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Comments Welcome

Executive Compensation, Incentives, and Risk[1]

This paper analyzes the link between equity-based compensation and created incentives by (1) deriving a measure of incentives suitable for both linear and non-linear compensation contracts, (2) analyzing the effect of risk on incentives, and (3) clarifying the role of the agent's private trading decisions in incentive creation. With option-based compensation contracts, the average pay-for-performance sensitivity is not an adequate measure of ex-ante incentives. Pay-for-performance covaries negatively with marginal utility and hence overstates the created incentives. Second, more noise in the performance measure implies that the manager is less certain about the effect of effort on performance, which in turn makes her less willing to exert effort. Finally, the private trading decisions by the manager have first-order effects on incentives. By reducing her holdings of the market asset, the manager achieves an effect similar to "indexing" the stock or option grant, making explicit indexation of the contract redundant.

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Introduction

Principal-agent theory frames the design of incentive plans for corporate managers as a trade-off between incentives and insurance. To induce managers to act in the interest of shareholders managerial wealth is linked to measures of corporate performance. At the same time, the noise in the available measures of performance burdens managers with inefficient levels of risk. The optimal incentive scheme balances the benefit of increased managerial effort with the deadweight loss from inefficient risk sharing.[2]

This characterization of the incentive compensation problem is silent about the translation of contracts into incentives and the direct effect of risk on incentive creation. Two different contracts can provide the same probability-weighted average link between managerial wealth and performance, but at the same time result in very different levels of ex-ante incentives. Similarly, the same incentive scheme creates different levels of incentives depending on the noisiness of the link between effort and performance.

This paper contributes to our understanding of the link between incentive compensation and created incentives by (1) deriving and analyzing an appropriate measure of incentives for both linear and non-linear compensation contracts, (2) analyzing the effect of risk on the incentives created by a given contract and (3) clarifying the role of the agent's private trading decisions on incentive creation. The mechanism by which executive compensation schemes translate into managerial incentives has not been analyzed in detail in the extant literature, resulting in much unnecessary confusion. The paper at hand attempts to fill this gap.

For the class of incentive problems considered in this paper, effort incentives are appropriately measured as the expected marginal effect of effort on utility. The effort incentives can be decomposed into (i) managers' expected marginal need for wealth, (ii) the expected marginal effect of effort on wealth and (iii) the covariation between need for wealth and effect of effort on wealth

[2] There is a vast empirical literature analyzing CEO compensation in the context of the principal-agent model. Murphy (1999) provides an excellent summary. More recent empirical work has focused on estimating the sensitivity of CEO compensation to corporate performance. See Jensen and Murphy (1990) and Hall and Liebman (1998) for two excellent examples. Other predictions of the agency model have been tested by Gibbons and Murphy (1992), Tufano (1996), Aggarwal and Samwick (1999), Cohen, Hall and Viceira (2000) and Bertrand and Mullainathan (1998, 2000) amongst others.

across states. The third incentive lever is often overlooked but turns out to be crucial for understanding incentive schemes, the effect of risk on incentives, and the relevant measure of risk for compensation schemes.

The results can be summarized as follows: With non-linear compensation contracts the link between measured performance and managerial wealth is state-dependent. The expected (probability-weighted average) pay-for-performance is not an adequate measure of ex-ante incentives. In particular, with convex, option-based compensation schemes pay-for-performance covaries negatively with marginal utility and overstates the actually created incentives by a substantial amount. A negative shock to the performance measure is associated with low pay-for-performance sensitivity and high marginal utility, while a positive shock is associated with high pay-for-performance sensitivity and low marginal utility. Hence options deliver a tight link between wealth and performance in states of nature in which the manager's need for additional funds is low. An efficient incentive scheme would display the opposite, concave pattern, rewarding managerial effort in high marginal utility states and offering a smaller pay-for-performance slope in low marginal utility states.

The second set of results is concerned with the direct effect of risk on incentives. Firstly, the effect of the covariation of the pay-performance link with marginal utility described in the previous paragraph is increasing in the volatility of the performance measure. Thus the wedge between average pay-for-performance and the actual incentives created by option-based contracts widens as risk increases. This finding is important for the measurement of incentives in the empirical literature, and for understanding the empirical relationship between incentives and risk (Prendergast, 2000b). Secondly, I demonstrate that the effect of risk on incentives depends on wether the link between effort and performance is itself stochastic. The standard principal-agent model utilizes an additive noise structure, implicitly assuming that the marginal effect of effort on measured performance is deterministic. Put differently, the additive model assumes that the manager knows with certainty how her effort affects final outcomes at the time she makes her decision. A direct and counterintuitive consequence of this assumption is that an increase in risk leads to an increase in managerial effort due to a "precautionary effort" effect.

I propose instead that a non-standard multiplicative noise structure better captures managers' uncertainty about the effect of their actions on outcomes. A multiplicative error structure allows the noise term to directly impact the effect of effort on performance. More noise in the performance measure then implies that the manager is less certain about the effect of effort on performance, which in turn makes her less willing to exert effort. Making the effect of effort on performance itself stochastic captures the intuition described by Meulbroek (2000) as "*rowing (...) does not affect the boat's progress very much relative to the effect of (a) hurricane*". Meulbroek's intuition is that risk beyond the manager's control should lower effort incentives. The analysis in Section 1 shows that this is indeed the case when the effect of effort on performance is random, but that the opposite and counterintuitive result obtains with an additive error structure.

Finally, I demonstrate that the private trading decisions of the manager have important effects on the incentives created by a given compensation contract. While the manager is prohibited from trading the company stock, I allow her to freely trade the market asset through her private account.[3] By reducing her holdings of the market asset in response to an equity-based compensation contract, the manager achieves an effect similar to "indexing" the stock or option grant. Failure to take the endogenous portfolio adjustment into account makes equity-based incentive compensation look less effective than it is. The trade-off between risk and incentives at the core of the principal-agent problem turns out to be a trade-off between idiosyncratic risk and incentives.

The results are illustrated by comparing the incentive effects of restricted stock grants with the incentive effects of restricted stock option grants.[4] Executive stock options have been recommended for incentive compensation

[3] Corporate executives are generally not permitted to sell their stock and option grants for a specified period of time, the "vesting period", and are also contractually precluded from hedging the risk by short-selling company stock.

[4] The approach taken in this paper is normative, without taking a stance on whether corporate boards or compensation commitees try to design optimal compensation contracts. See Core and Guay (1999) for evidence that firms use annual stock and option grants to achieve desired levels of incentives for their executives. Bertrand and Mullainathan (2000) find evidence that well-governed firms conform more closely with the optimal contracting view, while less well-governed firms conform to a "skimming view" of executive compensation. Yermack (1995, 1997) finds evidence that considerations beyond the optimal contracting model are present in executive compensation. See Crystal (1991) for a presentation of the skimming view.

because they deliver high pay-for-performance sensitivity (as measured by their delta) at a low cost (as measured by their Black-Scholes value). Several authors have recognized that the cost of option compensation is likely to be larger than the Black-Scholes value.[5] Managers are risk averse and undiversified, and hence demand a risk-premium to accept stock options as a replacement for cash compensation. This is in obvious contrast to outside investor, who through dynamic trading strategies are able to eliminate most or all of the risk in stock options.

Hall and Murphy (2000b) argue heuristically that not only is the Black-Scholes approach inappropriate to calculate a manager's valuation of options, but also that the option delta is an inappropriate measure of incentives. Using the change in the manager's cash-equivalent valuation in response to a change in stock price as their proposed measure of incentives, Hall and Murphy find that stock options are inefficient creators of managerial incentives when compared to grants of restricted stock. The reason for the numerically derived inefficiency of options remains something of a puzzle in their paper, in particular because the low valuations managers assign to option grants are by themselves insufficient in magnitude to explain the result.

It is straight-forward to show why options are inefficient using the decomposition of incentives introduced in this paper: The incentive effects of options are reduced substantially by the fact that the manager's marginal utility covaries negatively with pay-for-performance. A much higher level of average pay-for-performance sensitivity is needed to induce the same level of incentives with options as with stock. It is the combination of low managerial valuations and weak incentives that makes options inefficient means of incentive compensation. This result is robust to different scenarios for managerial wealth and the firm-specificity of wealth and human capital.

In Section 1, a simple model of managerial effort choice is introduced. I decompose the manager's first-order condition for effort into three drivers of incentives and discuss their economic interpretation. The insights gained from this exercise are applied in Section 2. In Section 2.1, the effort incentives created by stock and option grants are compared. Section 2.2 analyzes incentives under several scenarios for managerial wealth. Section 2.3 assesses

[5] See Lambert, Larcker and Verrecchia (1991), Meulbroek (2001) and Hall and Murphy (2000 a,b).

the effect of private trading in the market asset on incentives, and demonstrates how the usefulness of indexed options is reduced and even eliminated by endogenous portfolio adjustments. Section 2.4 analyzes the effect of stock price volatility on incentives and demonstrates the effect of assuming a multiplicative noise structure. Section 2.5 illustrates how high-powered incentive schemes can be structured using executive share purchase plans. This section also demonstrates that options may be the only means to create high levels of incentives if the manager is wealth constrained. The final section summarizes the results and concludes.

Section 1: The Effort Choice Model

Consider a model of managerial effort choice in which a single all-equity firm is run by a risk-averse manager for one period. The final value of the firm is determined by the manager's effort and a random shock, which can be interpreted as summarizing all factors beyond the manager's control. Final firm value per share is given by:

$$\widetilde{P_1} = \overline{P_1}(e) \cdot \varepsilon$$

with $\overline{P_1}'(e) > 0$, $\overline{P_1}''(e) < 0$, $E[\varepsilon] = 1$, $\varepsilon \geq 0$ and managerial effort $e \in [0, \infty)$. Managerial effort is unobservable by the principal. The shock to firm value is made up of a market component ε_m and an unsystematic component ε_i:

$$\widetilde{P_1} = \overline{P_1}(e) \cdot \varepsilon_m \cdot \varepsilon_i \tag{1}$$

with $E[\varepsilon_m] = E[\varepsilon_i] = E[\varepsilon_m \varepsilon_i] = 1$ and $\varepsilon_m, \varepsilon_i > 0$. The final value of the market asset is given by:

$$\widetilde{P_{1m}} = \overline{P_{1m}} \cdot \varepsilon_m$$

The model of firm value in (1) differs from the one most widely used in the principal-agent literature in that the shock to value is multiplicative.[6] This implies that the contribution of effort to firm value is no longer deterministic, but is instead itself a function of the random shock. The positive effect of effort on final value is exacerbated by a positive shock and dampened down by a negative shock. An example would be a manager who exerts effort on product improvement, in a market environment subject to random

[6] See Baker and Hall (1999) and Jin (2000) for typical models using an additive error structure.

demand shocks. Improving the product through higher effort always increases expected firm value, but the effect is much larger when accompanied by a positive demand shock. In the subsequent analysis, I clarify each instance in which the additive model delivers results different from my model.

