Agency Models of Executive Compensation

Christopher S. Armstrong
Armstrong_Christopher@gsb.stanford.edu

David F. Larcker
Larcker_David@gsb.stanford.edu

Stanford University
Graduate School of Business
518 Memorial Way
Stanford, CA 94305-5015

Che-Lin Su
c-su@kellogg.northwestern.edu

Northwestern University
J. L. Kellogg School of Management
Center for Mathematical Studies in Economics & Management Science
580 Leverone Hall
2001 Sheridan Road
Evanston, IL 60208-2014

Rough Draft: September 29, 2006

We would like to thank Kenneth Judd and Madhav Rajan for their helpful comments.

Agency Models of Executive Compensation

1. Introduction

Agency models of the economic relationship between the principal (or shareholders) of the firm and an agent (or executive) have provided many fundamental theoretical insights into the design of compensation arrangements. Although the normative propositions derived from these models are well accepted by economists, the theoretical agency model implications tend to be only weakly supported by empirical studies (e.g., Prendergast, 1999, 2002 and O'Reilly and Main, 2005). These mixed empirical results may be the result of measurement error for the primary theoretical constructs, lack of a direct relation between the structural model and the (presumably reduced form) equations used for hypothesis testing, and a variety of econometric problems (e.g., correlated omitted variables and endogeneity in the predictor variables).

In contrast to an econometric explanation, it is also conceivable that the research hypotheses derived from the agency model have limited association with the actual contracting environment producing the data used by researchers. In particular, it appears that researchers select model assumptions to produce mathematical tractability, as opposed to being descriptive representations of the important features in the actual decision making setting. Thus, while the derived analytical hypotheses may provide valuable normative prescriptions, these hypotheses may have little chance of explaining actual decision making behavior.

The purpose of this paper is to develop and analyze a moral hazard agency model based on observed characteristics of executives, typical compensation plans, and the stylized features of the contracting environment. In our primary model, a risk neutral principal selects the fixed salary, number of at-the-money stock options, and number of restricted shares to motivate a risk and effort averse agent. Consistent with observed contracting environment, the choice of fixed salary is assumed to be greater than or equal to zero (i.e., there is limited liability for the agent). The agent is assumed to have power utility where wealth plays an important role. The outside wealth consists of a fixed portion and a portfolio of pre-existing stock options and stock with a stochastic payoff. Finally, the agent exerts effort which affects the mean of the expected return distribution for the firm and this, in turn, affects all the moments of the lognormal distribution of stock price. We believe that this model structure captures many of the important real-world features of the contracting environment involving shareholders and executives.

Although our model shares some structural features with common agency representations, the assumptions render the model mathematically intractable. In addition, as we demonstrate, the traditional solution technique based on the first order approach (FOA) is generally invalid for our setting. As a result, we solve our problem numerically using the Grossman and Hart (1983) approach with a finite (but reasonably large) set of actions by the agent, discrete stock price outcomes, and continuous parameters for the agent's compensation contract. We solve this bi-level optimization problem model using state-of-the-art numerical algorithms applied to the resulting mathematical program with equilibrium constraints (MPEC).

Our approach is most closely related to the prior analytical and empirical work by Haubrich (1994), Margiotta and Miller (2000), Aseff and Santos (2005), and Dittman and Maug (2007). We select most of the parameters for our agency model using company-specific observed data (e.g., volatility, opportunity compensation level, etc.), solve the resulting optimization problem, and then compare the model results to observed compensation contracts. We restrict our analysis to firms in 2000 Fortune 500 where there was no turnover in chief executive officer (CEO) during the time period from 2001 to 2005.[1]

Our results indicate that the economic cost of moral hazard is quite large (i.e., the difference in expected dollar payoff to owners between the first-best and second-best solution). Specifically, the mean (median) expected level of moral hazard is $28.44 ($9.69) billion dollars or 101 (82) percent of the observed market value of firm. Consistent with Aseff and Santos (2005), restricting the compensation contract to fixed salary, at-the-money stock options, and restricted stock (as opposed to an unrestricted compensation contract) produces roughly the same expected payoff to owners in most cases. This result suggests that simple observed compensation contracts are robust (or close to the optimal second best contracts). However, unlike the conclusions by Hall and Murphy (2002) and Dittman and Maug (2007), we find that stock options are an important part of the optimal CEO compensation contract. Similar to the observations made by Core, Guay, and Verrecchia (2003) the incentive effects of fixed salary, at-the-money stock options, and restricted stock for some CEOs is dominated by the level and composition of the executive's pre-existing wealth. This observation is similar to that by Finally, we provide some very preliminary empirical analyses concerning the relation between predicted returns from our model and realized excess returns during the four-year time period from 2001 to 2004.

