimate the pay-for-performance sensitivity (PFP) of our second best compensation contracts. We find that PFP is small, similar in magnitude to the PFP estimates of Jensen and Murphy (1990a,b). Moreover, PFP is an increasing function of managerial career concerns and project quality.

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Table 1

2nd best solutions when the manager's reservation utility is U($1.00 cash).

V_L, V_{H1}, V_{H2}	α	m	X	k	V_H^*	Comp. Cost	Firm Value net of cost
75, 100, 150	.01	.0090	100.00	1.003	125.83	1.053	102.069
	.02	.0451	100.00	1.233	129.80	1.458	101.552
	.03	.0627	100.00	1.780	131.44	2.074	100.843
	.04	.0790	100.00	2.298	132.87	2.648	100.167
	.05	.0945	100.00	2.793	134.15	3.189	99.517
50, 100, 200	.01	.0251	100.00	1.297	155.56	1.562	104.611
	.02	.0451	100.00	2.467	159.59	2.915	103.105
	.03	.0627	100.00	3.560	162.89	4.149	101.686
	.04	.0790	100.00	4.596	165.74	5.297	100.334
	.05	.0945	100.00	5.586	168.31	6.378	99.034
25, 100, 250	.01	.0251	100.00	1.945	183.35	2.343	106.916
	.02	.0451	100.00	3.700	189.39	4.373	104.657
	.03	.0627	100.00	5.340	194.33	6.223	102.529
	.04	.0790	100.00	6.895	198.61	7.945	100.500
	.05	.0945	100.00	8.380	202.46	9.567	98.551

The risky project cash flows are uniformly distributed on the interval (V_L, V_H) with V_H uniformly distributed on the interval (V_{H1}, V_{H2}). The manager has a coefficient of relative risk aversion equal to 3.0. Alpha measures the magnitude of the manager's career (reputation) concerns; m measures the percent of the firm's outstanding shares underlying the manager's call option compensation; X is the option strike price; k measures the dollar amount of the manager's cash compensation. Managers pursue the risky project whenever their signal, $V_H > V_H^*$. Firm value is net of compensation costs.

Table 2

2nd best solutions when the manager's reservation utility is U($3.00 cash).

V_L, V_{H1}, V_{H2}	α	m	X	k	V_H^*	Comp. Cost	Firm Value net of cost
75, 100, 150	.01	.0019	100.00	3.000	125.16	3.011	100.114
	.02	.0083	100.00	3.005	125.75	3.052	100.071
	.03	.0208	100.00	3.021	126.99	3.133	99.972
	.04	.0412	100.00	3.048	129.07	3.258	99.784
	.05	.0732	100.00	3.084	132.19	3.418	99.449
50, 100, 200	.01	.0046	100.00	3.003	150.80	3.054	103.194
	.02	.0271	100.00	3.036	155.37	3.323	102.855
	.03	.0614	100.00	3.520	163.88	4.086	101.683
	.04	.0759	100.00	4.486	167.98	5.127	100.316
	.05	.0945	100.00	5.587	168.30	6.378	99.034
25, 100, 250	.01	.0090	100.00	3.009	177.49	3.159	106.206
	.02	.0451	100.00	3.700	189.39	4.373	104.657
	.03	.0627	100.00	5.340	194.33	6.223	102.529
	.04	.0790	100.00	6.895	198.62	7.945	100.500
	.05	.0945	100.00	8.380	202.46	9.567	98.551

The risky project cash flows are uniformly distributed on the interval (V_L, V_H) with V_H uniformly distributed on the interval (V_{H1}, V_{H2}). The manager has a coefficient of relative risk aversion equal to 3.0. Alpha measures the magnitude of the manager's career (reputation) concerns; m measures the percent of the firm's outstanding shares underlying the manager's call option compensation; X is the option strike price; k measures the dollar amount of the manager's cash compensation. Managers pursue the risky project whenever their signal, $V_H > V_H^*$. Firm value is net of compensation costs.

Table 3

2nd best solutions when the manager's reservation utility is U($5.00 cash).

V_L, V_{H1}, V_{H2}	α	m	X	k	V_H^*	Comp. Cost	Firm Value net of cost
75, 100, 150	.01	.0010	100.00	5.000	125.09	5.006	98.119
	.02	.0043	100.00	5.003	125.38	5.027	98.098
	.03	.0098	100.00	5.010	125.92	5.064	98.056
	.04	.0178	100.00	5.024	126.74	5.121	97.989
	.05	.0282	100.00	5.046	127.85	5.195	97.889
50, 100, 200	.01	.0023	100.00	5.001	150.39	5.027	101.222
	.02	.0109	100.00	5.014	151.99	5.135	101.105
	.03	.0286	100.00	5.055	155.56	5.357	100.816
	.04	.0600	100.00	5.123	161.95	5.697	100.197
	.05	.0945	100.00	5.586	168.30	6.378	99.034
25, 100, 250	.01	.0039	100.00	5.003	176.02	5.070	104.303
	.02	.0218	100.00	5.044	181.34	5.396	103.912
	.03	.0627	100.00	5.340	194.33	6.223	102.529
	.04	.0790	100.00	6.895	198.61	7.946	100.500
	.05	.0945	100.00	8.380	202.46	9.567	98.551

The risky project cash flows are uniformly distributed on the interval (V_L, V_H) with V_H uniformly distributed on the interval (V_{H1}, V_{H2}). The manager has a coefficient of relative risk aversion equal to 3.0. Alpha measures the magnitude of the manager's career (reputation) concerns; m measures the percent of the firm's outstanding shares underlying the manager's call option compensation; X is the option strike price; k measures the dollar amount of the manager's cash compensation. Managers pursue the risky project whenever their signal, $V_H > V_H^*$. Firm value is net of compensation costs.