The manager's utility function is increasing and concave in final wealth $\widetilde{W}_1$, and additively separable in wealth and effort. The manager has initial wealth of W_0, which she allocates optimally between the market and the riskless asset.[7] The cost of effort function $C(e)$ is increasing and convex in effort. I assume that the manager has an exogenously given reservation level of utility determined by her best outside opportunity.

Hence the manager has two decision variables: The optimal level of effort, and the optimal investment into the market asset. Denoting the share of private wealth invested into the market portfolio by α and the final value of the manager's compensation by $Y(\widetilde{P}_1)$, the manager's objective function is given by:

$$\begin{aligned} \underset{e,\alpha}{Max} \quad U(e,\alpha,W_0) &= E\left[u(\widetilde{W}_1)\right] - C(e) \\ s.t.\ \widetilde{W}_1 &= Y(\widetilde{P}_1(e)) + W_0\left(R_f + \alpha\left(\frac{\widetilde{P_{1m}}}{P_{0m}} - R_f\right)\right) \end{aligned}$$

The first-order conditions for effort choice and the optimal allocation of private wealth are given by:

$$f.o.c.\ effort\ choice \quad : \quad E\left[\frac{\partial u(\widetilde{W}_1)}{\partial e}\right] = \frac{\partial C(e)}{\partial e} \tag{2}$$

$$f.o.c.\ asset\ allocation \quad : \quad E\left[\frac{\partial u(\widetilde{W}_1)}{\partial W_1}\cdot\left(\frac{\widetilde{P_{1m}}}{P_{0m}} - R_f\right)\right] = 0 \tag{3}$$

To derive an optimal compensation contract, one maximizes the principal's objective function - generally taken as firm value net of compensation

[7] Later in the paper I also analyze scenarios in which part of private wealth is in the form of stock in the employing firm. Theoretically, the manager is allowed to invest further into the shares of her employer, which is never optimal given the assumptios. The diversified market portfolio has the same expected return as the firm's equity (assuming a beta of one), and investing into the firm's stock is equivalent to investing into a noisy version of the market asset.

costs - while taking the manager's optimal reaction to the compensation scheme into account.[8] Very restrictive assumptions are generally necessary to solve explicitly for the optimal contract.[9] This is not the approach taken in this paper, which instead analyzes the manager's optimal effort and allocation choices when faced with different, empirically relevant compensation schemes. This approach is close to the first step in the two-step approach proposed by Grossman and Hart (1983) for solving principal-agent models. Grossman and Hart search for an optimal incentive scheme for each level of effort, and subsequently optimize over implementable effort levels. For illustrative purposes, I will specialize the first-step analysis even further and restrict the set of admissible contracts to the empirically relevant building blocks stocks and options in the subsequent discussion.

Section 1.1: Decomposing Incentives

To understand how equity-based compensation contracts determine the effort level one needs to focus on the first-order condition for effort choice derived in (2). First isolate the terms which are directly affected by the design of the compensation scheme on the left-hand side of the first-order condition:

$$E\left[\frac{\partial u(\widetilde{W}_1)}{\partial \overline{P}_1}\frac{\partial \overline{P}_1}{\partial e}\right] = \frac{\partial c(e)}{\partial e}$$

$$\Leftrightarrow E\left[\frac{\partial u(\widetilde{W}_1)}{\partial \overline{P}_1}\right] = \frac{\frac{\partial c(e)}{\partial e}}{\frac{\partial \overline{P}_1}{\partial e}} \tag{4}$$

The left-hand side of (4) represents the pressure on the manager to exert effort, and is simply the manager's expectation of the derivative of her utility with respect to changes in the mean stock price. Inducing the manager to choose a high level of effort is the same as designing the incentive scheme to create a high value for this term. The two terms on the right-hand side - the

[8]See Grossman and Hart (1983) and Holmstrom and Milgrom (1987) for examples.

[9]In fact the optimal compensation scheme may not even be monotonic in the share price. Grossman and Hart (1983) demonstrate that incentive schemes may be decreasing in output for some range. Their result requires that the principal has detailed knowledge of the optimal actions he tries to implemenent, and of the stochastic relationship between actions and observable outcomes. Neither assumptions is likely to be fulfilled in reality, and non-monotonic incentive schemes do not appear to be empirically relevant.

marginal cost of effort and the derivative of mean stock price to effort - are beyond the control of the designer of the incentive contract.[10]

Next the incentive pressure term is decomposed into three incentive levers. The decomposition uses the definition of final firm value in (1) and gives the following expression for the incentive pressure generated by a contract:

$$Incentive\ Pressure:$$

$$\underbrace{E\left[\frac{\partial u(W_1)}{\partial W_1}\right]}_{Lever\ 1}\cdot\underbrace{\left(E\left[\frac{\partial W_1}{\partial P_1}\right]+Cov\left[\frac{\partial W_1}{\partial P_1},\varepsilon_m\varepsilon_i\right]\right)}_{Lever\ 2}$$
$$+\underbrace{Cov\left[\frac{\partial u(W_1)}{\partial W_1},\frac{\partial W_1}{\partial P_1}\varepsilon_m\varepsilon_i\right]}_{Lever\ 3} \tag{5}$$

The decomposition of incentives in (5) clarifies the drivers behind the manager's effort decision. The three incentive levers are the manager's expected marginal need for funds (Lever 1), the expected effect of effort on wealth (Lever 2) and the covariation of the marginal need for funds with the marginal effect of effort (Lever 3). In discussing the economic intuition behind the three incentive levers, I focus on equity based incentive compensation and in particular stock and options:[11]

(Lever 1) $E[u'(W_1)]$: Effort incentives are increasing in the expected marginal contribution of wealth to utility. The expected level of utility in principal-agent models is in most instances determined by the agent's outside opportunities.[12] The expected *marginal* utility of prudent (u"'>0) managers, and therefore effort incentives, are increasing in the variance of final wealth.

[10] Focusing on the benefits-from-effort part of the first-order condition while ignoring the cost-of-effort and productivity-of-effort parts is close in spirit to the approach taken by Baker and Hall (1999) in their empirical analysis.

[11] The decomposition of effort incentives in (5) applies to a wide range of incentive schemes. One could analyze incentive contracts based on accounting measures like profits or revenues using the same framework.

[12] There are at least two exceptions: If the manager has private information about the company at the time the contract is signed, then the principal-agent framework predicts the manager to earn rents above her reservation level. The level of rents in terms of

This is the first channel through which risk affects effort incentives: Holding everything else equal, a compensation scheme which burdens the manager with more risk increases the expected marginal need for funds. I label this the "precautionary effort effect".

(Lever 2) $E\left[W_1'(P_1)\right] + Cov\left[W_1'(P_1), \varepsilon_m \varepsilon_i\right]$: Effort incentives increase in the expected sensitivity of managerial wealth to the stock price. This incentive lever is closest to the "pay-for-performance" sensitivity used in most empirical studies of executive compensation.[13] It measures how closely managerial wealth is tied to stock-price performance. For linear compensation schemes, as with restricted stock grants, the pay-for-performance sensitivity is a constant and simply equal to the number of shares held by the manager. With non-linear, option-based compensation, the pay-for-performance sensitivity is itself random, and the *expected* pay-for-performance sensitivity matters for incentives. The covariance term is a result of the multiplicative error structure and discussed below.

(Lever 3) $Cov\left[u'(W_1), W_1'(P_1)\varepsilon_m \varepsilon_i\right]$: Effort incentives decrease in the negative covariance between marginal utility and the marginal effect of effort on wealth. The covariance is negative for two reasons: With a convex, option-based incentive scheme pay-for-performance covaries negatively with marginal utility. The pay-for-performance sensitivity of options is high when the stock price is high, which are the states of nature in which marginal utility is low. Options deliver the highest pay-for-performance sensitivity in those states in which the manager values the increase in wealth from effort the least. Secondly, even with a linear compensation scheme Lever 3 will still be negative of the error structure is multiplicative as assumed here. This effect will again be discussed below. Lever 3 is always zero if the contract is linear and the noise structure additive.

The decomposition of effort incentives is very general and helps to analyze the effects of a wide range of payoff patterns on behavior. To summarize,

expected utility will be the same across the incentive contracts considered here, which is all that is required for the argument. Second, if the manager is wealth and borrowing consrained, then it may not be possible to design a contract keeping the manager at her participation constraint. This is the case analyzed in Section 2.5.

[13] Pay-for-performance as measure of incentives is pervasive in the empirical and theoretical literature on incentive options. See Jensen and Murphy (1990), Hall (1998), Hall and Liebman (1998), Core and Guay (1998), Guay (1999) and Johnson and Tian (2000 a,b).

managers' effort incentives can be decomposed into (i) the expected marginal need for wealth (Lever 1), (ii) the expected marginal effect of effort on wealth (Lever 2) and (iii) the covariation between need for wealth and effect of effort on wealth across states (Lever 3).

How does the measure of effort incentives identified in (4) relate to the incentive measure proposed in Hall and Murphy (2000 a,b)? Hall and Murphy calculate the certainty equivalence valuation an executive assigns to a stock option grant, and then analyze how the valuation changes as the share price is increased.[14] An explicit characterization of the Hall and Murphy measure of incentives is derived in the Appendix and shown to be a rescaled version of the measure used here. The incentive measure in (4) has the advantage of being defined explicitly, thereby allowing us to analyze it in greater detail.

Two important insights about the effect of risk in compensation on incentives emerge from the decomposition:

(1) *The role of a state-contingent pay-performance link*: A compensation scheme introduces additional covariance risk into the manager's decision problem if the pay-for-performance sensitivity covaries with marginal utility (Lever 3). The incentive lever would be positive, i.e. contributing to effort incentives, if pay-for-performance moved positively with marginal utility.[15] Instead executive stock options have a pay-for-performance sensitivity of one when stock prices are high (in-the-money), and zero when stock prices are low (out-of-the-money). Marginal utility on the other hand tends to be high when stock prices are low and tends to be low when stock prices are high. Thus stock options translate managerial effort into managerial wealth primarily in those states of nature in which the manager needs the funds the least. This perverse pay-for-performance pattern of stock options lowers ex-ante effort incentives, and makes measured pay-for-performance sensitivities an upward-biased measure of managerial incentives.[16]

[14] The certainty equivalence approach to the valuation of executive stock options has been used first by Lambert, Larcker and Verrecchia (1991).