[1] We realize that these selection criteria reduce our ability to generalize our results. However, as discussed in Section 6, this sample enables us to provide some preliminary empirical analysis of the implications from our modeling.

The remainder of the paper consists of six Sections. The relevant prior research on observed executive compensation contracts is reviewed in Section 2. We specify our agency model and discuss parameter choices in Section 3. The methods used for our numerical optimization are developed in Section 4. Our numerical results are presented and discussed in Section 5. Section 6 provides some preliminary empirical results for the companies used in our numerical analysis. Conclusions and limitations are discussed in Section 7.

2. Prior Research

The analysis of compensation contract choice, especially the use of stock options and restricted stock, has been a popular topic for analytical and numerical research.[2] Guo and Ou-Yang (2006) examine a reasonably realistic model where agent effort affects both the mean and variance of the stock price distribution and agent wealth has an important impact on the choice of effort. In their model, the agent can take two costly actions to independently affect the mean and the variance of stock price. In order to use the first order approach (FOA) in their analytical and numerical analyses, the agent's utility function is assumed to be a somewhat unusual linear combination of two negative exponential functions. An interesting feature of this utility function is that the absolute risk aversion decreases as the agent has higher levels of consumption. Their (mostly numerical) results show that the relation between (i) the variance of stock price and pay-

[2] For example, using the certainty equivalent framework of Lambert, Larcker, and Verrecchia (1991) and power utility for the agent, Hall and Murphy (2002) argue that restricted stock (which is an option with an exercise price of zero) dominates options with non-zero exercise prices. One notable problem with the Hall and Murphy (2002) analysis is that their numerical evaluation of the partial derivative for a stock price does not include the expected relation between the agent's actions and the distribution of future stock price (i.e., stock price is assumed to be exogenously distributed, which implies the incentive effects from granting stock options to the agent are completely ignored).

for-performance need not be negative and (ii) pay-for-performance and stock price need not be positive. Thus, Guo and Ou-Yang (2006) demonstrate the importance of allowing the agent's effort to affect the mean and variance of stock price, as well as the critical role played agent wealth. However, they do not include limited liability, assume that output has a normal distribution, and do not include stock options in the agent's compensation contract.

Kadan and Swinkels (2006) analyze and provide some empirical tests of a model where the agent's compensation contract consists of salary and either stock options or restricted stock (i.e., a stock option with an exercise price of zero). Their formulation departs from the traditional agency model by incorporating a minimum payment constraint or limited liability (see Innes, 1990) and a positive probability that stock price is equal to zero or what they term as "non-viability risk." Using the FOA to represent the agent's problem, Kadan and Swinkels (2006) find that stock options dominate restricted stock when non-viability risk is zero.[3] They also provide some empirical evidence consistent with their basic analytical result. Specifically, bankruptcy (as a measure of non-viability) risk is negatively related to the use of restricted stock. In our view, this hypothesis seems odd because we do not observe that young technology firms (with a high probability of bankruptcy) using mostly restricted stock as opposed to stock options (e.g., Ittner, Lambert, and Larcker, 2003).

[3] In order to justify the FOA, Kadan and Swinkels (2006) assume that the distribution of F(x|e), or the cumulative distribution of stock price given the agent's choice of effort, satisfies the convexity of the distribution function (CDFC). It is interesting to think about what type distribution satisfies this assumption. In their numerical examples, F(x|e) is set to either (1 – e + ex) or (x + (1 – 2x)(1 – 2e)/2. It is difficult to image how these distributions translate into the real world distributions or how they are useful for motivating empirical tests of hypotheses generated by a model making these distributional assumptions.