Table 4

Pay-for-performance measures when the manager's reservation utility is fixed at $1.00.

V_L, V_{H1}, V_{H2}	α	Prob(risky)	Prob(V>X)	PFP
75, 100, 150	.01	0.4834	0.6026	0.0026
	.02	0.4041	0.6148	0.0112
	.03	0.3711	0.6196	0.0144
	.04	0.3425	0.6237	0.0169
	.05	0.3169	0.6273	0.0188
50, 100, 200	.01	0.4444	0.6087	0.0068
	.02	0.4041	0.6148	0.0112
	.03	0.3711	0.6196	0.0144
	.04	0.3426	0.6237	0.0169
	.05	0.3169	0.6273	0.0188
25, 100, 250	.01	0.4444	0.6087	0.0068
	.02	0.4041	0.6148	0.0112
	.03	0.3711	0.6196	0.0144
	.04	0.3426	0.6237	0.0169
	.05	0.3169	0.6273	0.0188

The risky project cash flows are uniformly distributed on the interval (V_L, V_H) with V_H uniformly distributed on the interval (V_{H1}, V_{H2}). The manager has a coefficient of relative risk aversion equal to 3.0. Alpha measures the magnitude of the manager's career (reputation) concerns. Prob(risky) measures the probability the manager chooses the risky project. Prob(V>X) measures the probability the risky project payoff exceeds the strike price on the manager's call option compensation. PFP measures pay-for-performance, the change in the manager's compensation value associated with a unit change in firm value.

Table 5

Pay-for-performance measures when the manager's reservation utility is fixed at $3.00.

V_L, V_{H1}, V_{H2}	α	Prob(risky)	Prob(V>X)	PFP
75, 100, 150	.01	0.4969	0.6005	0.0006
	.02	0.4850	0.6024	0.0024
	.03	0.4601	0.6063	0.0058
	.04	0.4186	0.6126	0.0106
	.05	0.3562	0.6218	0.0162
50, 100, 200	.01	0.4920	0.6013	0.0014
	.02	0.4463	0.6084	0.0073
	.03	0.3613	0.6210	0.0138
	.04	0.3202	0.6268	0.0152
	.05	0.3170	0.6273	0.0188
25, 100, 250	.01	0.4834	0.6026	0.0026
	.02	0.4041	0.6148	0.0112
	.03	0.3711	0.6196	0.0144
	.04	0.3426	0.6237	0.0169
	.05	0.3169	0.6273	0.0188

The risky project cash flows are uniformly distributed on the interval (V_L, V_H) with V_H uniformly distributed on the interval (V_{H1}, V_{H2}). The manager has a coefficient of relative risk aversion equal to 3.0. Alpha measures the magnitude of the manager's career (reputation) concerns. Prob(risky) measures the probability the manager chooses the risky project. Prob(V>X) measures the probability the risky project payoff exceeds the strike price on the manager's call option compensation. PFP measures pay-for-performance, the change in the manager's compensation value associated with a unit change in firm value.

Table 6

Pay-for-performance measures when the manager's reservation utility is fixed at $5.00.

V_L, V_{H1}, V_{H2}	α	Prob(risky)	Prob(V>X)	PFP
75, 100, 150	.01	0.4983	0.6003	0.0003
	.02	0.4924	0.6012	0.0013
	.03	0.4816	0.6029	0.0029
	.04	0.4651	0.6055	0.0050
	.05	0.4430	0.6089	0.0076
50, 100, 200	.01	0.4961	0.6006	0.0007
	.02	0.4801	0.6032	0.0032
	.03	0.4444	0.6087	0.0077
	.04	0.3805	0.6182	0.0141
	.05	0.3170	0.6273	0.0188
25, 100, 250	.01	0.4932	0.6011	0.0012
	.02	0.4577	0.6066	0.0061
	.03	0.3711	0.6196	0.0144
	.04	0.3426	0.6237	0.0169
	.05	0.3169	0.6273	0.0188

The risky project cash flows are uniformly distributed on the interval (V_L, V_H) with V_H uniformly distributed on the interval (V_{H1}, V_{H2}). The manager has a coefficient of relative risk aversion equal to 3.0. Alpha measures the magnitude of the manager's career (reputation) concerns. Prob(risky) measures the probability the manager chooses the risky project. Prob(V>X) measures the probability the risky project payoff exceeds the strike price on the manager's call option compensation. PFP measures pay-for-performance, the change in the manager's compensation value associated with a unit change in firm value.