[15] It would only be positive if the effect of effort on stock prices does not covary too negatively with marginal utility. This is always the case when the error structure is additive, i.e. the effect of effort on share prices is deterministic.

[16] There is a numerically small positive effect of convexity in the compensation contract on incentives through the covariance term in Lever 2. This effect is only present when the error structure for stock prices is multiplicative and is discussed in the next paragraph.

(2) *The effect of noise on incentives and the role of the error structure* : With an additive error structure risk affects incentives in two places: First, more volatility increases expected marginal utility for a prudent manager through the precautionary effort effect (Lever 1). The manager increases her effort level to compensate for the utility loss from more risk. This is the only effect of risk on incentives if the compensation contract is linear and the error structure is additive. Second, with a concave, option-based compensation contract the covariance between marginal utility and the pay-for-performance sensitivity becomes more negative as risk increases, lowering incentives (Lever 3).[17]

With a multiplicative error structure, the effect of effort on wealth is itself stochastic. This has two additional effects on incentives: *(a)* The primary effect is to lower effort incentives through the noise term ($\varepsilon_m \varepsilon_i$) in Lever 3. The manager is less willing to exert effort given that the effect of effort on performance is largest in good states, i.e. in states in which marginal utility is low. This effect is present with linear contracts but is exacerbated if the compensation contract uses options. In this case both the contractual pay-for-performance sensitivity and the effect of effort on performance move in the opposite direction from marginal utility, reinforcing each other to lower incentives. *(b)* The second effect is present only with option-based contracts and increases incentives through the covariance term in Lever 2. The pay-for-performance sensitivity of a convex contract is largest when the shock is positive, which are also the states of nature in which the effect of effort on performance is large. Hence the covariance term is positive and adds to incentives. The calibration analysis performed below shows that this advantageous effect of convex contracts is outweighed by the negative effect captured in Lever 3.

The next section illustrates the insights gained from the incentive decomposition by analyzing and comparing the efficiency of using stock and option grants in a realistic calibration of the model. The question whether stock or options are better suited to induce managerial incentives cannot be answered using the decomposition framework alone. While incentive options

[17] The decomposition of incentives indicates that the often stated view (see e.g. Bertrand and Mullainathan 2000, Oyer 2000) that adding uncorrelated noise to a compensation measure has no incentive effects is incorrect. Additional noise could either increase or decrease managerial incentives, but is always inefficient (Holmstom 1979, 1982).

link managerial wealth to performance primarily in states of nature in which the manager does not care much about the additional funds, they provide the link between wealth and performance at a much lower cost than stock grants. A typical at-the-money option with one year maturity has a Black-Scholes value of below 20% of the fair-market value of the underlying. The same option has a pay-for-performance sensitivity or delta of around 0.6. Hence a firm can grant five incentive options for the cost of one share, achieving a pay-for-performance sensitivity three times larger than with a stock grant.[18]

Section 2: Applying the Decomposition Framework

Compared to previous papers, the analysis of stock and option compensation is refined in two ways: First, the cost of inducing the *same level of effort incentives* with different compensation packages is compared. This allows to directly assess the effectiveness of compensation tools from the viewpoint of the firm, and does not suffer from the obvious shortcomings of comparing compensation packages with the same total cost to the firm.[19] Furthermore, the manager is allowed to trade the market asset through her private account. Thus the manager is able to react optimally to increases in compensation risk by adjusting the exposure of private wealth.

Section 2.1: Restricted Stock Grants versus Restricted Option Grants

This section compares grants of restricted stock with compensation based on restricted options.[20] Table I presents a stylized numerical example. Assume for now that the executive has no private wealth, so utility is evaluated

[18] As an example, take a one year at-the-money call option on a non-dividend paying stock with market value 100, 30% annualized volatility and a riskfree rate of 5%. The Black-Scholes value of the option is $14.23 with a Delta of 0.62.

[19] Comparing the incentive effects of different compensation contracts with the same cost to the firm is incompatible with the Principal-Agent model. An option grant of a given market value gives the manager lower expected utility than a stock grant of equal market value, but produces higher effort incentives. Clearly the manager's participation constraint cannot be binding for both contracts, and at least one of the contracts has to be suboptimal.

[20] The analysis in this paper is silent about the selection and retention effects of compensation. It is clear that these considerations are of first-order importance in almost any organization, and minimum threshold levels of performance may help to improve the talent pool available to the firm. Alternatively, options may be used in practice to improve the risk-taking incentives of managers, or because of their favorable accounting treatment.

only over the current compensation contract. While this assumption is clearly unrealistic and will be relaxed shortly, it exacerbates and helps to illustrate the countervailing effects. Both the idiosyncratic and the market wide noise term are assumed to be lognormally distributed. The share price has an annualized expected rate of return of 12 percent and a standard deviation of 30 percent. The risky market asset also has expected return of 12 percent, but a lower standard deviation of 15%. The risk-free rate is set to 5%. The horizon of the compensation contract is one year, and all awards are made at the beginning of the year. This includes cash payments, which are invested at the manager's own discretion.[21] The manager's outside opportunity is assumed to have a certainty equivalent value of $1 million. Finally, the manager has constant relative risk aversion preferences and with a coefficient of risk aversion equal to four.[22]

Panel A reports the incentives created by stock grants between $100,000 and $1 million. Column one shows the results for a stock grant of zero and a $1m cash payment. The expected utility from this compensation package corresponds to the manager's outside opportunity and sets the benchmark for all other contracts. Columns two to six report results for successively increasing stock grants. The cash portion of compensation is adjusted to keep the level of expected utility equal to the executive's outside opportunity.

The executive values the stock grant by less than its fair market value. The ratio of the executive's valuation relative to the market value of the stock grant is reported in the second row of Panel A. This is the result noted by Lambert, Larcker and Verrecchia (1991), Hall and Murphy (2000 a,b) and Meulbroek (2001) for option grants, and due to the fact that any risk-averse agent prefers the higher Sharpe-ratio offered by the risky market asset.[23]

[21] More appropriately, cash renumeration should be discounted at the borrowing rate of the company, risk-adjusted for the level of seniority. To do so requires an assumption about the probability of default on managerial compensation, which is likely to be low. Small changes to the discount rate do not change any of the results.

[22] The assumption of constant relative risk aversion is the same preference specification as used by Hall and Murphy (2000 a,b). Using risk aversion coeffcients between 2 and 8 yields qualitatively similar results.

[23] The result is in fact slightly different from Hall and Murphy (2000a,b) and closer to Meulbroek (2001), since both our model and Meulbroek explicitly compare the executive stock or option grant to an investment into the market asset. Unlike Meulbroek, the manager optimally invests her private wealth and any cash portion of compensation.

Thus the manager has to be compensated for the risk in company stock and the total compensation cost rises above the $1 million outside option (row 3). The manager's allocation of the cash component of compensation between the market asset and the riskfree asset is reported in row 4.

Next is the core of the analysis: the effect of the compensation grants on incentives.[24] The absolute levels of the incentive levers are not meaningful since the marginal effect of effort on the mean stock price has been divided out. I normalize the level of total incentives achieved with a $100,000 stock grant to 1000, and measure all incentives relative to this yardstick. As expected, total incentives (row 11) rise with the size of the stock grant. The decomposition into the incentive levers illustrates how this increase is allocated between the manager's expected marginal need for funds (Lever 1), the expected effect of effort on wealth (Lever 2) and the co-movement between marginal utility and the marginal effect of effort (Lever 3):

With expected utility fixed at the manager's best outside opportunity, expected marginal utility is increasing in the volatility of wealth. Following row 5 across panels, expected marginal utility does indeed increase in the size of the stock grant. This is the precautionary effort effect.

Row 6 reports Lever 2, the expected marginal effect of effort on managerial wealth. For restricted stock grants, this is trivially equal to the pay-for-performance sensitivity, which in turn is equal to the number of shares the manager receives. Row 9 reports the product of Levers 1 and 2, i.e. the product of expected marginal need for funds and the expected marginal effect of effort on wealth. This product would be the correct measure of incentives with a linear compensation contract and an additive error structure. The multiplicative error structure of our model causes the covariance between

[24]Several caveats apply to the analysis of incentives: First, a tenfold increase in the measured incentive pressure does not necessarily translate into ten times higher effort. The optimal increase in effort depends on both the cost-of-effort function and the effect of effort on the expected share price. Second, the higher cost of effort which the manager needs to be compensated for is ignored. I have experimented with both linear and quadratic cost-of-effort functions with qualitatively similar results to the ones presented. Finally, the effect of effort on the stock price at time zero is ignored. The analysis should be interpreted as a comparison between different rational expectations equilibria in which the initial stock price is normalized to a common level, and not as a comparative statics analysis of a single equilibrium. Calculating the full rational expectations equilibrium by making the initial firm value both linear and quadratic functions of effort yields qualitatively similar results.

marginal utility and effort effect to be negative (Lever 3 in row 10). The effect is economically significant - the incentives from a $1 million stock grant are reduced by 22%.

The interesting question for the designer of incentive schemes is whether the same level of incentives can be achieved more cheaply using incentive options. The results are reported in Panel B of Table I. Following common practice, I assume that the strike price of all stock options is set at the money.[25]

Consistent with previous research, the executive values option grants by much less than their Black-Scholes value (row 2). Comparing Panel A with Panel B, these subjective valuations are considerably lower than for stock grants. This causes the total compensation cost to rise rapidly with the size of the grant (row 3). The allocation to the market asset is again reported in row 4.

Strikingly, the total compensation cost for achieving the *same* level of incentives is consistently higher with stock options than with restricted stock. The loss from using options instead of stock is reported at the bottom of Panel B. Two effects combine to make options inefficient creators of incentives: One is the low valuation the manager puts on option grants (row 2). The second effect is that the incentives induced by options are much lower than their pay-for-performance sensitivity would lead to expect. The decomposition of incentives into the three levers illustrates the effect:

Expected marginal utility (Lever 1) again increases in the volatility of wealth, and more rapidly in the option case than with stock grants. Granting options induces more risk into managerial wealth than granting stock, thereby increasing the manager's effort incentives. The contribution of precautionary effort to total effort incentives increases from 0.2% in column 2 to 41% in the last column.