Our paper is most closely related to the prior analytical and empirical work by Haubrich (1994), Margiotta and Miller (2000), Aseff and Santos (2005), and Dittman and Maug (2007). Each of these papers develops an analytical agency model for compensation decisions and assesses whether observed compensation choices are consistent with the optimizing behavior implicit in their model. For example, Haubrich (1994) examines a simple two-state, finite action agency model and numerically applies the solution approach developed by Grossman and Hart (1983). The free parameters in the model are set using observed descriptive statistics and the agent's utility function is assumed to be characterized as negative exponential (CARA). Haubrich (1994) shows that the pay-for-performance estimates in Jensen and Murphy (1990), which many observers assumed to be "too small," are roughly consistent with profit sharing parameter implied by a simple agency model.

Margiotta and Miller (2000) develop and estimate a dynamic structural model of contracting in a moral hazard setting. The principal's problem is to select a compensation contract to motivate a risk and effort averse agent (subject to individual rationality and incentive compatibility constraints). The agent's effort choice maximizes an inter-temporal consumption problem with an explicit budget constraint. This complex model is estimated using generalized method of moments and the parameter estimates enable Margiotta and Miller (2000) to quantify the cost of moral hazard in the aerospace, chemicals, and electronics industries. If the compensation data used in the estimation are generated by the assumed structural model, the resulting structural parameters can be used to estimate the cost of moral hazard. Using the data originally collected by Masson (1971) and extended by Antle and Smith (1985), the estimates in Margiotta and Miller

(2000) imply that the cost of moral hazard ranges from $83 to $263 million (in 1967 dollars).[4] This is one of the first papers to provide an explicit estimate for the economic cost of moral hazard. However, one important limitation of this analysis is that the role of managerial wealth is ignored.

Aseff and Santos (2005) examine a standard agency model with the agent taking either a high or low action which results in a continuous stock price outcome. They also assume that the FOA can be used to represent the agent's problem. The agent's salary is bounded from below (but can be negative), the compensation contract consists only of fixed salary and stock options, agent wealth is explicitly considered in the model, and the power function is used to represent the agent's utility function. The primitive model inputs are developed by selecting parameters to mimic observed compensation payments and stock prices for a typical firm. Their numerical results suggest that the cost of moral hazard (where the agent selects the low action) to the principal is large, but that the use of a simple stock option contract can motivate the agent to select the high action with a very small additional cost. Assuming that the use of the FOA is consistent the selected distributions and compensation contracts, Aseff and Santos (2005) provide some important insights into the robust nature of observed compensation contracts.

Finally, Dittmann and Maug (2007) consider an agency model with a variety of realistic features and rely on the FOA to assess whether observed CEO compensation contracts are optimal. They find the very surprising result that stock options should almost never be part of the compensation contract for CEOs. Although this is a

[4] Ferrall and Shearer (1999) implement a similar type of analysis for the salary and profit sharing contract by miners. They also find that the cost of moral hazard and the cost caused by the choice of an inefficient contract form are substantial.

provocative conclusion, there are two questionable aspects in their analysis. First, they appear to assume that the beginning stock price anticipates the optimal effort that will be selected by the agent for a given compensation contract. If stock options are issued at-the-money and the strike price already reflects the optimal agent effort, stock options have little incentive effect because the payoff to the agent (i.e., the intrinsic value) will be zero in expectation. Thus, it is not surprising that stock options do not enter the "optimal" contract in the analysis by Dittman and Maug (2007). Second, their analysis relies on the ability of the FOA to construct a measure for the incentives imposed on the agent. Unfortunately, as we demonstrate below, the combination of lognormal prices and power utility for the agent renders the FOA invalid and their use of the utility-adjusted pay for performance sensitivity is problematic.

In our subsequent analysis, we embrace the research strategy used by Haubrich (1994), Margiotta and Miller (2000), Aseff and Santos (2005), and Dittman and Maug (2007). That is, we develop an economic model where the principal and agent are both optimizing and then compare the model outputs to actual compensation data. We also incorporate a number of the structural features from Aseff and Santos (2005), Guo and Ou-Yang (2006), and Kadan and Swinkels (2006) in our model. In the next Section, we develop a model that extends prior work in several important ways and provides the basis for our analysis of observed compensation practice.

3. Agency Model

3.1 Basic Model Structure

Our model is based on a traditional single period agency setting with a risk neutral principal and a risk and effort averse agent.[5] Rather than selecting a set of assumptions to produce mathematical tractability, we develop the structure of our model based on features of the contracting environment that are observed in the real world. The cost associated with this choice is that the resulting model will be mathematically intractable and numerical methods will be required to generate example solutions. However, we believe that the insights produced by such a model outweigh the absence of a closed form solution for the contract.

In our model, the risk and effort averse agent has an additively separable utility function defined over terminal wealth (which consists of pre-existing wealth and the current period's compensation) and effort. The agent's disutility of effort is a convex and increasing function of effort. The agent selects an effort level to maximize the expected utility of flow compensation provided by the principal and existing wealth less the disutility of effort. We assume that the agent's effort choice is made to satisfy the incentive compatibility (IC) constraints. Finally, we assume that the effort choice affects both the mean and variance of the stock price distribution.[6]

The risk neutral principal selects a compensation contract to maximize the expected payoff net of the expected compensation payment to the agent. The contract space is

[5] Our model only focuses on incentive issues. We do not consider other potentially important determinants of contract choice such as taxes, executive selection, and differential accounting treatments (e.g., salary versus stock options). This is a limitation of our analysis, as well as the prior research reviewed in Section 2.

[6] As discussed below, the agent's action affects one of the parameters of the lognormal stock price distribution, which effects all of the moments of the price distribution, including the mean and variance.

constrained to include fixed salary, stock options that are granted at-the-money (similar to most actual option grants), and restricted stock. The principal selects the level of salary, number of stock options, and number of restricted shares in the flow pay for the agent. Although this is a simplified characterization of actual executive compensation contracts, base salary, stock options, and restricted stock capture the majority of the value of compensation paid to executives. Similar to observed compensation arrangements, we also require the salary to be non-negative (i.e., the agent has limited liability).

The principal also observes the dollar level and individual components of the agent's wealth at the beginning of the period. This is a reasonable assumption for the stock options and shares owned by the agent since these amounts are disclosed in proxy statements, but it is perhaps more questionable for the other cash component of agent wealth. We assume that the compensation payment satisfies the traditional individual rationality (IR) constraint that the utility of compensation is greater than or equal to the expected utility of the outside reservation wage that the agent can earn in the labor market. This reservation wage is assumed to be constant and known to both the agent and the principal.

The structure of our basic agency model (exclusive of the agent's pre-existing holdings and fixed wealth) is given by the following program (#1):

$$\underset{\alpha,\beta_1,\beta_2}{\max imize}\ E\left[NP - \left(\alpha + \beta_1 P + \beta_2 \max\{P - K, 0\}\right)\right]$$

$$\text{subject to} \quad a \in \arg\max_a \left\{E\left[U\left(\alpha + \beta_1 P + \beta_2 \max\{P - K, 0\}\right)\right] - D(a)\right\} \qquad \text{(IC)}$$

$$E\left[U\left(\alpha + \beta_1 P + \beta_2 \max\{P - K, 0\}\right)\right] - D(a) \geq U \qquad \text{(IR)}$$

$$\alpha \geq 0 \qquad \text{(LL)}$$

$$\beta_1, \beta_2 \geq 0 \qquad \text{(SS)}$$

$$\beta_1 + \beta_2 \leq N \qquad \text{(TS)}$$

where N is the number of shares outstanding,[7] P is the terminal per share price of the firm's stock, α is the fixed salary payment, β_1 is the number of shares of restricted stock granted to the agent, β_2 is the number of options granted to the agent with a strike price of K, D(a) is the agent's disutility of effort, and U is the agent's reservation utility. (IC) and (IR) denote the agent's incentive compatibility and individual rationality constraints, respectively, (LL) is the limited liability constraint, (SS) is the constraint that precludes the agent from short sales or writing call options, and (TS) prevents the agent's equity-based compensation from exceeding the firm's total shares outstanding.