Lever 2, the expected marginal effect of effort on managerial wealth, is equal to the expected pay-for-performance sensitivity plus the covariance between pay-for-performance and the noise term. The remarkable result is

[25] Murphy (1999) reports that this is the case for about 95% of all option grants granted to CEOs in the US.

that Lever 2 takes huge values with option grants compared to its value with stock grants. The average link between effort and managerial wealth is substantially tighter in Panel B than in Panel A. An econometrician focused on estimating pay-for-performance sensitivities would conclude that the recipient of the option grants in Panel B has substantially higher effort incentives than the recipient of the stock grants in Panel A.

The reason why this conclusion would be false is Lever 3: The covariance between marginal utility and the marginal effect of effort on wealth is large and negative. It becomes rapidly more negative with the size of the option grant, reducing the manager's effort incentives by 24% in column 2 and 72% in column 6. Much of the pay-for-performance sensitivity (Lever 2) of options does not translate into incentives because of the pay-for-performance pattern across states: Effort translates into higher wealth in those states in which the manager values the additional funds the least.

The composition of effort incentives from the three levers is illustrated in Diagram I. Panel A presents the case of stock grants and Panel B the case of option grants. It is striking to see how the product of expected marginal need for funds (Lever 1) and expected marginal effect of effort on wealth (Lever 2) shoots up with the size of the option grant, while total incentives remain at moderate levels due to the dampening effect of Lever 3. The broken line represents the expected pay-for-performance sensitivity and lies substantially above the actual incentives created by options. Hence an empirical analysis estimating pay-for-performance as measure of incentives severely overstates the effect of options relative to the effect of equity.

Section 2.2: Private Wealth and Firm-Related Wealth

The analysis in the preceding section is unrealistic in that the manager does not have any wealth beyond the current compensation contract. Clearly, senior managers have substantial private wealth, with at least a portion of it held in equity in the firm from previous grants (Hall and Liebman, 1998). The incentive effects of the compensation contract will be weakened by wealth held outside the firm, and reinforced by additional wealth held in securities of the firm. Unfortunately, there does not exist reliable data on the non-firm wealth held by executives. Following standard practice I use several ratios of firm-related to non-firm wealth in the analysis. The results from the previous section turn out to be robust to the different scenarios.

I assume that the manager has current wealth of ten million dollars,[26] and analyze three different scenarios for the ratio of firm-related to non-firm wealth. The personal wealth tied up in the firm can be interpreted as an equity stake, potentially from previous stock or option grants, or as firm-specific human capital. The executive's allocates her non-firm wealth optimally between cash and the risky market asset, with the optimality condition given by (3). Importantly, the executive is prohibited from selling prior equity stakes when faced with a new grant. This assumption can be justified by contractual restrictions on the sale of company stock, legal restrictions on insider sales, the bad signal conveyed to equity markets through insider sales, and by the inalienability of firm-specific human capital.[27] The other assumptions for the calibration exercise are the same as in Table I.

Table II repeats the analysis of incentive creation from Table I for three wealth scenarios. In Panel A, the executive has 25% of her $10 million wealth invested in the firm. Panels B and C show the results when the executive has 0% and 50% of wealth in the firm respectively. To conserve on space, only the cost difference between using either stock or option grants to create the same incentives is reported for the latter two cases. The effort incentives of an executive with 25% of wealth tied to the firm and a $1m cash grant are normalized to 1000. All other incentive levels are measured relative to this normalization.

The message from Table II is simple: First, stock grants retain their efficiency advantage over option grants when the manager has private wealth for all the scenarios considered. Second, the cost advantage of stock grants (holding incentives constant) is increasing in the share of private wealth tied to the firm. The source of the inefficiency of option compensation is again twofold: First, the manager values option grants at much lower levels than stock grants in all scenarios. Second, the covariance of marginal utility and

[26]This number is roughly consistent with the empirical results reported in Hall and Liebman (1998). The assumption of private wealth of $10m has also been used by Lambert, Larcker and Verrecchia (1991) in their analysis of executive compensation.

[27]Empirically, Ofek and Yermack (2000) report that executives with large equity holdings reduce their unrestricted stock holdings in face of new grants. Bettis, Coles and Lemmon (2000) examine policies and procedures installed by public companies to restrict trading in the stock by corporate insiders. Core and Guay (2001) analyze the polar opposite case in which the manager is allowed to reduce her prior holdings by exactly the size of the grant.

marginal effect of effort on wealth is substantially more negative with option grants than stock grants (Lever 3). Both effects become more pronounced as the percentage of wealth tied to the firm increases.[28] The composition of total effort incentives in the case with private wealth and 25% of it tied to the firm is illustrated in Diagram II. Panel A presents the case of stock grants and Panel B the case of option grants. The similarity to the analysis without private wealth is obvious.

Section 2.3: The Effect of Private Trading on Valuation and Incentives

A novelty in this paper is that the manager is allowed to freely trade the market asset through her private account. This enables her to compensate for the systematic component of risk in the compensation package by reducing the exposure of non-firm wealth. The no-short-sale restriction on company stock forces the executive to bear the non-systematic risk in returns, motivating a further reduction in her holdings of the market asset.[29]

The endogenous reduction in market exposure was evident in all the cases analyzed so far. In Table II (Panel A), the executive reacts to larger stock grants by reducing the market component in her non-firm portfolio from 91% without a stock grant to 9% for a $1m stock grant. In Panel B, the executive reacts to larger option grants by reducing the allocation to the market from 91% to 17%. In unreported results I force the manager to keep her portfolio allocation unchanged as the size of the grant increases. This leads to both lower managerial valuations of the grants and lower incentives. Thus ignoring the manager's ability to adjust the market exposure of her private portfolio back to optimal levels makes equity-based compensation appear less efficient than it is.

[28] An interesting observation is that the incentives created purely by the portion of private wealth tied to the firm is more than twice as large in the 50% firm-specific wealth scenario than in the 25% scenario. Thus at least for some range, there are "increasing returns" in terms of incentives created by the number of shares in managerial wealth. The cause is the precautionary effort effect, with expected marginal utility (Lever 1) rising faster than the covariance term in Lever 3 becoming more negative.

[29] The observation that the executive reduces her allocation to the market asset in face of unhedgable idiosyncratic risk in the stock grant holds true for most reasonable utility functions. See Gollier and Pratt (1996) for conditions under which risk-taking is reduced in face of unavoidable background risk.

Intuitively, by reducing her holdings of the market asset, the manager achieves an effect similar to "indexing" the stock or option grant. Both academics and practitioners have argued forcefully for the use of executive stock options indexed to some measure of stock market performance.[30] The theoretical rational is provided by the literature on the optimality of relative performance evaluation.[31] Measuring managerial performance relative to an index reduces the amount of exogenous noise in the performance measure, preventing the principal from rewarding underperforming managers in a rising stock market and from punishing outperforming managers in a declining market. Furthermore, indexed options are considerably less expensive than standard options. At first glance, it therefore appears that indexed stock options are a more efficient creator of effort incentives than standard options.

My analysis broadly confirms this intuition, and adds two important insights: Even compared to indexed options, restricted stock remains a more cost-efficient creator of effort incentives. Furthermore, endogenizing the manager's private asset portfolio reduces the advantage of indexed over non-indexed options. With non-indexed options, the manager receives additional exposure to market risk through the option grant, and aggressively reduces the market exposure of her private portfolio. With indexed options, the grant does not contain additional exposure to market risk, and the adjustment of the private portfolio is small. Thus trading in the private portfolio allows the manager to adjust her market exposure in response to grants of non-indexed options, reducing the benefit of indexation. In the static framework considered here, the manager is not able to perfectly replicate the indexation through private trading. If the manager was allowed to continuously adjust her portfolio over the life of the option grant, the advantage of indexed over standard options is bound to vanish completely.

Table III presents the numerical results. Similar to the analysis for standard options, I determine grants of indexed options which induce the same level of effort incentives as the restricted stock grants in Panel A of Table II. To preserve space, I focus again on the scenario in which 25% of private wealth is tied to the firm. All other assumptions are the same as in the previous analysis, and the normalization of incentives from Table II is

[30] See especially Rappaport (1999) for this argument.

[31] See Holmstrom (1982) and Gibbons and Murphy (1990).

retained.[32]

At the bottom of Table III, the total cost of compensation is compared to restricted stock and non-indexed options. Incentive creation with indexed options is more expensive than with stock grants, but less expensive than with standard non-indexed options. Indexed options are more efficient because they deliver pay-for-performance more cheaply than standard options, and because less pay-for-performance is required to generate incentives. The latter is due to a less negative covariance between pay-for-performance and marginal utility (Lever 3). The advantage of indexed options is reduced by a lower ratio of managerial valuation to market valuation compared to standard options, but not sufficiently to overturn the result.

To assess how the manager's private trading affects the results, the comparative analysis is repeated while preventing the manager from adjusting the market exposure of her private portfolio. With the allocation of private wealth to the market asset fixed, the cost advantage of indexed options over standard options increases substantially, and almost doubles in the last column of Table III. This confirms the intuition that (even in a static model) private trading allows the manager to reap much of the benefits of indexation simply by optimally trading in the market asset.

The analysis underscores the need to distinguish between systematic and non-systematic risk when designing compensation schemes: The executive easily adjusts her exposure to the market factor to optimal levels. For the range of parameters considered, this does not involve shorting the market, and hence whether the manager faces short-sale constraints is irrelevant. The trade-off between risk and incentives at the core of the principal-agent problem turns out to be a trade-off between idiosyncratic risk and incentives.[33]

Section 2.4: The Effect of Noise in the Performance Measure

The introduction raised the question whether more exogenous noise in the performance measure increases or decreases managerial effort with a given

[32] The market value of the indexed options, equal to the cost of granting indexed options to the firm, is calculated using the pricing model of Margrabe (1978) as presented in Johnson and Tian (2000a).

[33] Li (2000) provides a closely related discussion of how *optimal* incentive levels are affected by idiosyncratic risk only and unaffected by systematic risk.

compensation contract. The incentive decomposition identifies two counteracting forces: More noise in the performance measure increases Lever 1 and Lever 2 and hence increases effort incentives. At the same time the link between effort and wealth becomes moire noisy, making the covariance between marginal utility and the marginal effect of effort on wealth more negative (Lever 3).

To assess the net effect of noise on effort, I repeat the analysis from Section 2.2 and increase the annualized standard deviation of stock returns from 30% to 80%.[34] For brevity, the only results shown are for the scenario in which the manager has $10 million in private wealth, 25% of which is tied to firm performance. The results are reported in Table IV, and the normalization of effort incentives from Table II is maintained.

Panel A reports the effort incentives created by restricted stock grants between zero and one million dollars. The incentive levels are substantially lower than with 30% volatility. As predicted, the precautionary effort effect (Lever 1) increases effort incentives, but the negative effect of Lever 3 is substantially larger.

Panel B uses incentive options to create the same level of incentives as in Panel A. Options turn out to be extremely inefficient creators of incentives under the high-noise scenario, with the cost advantage of stock rising by an order of magnitude relative to the low-noise scenario in Table II. The increased inefficiency of options is caused by a large drop in managerial valuations relative to market values, and by substantially larger negative values for Lever 3. The incentive decomposition for the high-noise scenarios is illustrated in Diagram 3.

Pay-for-performance overstates actual incentives especially severely when options are granted in a high-noise environment, a case with obvious empirical relevance. The observation of incentives decreasing in volatility for a given level of (measured) pay-for-performance has not been emphasized in the optimal contracting literature. This omission seems to be due to the focus on models with additive noise terms which allow analytical solutions.

[34] Meulbrok (2000) reports that for a sample of publicly traded Internet companies the median anualized standard deviation of returns is well above 100%.

Section 2.5: Slack Participation Constraints and Share Purchase Programs

The results presented so far indicate that options are inferior creators of managerial incentives when compared to restricted stock. A maintained assumption in the analysis was that the managers is always at her participation constrained. This was achieved by reducing the cash component of compensation at the same time as the size of the stock or option grant was increased. This raises an obvious problem when the level of desired incentive is very high and hence requires a very high pay-for-performance sensitivity: Either the cash component becomes negative, i.e. the manager purchases additional shares with her own funds, or the participation constraint will no longer be binding. But simply increasing the size of the stock grant above the manager's participation constraint does by no means guarantee that the desired level of incentives will be achieved: Making the manager richer lowers his expected marginal need for additional funds (Lever 1) and may in fact result in *lower* incentives.

Negative cash compensation can be implemented by offering shares to the executive for purchase at a discounted price. This allows to leave expected utility at the reservation level, avoiding the negative wealth effect on incentives, and lowers the cost of compensation. Stock purchase plans for executives are common in practice.[35] For the purpose of illustration consider a simple scheme in which the manager receives no cash payment, a stock grant that leaves her expected utility at the reservation level, and the option to purchase a set number of additional shares at a company-specified price. The purchase price is chosen such that the executive is indifferent between buying or rejecting the additional shares.

Table V presents the results of this analysis. Panel A reports the results with the share purchase program. For comparison, Panel B shows the results when option grants are used to achieve the same level of incentives. For brevity the only results shown are again for the scenario in which 25% of $10 million in wealth is tied to the firm. All other assumptions are the same as in the Section 2.2, and the normalization of incentives from Table II is maintained.

Column 1 of Panel A reports the incentives created if compensation con-

[35] See Salter (2000) for a description of the institutional details.

sists of a $1.05 million restricted stock grant. This grant provides the manager with the same expected utility as $1m in cash, and no further cash compensation is needed to attain the reservation level of expected utility. Columns 2 to 6 have the manager purchase additional shares with her own funds to increase the total inflow of stock into her portfolio, reported in row 1. The amount paid by the manager for the additional shares is reported in row 3.

Panel B uses restricted option grants to create the same levels of incentives. The results are similar to Table II and indicate that option compensation is again less efficient than the combination of stock grants and share purchase plan. The cost advantage of stock over option compensation is below Panel B, and rises from $13,603 for a $1.05m stock grant to $97,492 for a $3m stock grant.

Finally, Panel C uses simple stock grants without purchase plan in an attempt to create effort incentives equal to the ones in Panel A and B. This attempt fails: Simply granting the manager more restricted stock raises her expected utility, lowers her expected marginal utility (Lever 1) and therefore decreases her incentives to exert effort. The increase in pay-for-performance sensitivity (Lever 2) is insufficient to compensate. In fact incentives *decrease* as the size of the option grant increases. Without the requirement to invest private funds, the manager simply becomes too rich to be motivated.

The conclusion from Table V is straight-forward: To achieve high levels of effort incentives, stock grants are optimally combined with a share purchase program requiring the executive to put her own money on the line. If this is impossible, for instance because the manager has insufficient funds on her own and is borrowing constrained, then options may be the only means by which the desired level of incentives can be achieved. Whether this case is empirically relevant and therefore a valid explanation for the prevalence of executive stock options in practice is an interesting topic for future research. A closely related argument for the usage of options has been advanced by Maug and Peng (2000) who argue that options are part of the optimal compensation contract when managers are liquidity constrained and cannot borrow against future compensation.

Summary and Conclusion

The analysis of the connection between compensation schemes and managerial effort incentives has yielded several interesting results:

Careful consideration has to be given to the co-movement of compensation and marginal utility when designing compensation schedules. The link between managerial wealth and corporate performance should not be restricted to states of nature in which performance is good. Grants of restricted options are a prime example of a scheme which fails on this account. The negative covariance of pay-for-performance and marginal utility reduces ex-ante effort incentives substantially, and the more so the higher the volatility of stock returns. The combination of low managerial valuations of incentive options and inefficient incentive creation makes options inferior means of producing effort incentives.

If the effect of managerial effort on performance is stochastic, then the incentives induced by a given compensation contract are decreasing in the volatility of the performance measure. Thus the link between managerial wealth and performance necessary to achieve a desired level of effort incentives is increasing in the level of noise.

Pay-for-performance is a systematically biased measure of incentives. It understates the incentives generated by equity holdings relative to the incentives generated by option grants. The bias is again increasing in the volatility of stock returns, offering an additional explanation for the empirical finding that pay-for-performance does not decrease with volatility as predicted by the optimal contracting framework.

Finally, the trading behavior of managers plays an important role in the optimal design of compensation contracts. Designing compensation schemes under the assumption that the manager does not adjust her portfolio in response to a compensation contract makes equity-based compensation look considerably less effective than it is: The costs of compensating the executive are overstated, and incentive effects are understated. Furthermore, the benefit of indexing compensation schemes to market or industry returns is reduced or even eliminated when the manager is able to freely trade the index through her private account. This result may explain the empirical absence of indexation in executive compensation schemes.

Appendix: The Certainty Equivalence Approach

This appendix derives the relationship between the incentive measure used in this paper and the certainty equivalence measure used by Hall and Murphy (2000a,b). The certainty equivalence valuation for a single stock option is defined as the amount of riskless cash compensation the executive would exchange for the option. Suppose that the executive has non-firm-related wealth of W_0, holds S shares of company stock, and is granted an option to buy one share at exercise price X next period. Following Hall and Murphy, assume for simplicity that W_0 is invested at the risk-free rate. The executive's next period wealth is given by:

$$\widetilde{W_1} = W_0 \cdot R_f + S \cdot \widetilde{P_1} + Max[\widetilde{P_1} - X, 0]$$

If instead of the option the executive receives an amount V in cash, W_1 is given by:

$$\widetilde{W_1^V} = (W_0 + V) \cdot R_f + S \cdot \widetilde{P_1}.$$

The certainty equivalence value of the option is defined as the amount of cash V which equates

$$EU[\widetilde{W_1}] = EU[\widetilde{W_1^V}]. \tag{6}$$

Hall and Murphy calculate V numerically, and define their measure of incentives as the derivative of V with respect to the beginning stock price. Applying the implicit function theorem to (6), it is straightforward to show that the derivative is given by

$$\frac{dV}{dP_0} = \frac{1}{R_f \cdot EU'[\widetilde{W_1^V}]} \left[E\left(\frac{\partial U[\widetilde{W_1}]}{\partial P_0}\right) - E\left(\frac{\partial U[\widetilde{W_1^V}]}{\partial P_0}\right)\right] \tag{7}$$

Recall that the measure of incentives used in this paper is given by

$$E\left(\frac{\partial U[\widetilde{W_1}]}{\partial \overline{P_1}}\right) = E\left(\frac{\partial U[\widetilde{W_1}]}{\partial \widetilde{P_1}} \cdot \widetilde{\varepsilon}_m \widetilde{\varepsilon}_i\right)$$

where $\overline{P_1}$ is defined as the expectation of $\widetilde{P_1}$. Hence the Hall and Murphy measure of incentives in (7) is essentially a linear transformation of the incentive measure introduced in this paper. The only economically meaningful difference is that Hall and Murphy consider the derivative of the certainty equivalence valuation with respect to the grant-date stock price, while our measure uses the derivative with respect to the maturity date stock price.

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Table I: Incentives With No Private Wealth

Panel A: Restricted Stock Grants

1	**Stock Grant in $**	**0**	**100,000**	**300,000**	**500,000**	**700,000**	**1,000,000**
2	Valuation-to-Cost Ratio	100%	98.97%	97.04%	95.24%	93.53%	91.08%
3	**Total Cost to Firm in $**	1,000,000	1,001,030	1,008,882	1,023,809	1,045,298	1,089,233
4	Personal Investment into Market Asset	90.85%	89.85%	87.25%	83.05%	74.95%	9.15%
	Incentive Levers:						
5	**Lever 1: Expected Marginal Utility**	**1.088**	**1.089**	**1.097**	**1.112**	**1.134**	**1.183**
6	**Lever 2: Expected Marginal Effect of Effort on Wealth**	**0**	**1,000**	**3,000**	**5,000**	**7,000**	**10,000**
7	of which: E(W'(P))	0	1,000	3,000	5,000	7,000	10,000
8	Cov(W',noise)	0	0	0	0	0	0
9	Product of Lever 1 and Lever 2	0	1,089	3,291	5,560	7,940	11,827
10	**Lever 3: Covariance of Marginal Utility and Marginal Effect of Effort on Wealth**	**0**	**-89**	**-383**	**-824**	**-1,414**	**-2,618**
11	**Total Incentives**	**0**	**1,000**	**2,908**	**4,737**	**6,526**	**9,208**