One important feature missing in program #1 is the role of the agent's pre-existing fixed wealth and equity portfolio holdings of stock and options on the firm's stock. Although the principal's choice variables are the same as the case without pre-existing wealth, the flow compensation parameters only alter the agent's incentives incremental to those produced by the pre-existing wealth. When we incorporate pre-

[7] Note that number of shares granted to the agent (i.e., β_1) is a reduction to the principal's ownership of the firm, N. However, rather than modeling the options granted to the agent (i.e., β_2) as a reduction of the principal's equity in only certain states (i.e., when P > K), we model stock options as if a cash payment is made to satisfy this claim upon the realization of the stock price.

existing wealth into the optimization, the principal's problem is characterized by the following maximization program (#2).

$$\max_{\alpha,\beta_1,\beta_2} imize \ E\left[(N-S)P - Compensation - Options\right]$$

subject to $\quad a \in \arg\max_{a} \{E[U(Wealth + Compensation) - D(a)]\}$ (IC′)

$E[U(Wealth + Compensation) - D(a)] \geq U'$ (IR′)

$\alpha \geq 0$ (LL)

$\beta_1, \beta_2 \geq 0$ (SS)

$\beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 + S \leq N$ (TS′)

where S is the agent's pre-existing shares and Compensation is the agent's compensation in the current period with the following payoff:

$$Compensation = \alpha + \beta_1 P + \beta_2 \max\{P - K, 0\}$$

Options represents the payoff from the agent's pre-existing options which, as discussed further below, fall into three different categories, and β_3, β_4, and β_5 (K_1, K_2, and K_3) are the number (exercise price) of options in each category.[8] The payoff for the pre-existing option is defined as follows:[9]

$$Options = \beta_3 \max(P - K_1, 0) + \beta_4 \max(P - K_2, 0) + \beta_5 \max(P - K_4, 0)$$

Wealth is sum of the agent's pre-existing fixed wealth, shares, and stock options. U′ is the agent's reservation utility for <u>both</u> wealth and compensation and is defined as follows:

$$U' = E[U(Wealth + ExternalWage)]$$

[8] The three categories are options granted last period, exercisable options, and unexercisable options. This is further discussed in Section 3.3.

[9] We model the payoff from the pre-existing options as a contingent cash payment from the principal to the agent for the realized intrinsic value of the options.

The constraint (TS′) precludes the agent from owning more shares and options (both pre-existing and from the current period's compensation) than there are shares of the firm outstanding. The remaining constraints are similar to those discussed above for program #1.

3.2 Descriptive Statistics for the Sample

Our sample consists of 16 firms in the 2000 through 2004 Fortune 500 where there was no turnover in chief executive officer (CEO) during the time period from 2001 to 2004. We impose this requirement because we use the four-year period after contracting to measure aggregate annual compensation and evaluate firm performance. As should be expected, the mean (median) firm has very large with a market capitalization of $36,021 million ($9,920 million) (see Table 1). This sample also spans a variety of industrial and service sectors of the economy.

3.3 Measurement of Model Parameters

We assume that agent's utility function can be characterized as a member of power class of functions, or $U(W + s) = \frac{1}{1-\delta}(W+s)^{1-\delta}$ for $\delta \geq 0$, where δ is the coefficient of relative risk aversion, W is the agent's pre-existing wealth, and s is the current period (or flow) compensation. This utility function exhibits decreasing absolute and constant relative risk aversion (CRRA). This choice is supported by the prior empirical work by Friend and Blume (1975) and Litzenberger and Ronn (1986). We adopt the power utility rather than the more common (at least in analytical work) negative exponential utility (CARA) because we believe that managerial wealth is an important factor for understanding executive incentives. Friend and Blume (1975) estimate the risk aversion parameter for the power utility to be between two and three. Kocherlakota (1990) argues that this parameter is probably higher (perhaps in excess of ten), although Lucas (1994) suggests that the parameter should be around 2.5. Consistent with prior research, we set the coefficient of relative risk aversion to two in our subsequent analyses.

Since a complete measure of CEO wealth is not available from public data, we develop a proxy for this parameter. We assume that CEO wealth is composed of a fixed (nonstochastic) portion that is uncorrelated with stock price and a stochastic portion composed of existing stock options and shares owned by the CEO. We estimate the fixed dollar amount of CEO wealth as five times cash compensation (salary plus bonus) plus an estimate of the value for the supplemental executive retirement plan (measured as the present value, discounted at the risk-free rate, of a 15 year annuity equal to 60% of the CEO's salary and bonus in the most recent year that starts paying out five years after the current year).