Panel B: Restricted Option Grants Achieving the Same Level of Incentives

1	**Option Grant in $**	**0**	**21,493**	**72,319**	**138,255**	**229,967**	**481,558**
2	Valuation-to-Cost Ratio	100%	92.89%	79.63%	67.05%	54.76%	36.05%
3	**Total Cost to Firm in $**	1,000,000	1,001,527	1,014,731	1,045,560	1,104,044	1,307,950
4	Personal Investment into Market Asset	90.85%	82.85%	67.05%	51.65%	36.85%	16.85%
	Incentive Levers:						
5	**Lever 1: Expected Marginal Utility**	**1.088**	**1.089**	**1.101**	**1.123**	**1.155**	**1.229**
6	**Lever 2: Expected Marginal Effect of Effort on Wealth**	**0**	**1,203**	**4,046**	**7,735**	**12,867**	**26,943**
7	of which: E(W'(P))	0	1,042	3,507	6,704	11,152	23,352
8	Cov(W',noise)	0	160	539	1,031	1,715	3,591
9	Product of Lever 1 and Lever 2	0	1,310	4,454	8,683	14,866	33,123
10	**Lever 3: Covariance of Marginal Utility and Marginal Effect of Effort on Wealth**	**0**	**-310**	**-1,546**	**-3,947**	**-8,340**	**-23,914**
11	**Total Incentives**	**0**	**1,000**	**2,908**	**4,737**	**6,526**	**9,208**
	Cost Advantage of Stock Grant in $	**0**	**497**	**5,850**	**21,751**	**58,747**	**218,716**

Table II: Incentives with $10 Million in Private Wealth

Panel A1: Restricted Stock Grants, 25% of Private Wealth tied to Firm

1	**Stock Grant in $**	**0**	**100,000**	**300,000**	**500,000**	**700,000**	**1,000,000**
2	Valuation-to-Cost Ratio	100%	95.47%	95.29%	95.13%	94.96%	94.71%
3	**Total Cost to Firm in $**	**1,000,000**	**1,004,531**	**1,014,141**	**1,024,375**	**1,035,313**	**1,052,891**
4	Personal Investment into Market Asset	88.25%	88.15%	87.85%	87.65%	87.35%	86.85%
	Incentive Levers:						
5	**Lever 1: Expected Marginal Utility**	**0.04466**	**0.04468**	**0.04471**	**0.04476**	**0.04480**	**0.04486**
6	**Lever 2: Expected Marginal Effect of Effort on Wealth**	**25,000**	**26,000**	**28,000**	**30,000**	**32,000**	**35,000**
7	of which: E(W'(P))	25,000	26,000	28,000	30,000	32,000	35,000
8	Cov(W',noise)	0	0	0	0	0	0
9	Product of Lever 1 and Lever 2	1,117	1,162	1,252	1,343	1,433	1,570
10	**Lever 3: Covariance of Marginal Utility and Marginal Effect of Effort on Wealth**	**-117**	**-123**	**-136**	**-151**	**-165**	**-188**
11	**Total Incentives**	**1,000**	**1,039**	**1,116**	**1,192**	**1,268**	**1,382**

Panel A2: Restricted Option Grants Achieving the Same Level of Incentives, 25% of Wealth tied to firm

1	**Option Grant in $**	**0**	**23,024**	**69,793**	**117,559**	**166,341**	**241,546**
2	Valuation-to-Cost Ratio	100%	77.70%	76.62%	75.56%	74.54%	72.97%
3	**Total Cost to Firm in $**	**1,000,000**	**1,005,133**	**1,016,317**	**1,028,731**	**1,042,357**	**1,065,296**
4	Personal Investment into Market Asset	88.25%	87.35%	85.65%	83.85%	82.15%	79.55%
	Incentive Levers:						
5	**Lever 1: Expected Marginal Utility**	**0.04466**	**0.04468**	**0.04472**	**0.04476**	**0.04481**	**0.04488**
6	**Lever 2: Expected Marginal Effect of Effort on Wealth**	**25,000**	**26,288**	**28,905**	**31,577**	**34,307**	**38,514**
7	of which: E(W'(P))	25,000	26,117	28,385	30,701	33,066	36,713
8	Cov(W',noise)	0	172	520	877	1,240	1,801
9	Product of Lever 1 and Lever 2	1,117	1,175	1,293	1,413	1,537	1,729
10	**Lever 3: Covariance of Marginal Utility and Marginal Effect of Effort on Wealth**	**-117**	**-136**	**-177**	**-221**	**-269**	**-346**
11	**Total Incentives**	**1,000**	**1,039**	**1,116**	**1,192**	**1,268**	**1,382**

Cost Advantage of Stock Grant in $	**0**	**602**	**2,176**	**4,356**	**7,044**	**12,405**

Panel B: 0% of Private Wealth tied to Firm

Cost Advantage of Stock Grant in $	**0**	**32**	**364**	**1,082**	**2,168**	**4,476**

Panel C: 50% of Private Wealth tied to Firm

Cost Advantage of Stock Grant in $	**0**	**1,767**	**5,702**	**10,685**	**16,602**	**27,241**

Table III: Incentives with Indexed Option Grants and $10 Million in Private Wealth

Restricted *Indexed* Option Grants Achieving the *Same Level of Incentives* as in Panel A1 of Table II, 25% of Wealth tied to firm

1	**Option Grant in $**	**17,826**	**54,084**	**91,203**	**129,199**	**187,876**
2	Valuation-to-Cost Ratio	72.31%	71.29%	70.11%	68.96%	67.26%
3	**Total Cost to Firm in $**	**1,004,936**	**1,015,530**	**1,027,257**	**1,040,098**	**1,061,509**
4	Personal Investment into Market Asset	88.25%	88.25%	88.25%	88.15%	88.15%
	Incentive Levers:					
5	**Lever 1: Expected Marginal Utility**	**0.04468**	**0.04471**	**0.04475**	**0.04479**	**0.04486**
6	**Lever 2: Expected Marginal Effect of Effort on Wealth**	**26,164**	**28,532**	**30,956**	**33,438**	**37,270**
7	of which: E(W'(P))	25,987	27,993	30,047	32,150	35,397
8	Cov(W',noise)	178	539	909	1,288	1,873
9	Product of Lever 1 and Lever 2	1,169	1,276	1,385	1,498	1,672
10	**Lever 3: Covariance of Marginal Utility and Marginal Effect of Effort on Wealth**	**-130**	**-160**	**-193**	**-229**	**-290**
11	**Total Incentives**	**1,039**	**1,116**	**1,192**	**1,268**	**1,382**

Cost Advantage of Stock in $	**404**	**1,389**	**2,882**	**4,785**	**8,618**
Cost Advantage over Standard Options in $	**197**	**787**	**1,474**	**2,259**	**3,787**
Cost Advantage over Standard Options in $ *with the allocation to the market asset fixed*.	**262**	**975**	**2,155**	**3,644**	**6,734**

Table IV: Incentives with $10 Million in Private Wealth and High Volatility

Panel A: Restricted Stock Grants, 25% of Private Wealth tied to Firm, 80% Standard Deviation

1	**Stock Grant in $**	**0**	**100,000**	**300,000**	**500,000**	**700,000**	**1,000,000**
2	Valuation-to-Cost Ratio	100%	73.44%	72.79%	72.14%	71.53%	70.63%
3	**Total Cost to Firm in $**	**1,000,000**	**1,026,563**	**1,081,641**	**1,139,297**	**1,199,297**	**1,293,672**
4	Personal Investment into Market Asset	88.95%	88.85%	88.75%	88.55%	88.45%	88.25%
	Incentive Levers:						
5	**Lever 1: Expected Marginal Utility**	**0.0513**	**0.0515**	**0.0517**	**0.0519**	**0.0521**	**0.0524**
6	**Lever 2: Expected Marginal Effect of Effort on Wealth**	**25,000**	**26,000**	**28,000**	**30,000**	**32,000**	**35,000**
7	of which: E(W'(P))	25,000	26,000	28,000	30,000	32,000	35,000
8	Cov(W',noise)	0	0	0	0	0	0
9	Product of Lever 1 and Lever 2	1,283	1,340	1,448	1,556	1,666	1,832
10	**Lever 3: Covariance of Marginal Utility and Marginal Effect of Effort on Wealth**	**-393**	**-422**	**-473**	**-527**	**-582**	**-669**
11	**Total Incentives**	**889**	**918**	**975**	**1,030**	**1,084**	**1,163**

Panel B: Restricted Option Grants Achieving the *Same Level of Incentives*

1	**Option Grant in $**	**0**	**63,118**	**197,706**	**344,350**	**504,671**	**774,685**
2	Valuation-to-Cost Ratio	100%	37.01%	35.11%	33.26%	31.47%	28.88%
3	**Total Cost to Firm in $**	**1,000,000**	**1,039,758**	**1,128,292**	**1,229,818**	**1,345,843**	**1,550,974**
4	Personal Investment into Market Asset	88.95%	88.45%	87.35%	86.45%	85.45%	84.05%
	Incentive Levers:						
5	**Lever 1: Expected Marginal Utility**	**0.0513**	**0.0515**	**0.0517**	**0.0520**	**0.0522**	**0.0525**
6	**Lever 2: Expected Marginal Effect of Effort on Wealth**	**25,000**	**26,619**	**30,071**	**33,833**	**37,945**	**44,871**
7	of which: E(W'(P))	25,000	26,041	28,259	30,677	33,320	37,772
8	Cov(W',noise)	0	578	1,812	3,156	4,625	7,100
9	Product of Lever 1 and Lever 2	1,283	1,372	1,556	1,758	1,980	2,357
10	**Lever 3: Covariance of Marginal Utility and Marginal Effect of Effort on Wealth**	**-393**	**-454**	**-581**	**-728**	**-896**	**-1,194**
11	**Total Incentives**	**889**	**918**	**975**	**1,030**	**1,084**	**1,163**
	Cost Advantage of Stock in $	**0**	**13,196**	**46,651**	**90,522**	**146,546**	**257,303**

Table V: Share Purchase Programs with $10 Million in Private Wealth

Panel A: Restricted Stock Grants and Stock Purchases, 25% of Private Wealth tied to Firm

1	**Stock Grant in $**	**1,056,326**	**1,400,000**	**1,800,000**	**2,200,000**	**2,600,000**	**3,000,000**
2	Valuation-to-Cost Ratio	94.67%	94.39%	94.07%	93.76%	93.44%	93.14%
3	**Cash Grant in $**	**0**	**-321,484**	**-693,281**	**-1,062,656**	**-1,429,531**	**-1,794,063**
4	**Total Cost to Firm in $**	**1,056,326**	**1,078,516**	**1,106,719**	**1,137,344**	**1,170,469**	**1,205,938**
5	Personal Investment into Market Asset	86.75%	86.25%	85.55%	84.75%	83.95%	82.95%
	Incentive Levers:						
6	**Lever 1: Expected Marginal Utility**	**0.04487**	**0.04496**	**0.04507**	**0.04518**	**0.04531**	**0.04544**
7	**Lever 2: Expected Marginal Effect of Effort on Wealth**	**35,563**	**39,000**	**43,000**	**47,000**	**51,000**	**55,000**
8	of which: E(W'(P))	35,563	39,000	43,000	47,000	51,000	55,000
9	Cov(W',noise)	0	0	0	0	0	0
10	Product of Lever 1 and Lever 2	1,596	1,753	1,938	2,124	2,311	2,499
11	**Lever 3: Covariance of Marginal Utility and Marginal Effect of Effort on Wealth**	**-192**	**-220**	**-255**	**-291**	**-330**	**-371**
12	**Total Incentives**	**1,404**	**1,533**	**1,683**	**1,832**	**1,980**	**2,128**