The stochastic wealth consists of shares of stock, restricted stock, and stock options owned by the CEO. Since complete information about the executive holdings are not available, we use the Core and Guay (2002) one-year approximation method with the information reported in the first proxy statement of our sample period (i.e., for the 2000 fiscal year end). This proxy statement reports the agent's stock and restricted stock holdings from prior periods (which we group together and refer to as "pre-existing stock"), the number of exercisable options and their inferred average strike price ("pre-existing exercisable options"), the number of unexercisable options and the inferred average strike price ("pre-existing unexercisable options"), and the number and actual strike price of any option grants from the year prior to the proxy ("pre-existing new options").[10] The one-year approximation method assumes that the unexercisable (exercisable) options have a remaining life of one year (four years) less than the life of the newly granted options.[11] This distinction, however, is lost in our single period setup, because we implicitly assume that all of the pre-existing option grants, as well as any new grants in the optimal compensation package have the same life and, accordingly, the same potential time value. The mean (median) fixed wealth for CEO sample is about \$31.36 (\$27.29) million (Table 1). Moreover, CEOs also have substantial wealth invested in their company's equity though both stock and option holdings.

Consistent with a large body of finance research and the basic distributional assumption for the Black-Scholes model, we assume that the firm's stock price is characterized by a two parameter (μ and σ) lognormal distribution.[12] We assume that the agent's action impacts only the μ parameter (i.e., we assume that σ, the variance of the returns process, is exogenous) which shifts the mean of the underlying normal returns distribution and affects all moments of the lognormal price distribution. Specifically, a shift in μ will affect the mean ($\exp[\mu + \sigma^2/2]$) and variance ($[\exp(\sigma^2) - 1] \cdot \exp[2\mu + \sigma^2]$) of the lognormal distribution. This enables us to capture the natural risk-return tradeoff associated with agent effort because increases in effort increase both the mean and variance of the lognormal distribution price distribution. The parameter σ is

[10] If there was more than a single option grant in the prior year, we aggregate the options together as if there were a single grant of the total number of options with a strike price that preserves the sum of the total Black-Scholes value of the individual grants. Thus, we fix the number of options in the aggregate grant equal to the total number of options in the individual grants, and the Black-Scholes value of the aggregate grant equal to the sum of the Black-Scholes value of the individual grants and solve for the unique strike price and use the resulting number as the strike price for the "pre-existing new options."

[11] For the typical option grant with a ten year life, the one-year approximation method implies an estimated life of nine years and six years, respectively, for the unexercisable and exercisable options.

[12] This assumption implies that returns are normally distributed, with mean μ and variance σ^2.

measured using the standard deviation of daily returns over the prior year. The mean (median) annual σ for our sample is 0.494 (0.476)

One especially crucial modeling choice is the "production technology" that translates the agent's effort (e.g., choice of strategy, operational investments, long-term investments, and other similar managerial tasks) into μ. We arbitrarily restrict (and implicitly scale) agent effort to take discrete integer values between zero and 100. We also assume that μ is a piecewise linear function of the agent's effort (see the illustrative examples for Black and Decker and Hewlett Packard in Figure 1). At an effort equal to zero, we assume the firm earns the risk-free rate of return. Since this return is less than the firm's estimated cost of capital,[13] μ of the lognormal price distribution will be negative, which implies a negative expected abnormal return. At an effort level of 29 (or the 30th action), we assume that μ is equal to zero, which implies the firm's expected return will equal its cost of capital. At an effort level of 100, we assume that the firm earns an annual rate of return equal to the annualized return implied by the high four-year target price reported by Value Line. The value of μ implied by intermediate effort choices are (piecewise-) linearly interpolated between these three points. We report the slope of each piece in Table 1 and we find that the production technology is concave (convex) for eight (eight) of the firms in our sample.

Finally, in order to calculate each agent's reservation utility for the (IR) constraint, we assume that the agent's compensation in the external labor market over the next four years would equal four times the median (three-digit SIC) industry compensation for the

[13] We estimate the cost-of-capital for each company using the Capital Asset Pricing Model with a risk-free rate and market-risk premium equal to 5.24% and 6.00%, respectively (which are approximately the prevailing rates at the beginning of our sample period). Each company's Beta was estimated using monthly returns over the prior 60 months. These values are reported in Table 1 (Panel A).

most recent year for all CEO's in the Fortune 500.[14] We use four years in this computation because this captures the approximate term for a CEO and we are using the four-year Value Line forecast for returns. The agent's expected utility from the pre-existing (fixed and stochastic) wealth plus the industry median compensation is evaluated over the firm's price distribution induced by an action equal to zero (i.e., the firm's expected return is equal to the risk-free rate less the cost-of-capital) and the agent experiences no associated disutility of effort.