Panel B: Restricted Option Grants Achieving the *Same Level of Incentives*, 25% of Wealth tied to firm

1	**Option Grant in $**	**255,945**	**345,792**	**454,905**	**569,386**	**689,654**	**816,476**
2	Valuation-to-Cost Ratio	72.68%	70.91%	68.88%	66.85%	64.83%	62.84%
3	**Total Cost to Firm in $**	**1,069,929**	**1,100,596**	**1,141,585**	**1,188,761**	**1,242,544**	**1,303,430**
4	Personal Investment into Market Asset	79.05%	76.05%	72.55%	69.05%	65.55%	62.15%
	Incentive Levers:						
5	**Lever 1: Expected Marginal Utility**	**0.04490**	**0.04500**	**0.04512**	**0.04526**	**0.04541**	**0.04558**
6	**Lever 2: Expected Marginal Effect of Effort on Wealth**	**39,320**	**44,347**	**50,452**	**56,857**	**63,586**	**70,682**
7	of which: E(W'(P))	37,412	41,769	47,060	52,612	58,444	64,594
8	Cov(W',noise)	1,908	2,578	3,392	4,246	5,142	6,088
9	Product of Lever 1 and Lever 2	1,765	1,995	2,276	2,573	2,888	3,222
10	**Lever 3: Covariance of Marginal Utility and Marginal Effect of Effort on Wealth**	**-362**	**-462**	**-593**	**-741**	**-907**	**-1,094**
11	**Total Incentives**	**1,404**	**1,533**	**1,683**	**1,832**	**1,980**	**2,128**
	Cost Advantage of Stock in $	**13,603**	**22,081**	**34,866**	**51,417**	**72,076**	**97,492**

Panel C: Restricted Stock Grants without Stock Purchases, 25% of Private Wealth tied to Firm

1	**Stock Grant in $**	**1,056,326**	**1,400,000**	**1,800,000**	**2,200,000**	**2,600,000**	**3,000,000**
2	Valuation-to-Cost Ratio	94.67%	71.43%	55.56%	45.45%	38.46%	33.33%
3	**Total Cost to Firm in $**	**1,056,326**	**1,400,000**	**1,800,000**	**2,200,000**	**2,600,000**	**3,000,000**
4	Personal Investment into Market Asset	86.75%	86.45%	85.95%	85.55%	85.15%	84.75%
	Incentive Levers:						
5	**Lever 1: Expected Marginal Utility**	**0.04487**	**0.03997**	**0.03508**	**0.03093**	**0.02739**	**0.02435**
6	**Lever 2: Expected Marginal Effect of Effort on Wealth**	**35,563**	**39,000**	**43,000**	**47,000**	**51,000**	**55,000**
7	of which: E(W'(P))	35,563	39,000	43,000	47,000	51,000	55,000
8	Cov(W',noise)	0	0	0	0	0	0
9	Product of Lever 1 and Lever 2	1,596	1,559	1,508	1,454	1,397	1,339
10	**Lever 3: Covariance of Marginal Utility and Marginal Effect of Effort on Wealth**	**-192**	**-193**	**-193**	**-191**	**-188**	**-184**
11	**Total Incentives**	**1,404**	**1,365**	**1,316**	**1,263**	**1,209**	**1,155**

Diagram 1A: Effort Incentives from Stock Grants

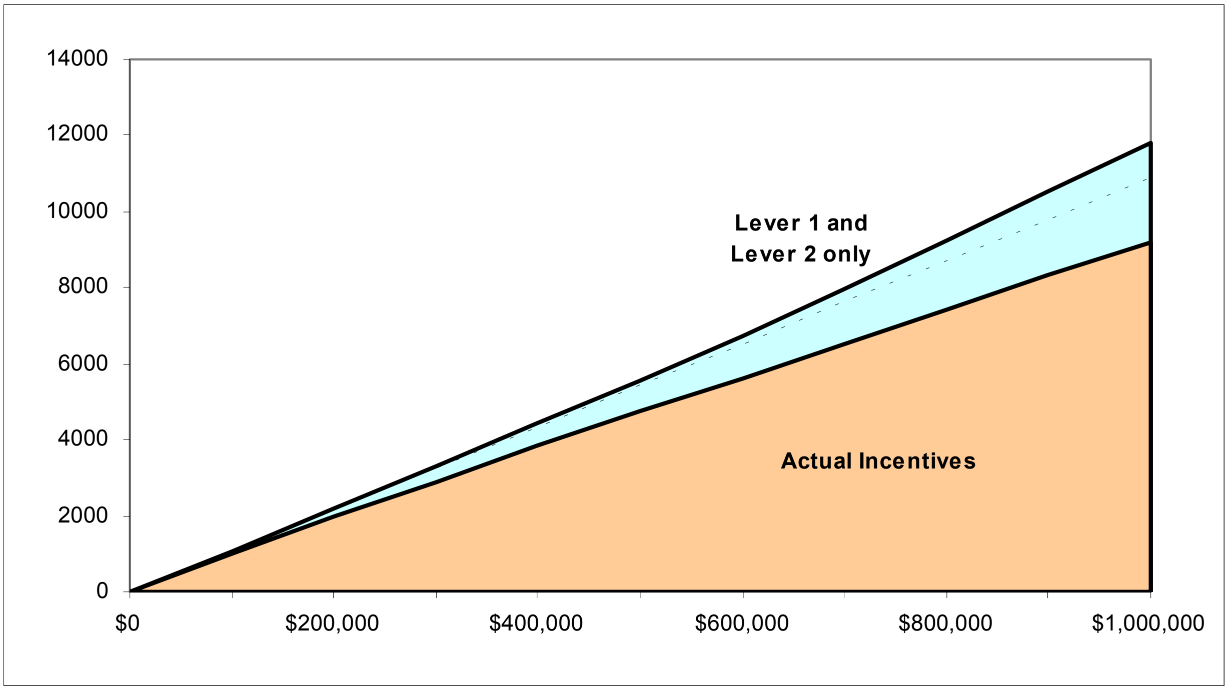


Diagram 1B: Effort Incentives from Option Grants

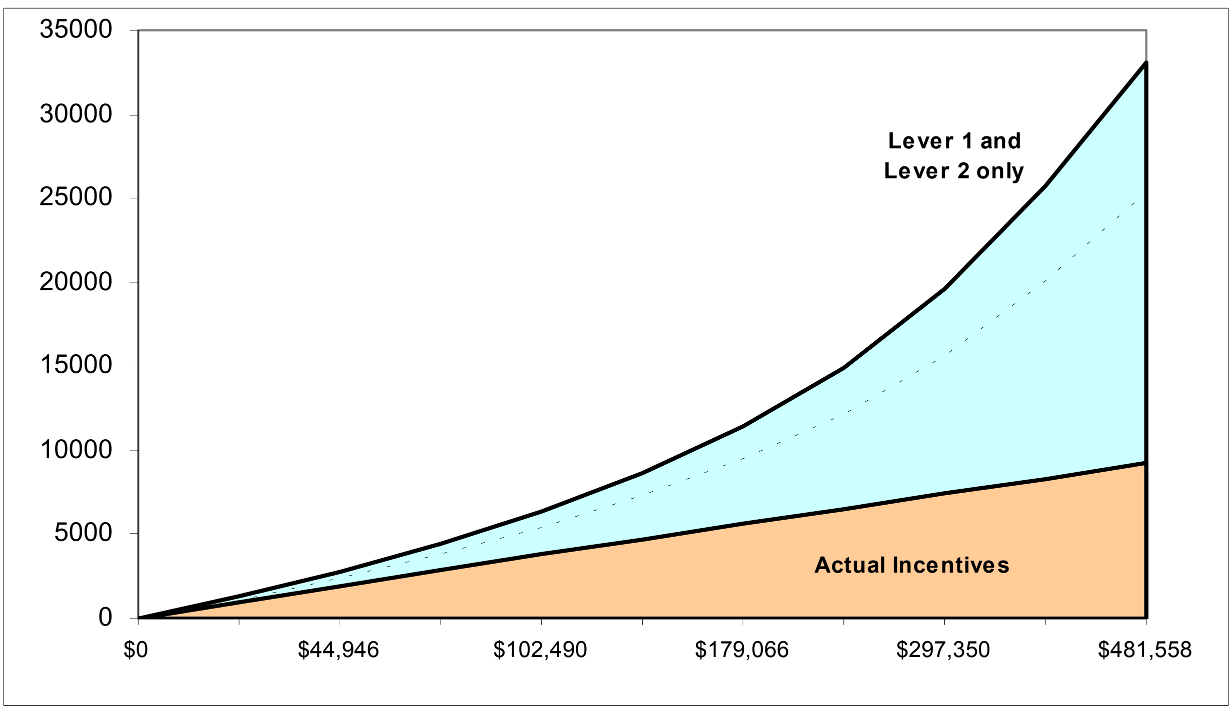


Diagram 1A presents the effort incentives created by restricted stock grants with market values between zero and one million dollar. **Diagram 1B** presents the decomposition for option grants creating the same level of incentives (note the difference in scale). The actual incentive levels are shaded dark. The light area represents the negative effect of Lever 3, the covariance between marginal utility and the marginal effect of effort on wealth. The broken line represents the expected pay-for-performance sensitivity, which is the most common measure of incentives.

Diagram 2A: Effort Incentives from Stock Grants with Private Wealth

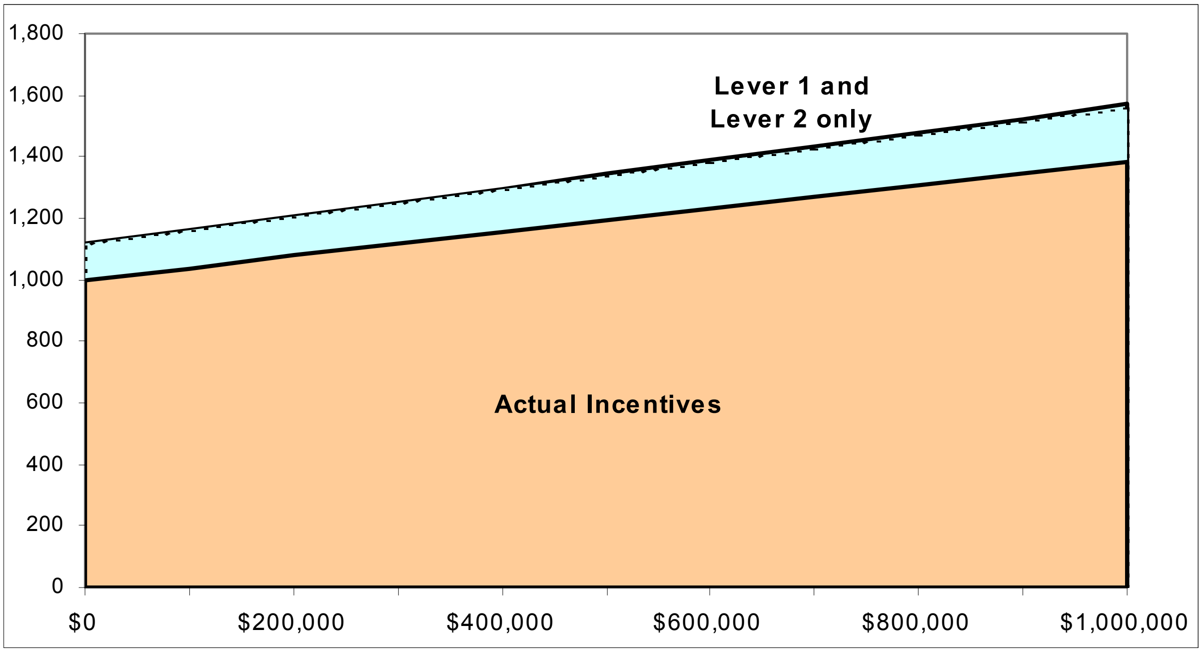
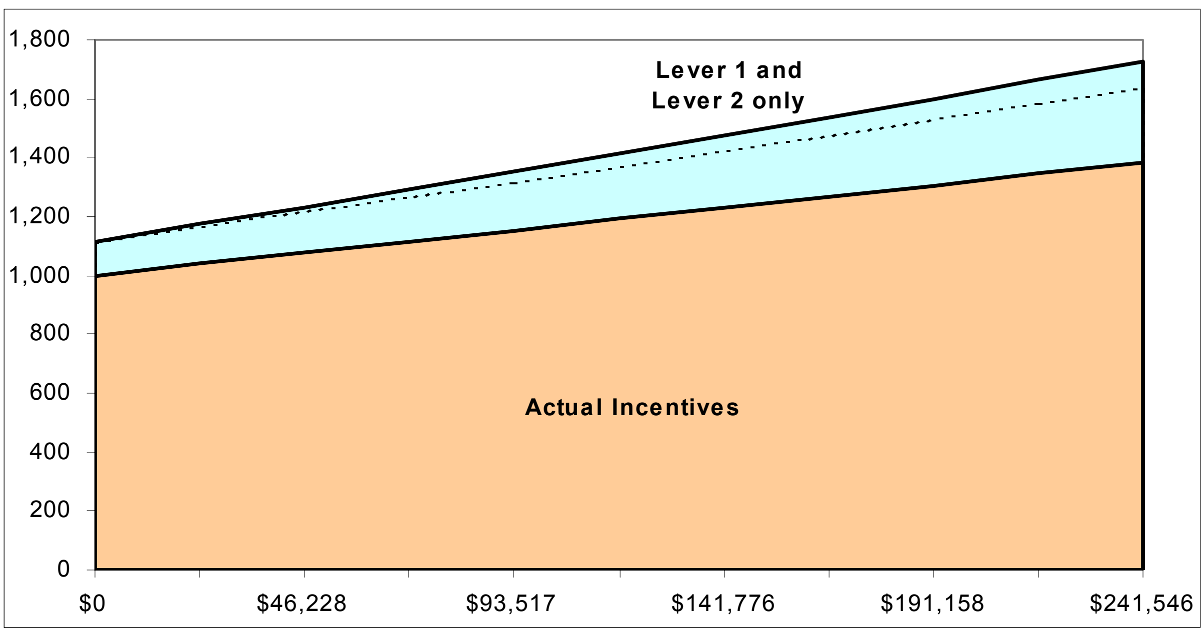


Diagram 2B: Effort Incentives from Option Grants with Private Wealth



The manager is assumed to have $10 million in private wealth, 25% of which is tied to corporate performance. **Diagram 2A** presents the effort incentives created by restricted stock grants with market values between zero and one million dollar. **Diagram 2B** presents the decomposition for option grants creating the same level of incentives. The actual incentive levels are shaded dark. The light area represents the negative effect of Lever 3, the covariance between marginal utility and the marginal effect of effort on wealth. The broken line represents the expected pay-for-performance sensitivity, which is the most common measure of incentives.

Diagram 3A: Effort Incentives from Stock Grants with 80% Volatility

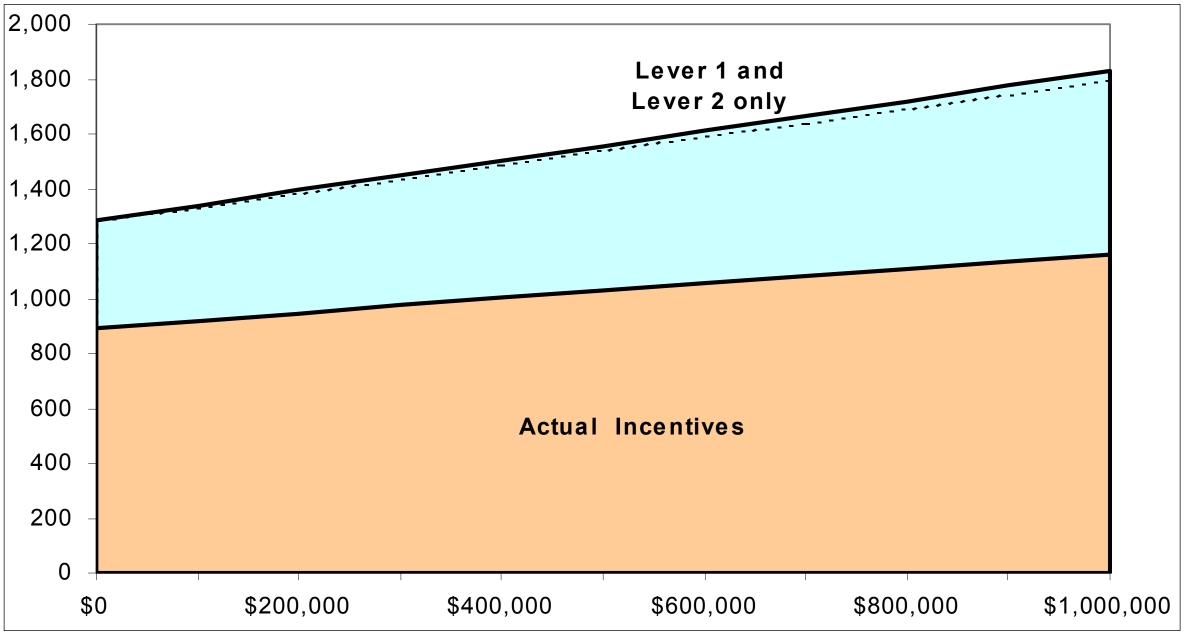
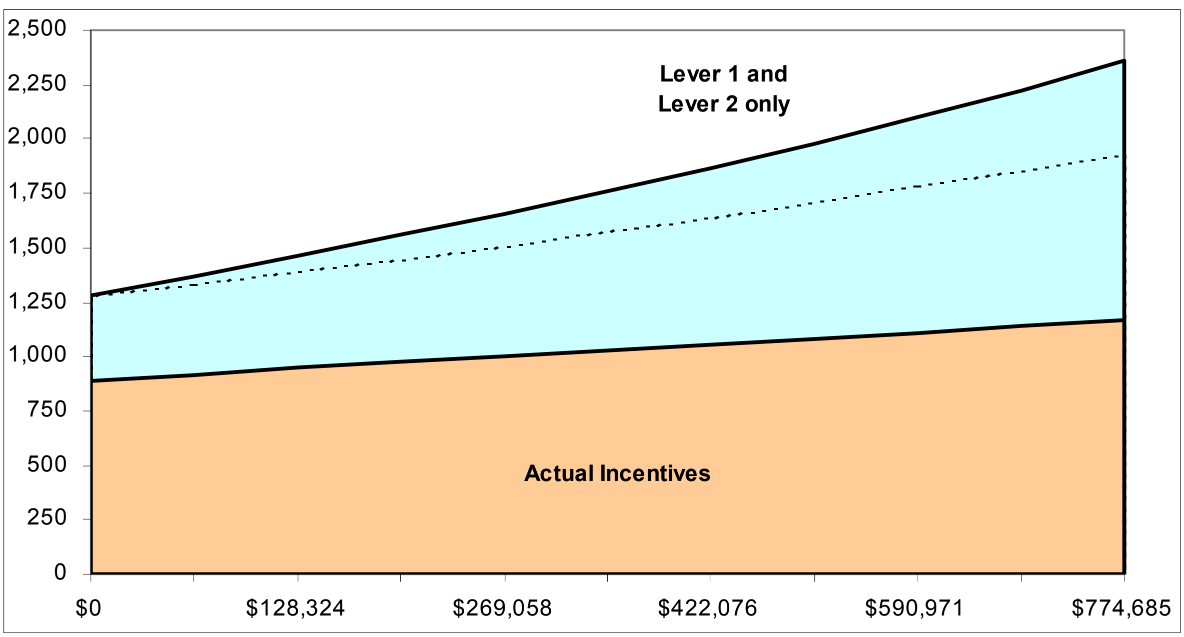


Diagram 3B: Effort Incentives from Option Grants with 80% Volatility



The manager is assumed to have $10 million in private wealth, 25% of which is tied to corporate performance. The noise level in the stock price has been raised to 80% annualized volatility, up from 30% in Diagram 2. **Diagram 3A** presents the effort incentives created by restricted stock grants with market values between zero and one million dollar. **Diagram 3B** presents the decomposition for option grants creating the same level of incentives (note the difference in scale). The actual incentive levels are shaded dark. The light area represents the negative effect of Lever 3, the covariance between marginal utility and the marginal effect of effort on wealth. The broken line represents the expected pay-for-performance sensitivity, which is the most common measure of incentives.