4. Numerical Optimization Issues

4.1 Inapplicability of the First Order Approach

Most analytical and numerical analyses of agency models rely on the FOA as part of their solution technique. This approach replaces the continuum of the agent's (IC) constraints with the first-order condition for an optimum. This "relaxed" version of the problem is amenable to solution by standard nonlinear optimization techniques. While there are sufficient conditions where the FOA is known to be appropriate (e.g., Rogerson, 1985; Jewitt, 1988, and Araujo and Moreira, 2001), there are no known necessary conditions for its application. However, the sufficient conditions found in the literature are highly specialized (e.g., CDFC and MLRP) and can easily fail in the economic setting described in Section 3. Thus, it is important to verify the validity of the FOA for our economic setting.

[14] Because the median industry compensation for all industries represented in our sample includes stock options, we used the industry median annual Black-Scholes value of the options granted. We then calculate the company-specific number of at-the-money options that would yield the industry median Black-Scholes value and use this number for the industry median compensation.

It is straightforward to demonstrate the likely failure of the FOA for our problem. The agent's expected utility versus effort choices under the optimal compensation contract (consisting of salary, at-the-money stock options, and restricted stock) is plotted in Figure 2 for Archer Daniels Midland and Paccar. For both companies, this function has a "double hump" and expected utility is not a concave function of effort. Since this type of agent response violates the FOA, we do not use the "relaxed" version for generating our numerical solutions.[15]

4.2 Basic Mathematical Program

Given the constraints and distributional assumptions of our model, it is not possible to develop a closed form mathematical solution to the principal's problem. Similar to prior research, we analyze our model using numerical optimization methods. We represent our model using discrete actions by the agent and continuous compensation contract parameters. The use of discrete actions allows us to employ the solution techniques of Grossman and Hart (1983) to avoid the use the FOA and facilitate the finding of a globally optimal solution for the compensation contract.[16]

Since there are only finitely many actions, the Grossman and Hart (1983) approach first replaces the agent's incentive compatibility constraint (IC) with the following set of inequalities:

$$E\left[U\left(\alpha + \beta_1 P + \beta_2 \max\{P - K, 0\}\right) | \, a\right] - D(a) \geq$$
$$E\left[U\left(\alpha + \beta_1 P + \beta_2 \max\{P - K, 0\}\right) | \, a_i\right] - D(a_i)$$

[15] Note that it is not necessary to show that the agent's expected utility is not a concave function of the action, but it is sufficient. The agent's expected utility could be concave in action for any (or all) given contract(s) and the FOA could still fail.

[16] It is important to note that our action space is much larger than the typical binary action space (i.e., high or low action) that is common in most prior research. We use 101 discrete actions by the agent and 501 discrete stock prices for each action in our numerical analysis.

for each of the agent's i = 1 … M possible actions. A binary variable $y_i \in \{0,1\}$ associated with each action $a_i \in A$ is then introduced so that $y = (y_1,\ldots, y_M) \in R^M$. Finally, let e_M denote the vector of all ones in R^M. The program for the optimal contract in program (#1) can then be reformulated as the following mixed-integer non-linear program (MINLP), which we refer to as program (#3)[17]:

$$\underset{\alpha,\beta_1,\beta_2}{\max imize}\ E\left[NP - (\alpha + \beta_1 P + \beta_2 \max\{P-K,0\}) \mid \left(\textstyle\sum_{i=1}^{M} y_i a_i\right)\right]$$

subject to

$$y \in \underset{\tilde{y}:\tilde{y}\in\{0,1\},\sum \tilde{y}=1}{\arg\max} \left\{E\left[U(\alpha + \beta_1 P + \beta_2 \max\{P-K,0\}) \mid \left(\textstyle\sum_{i=1}^{M} y_i a_i\right)\right]\right\} - D\left(\textstyle\sum_{i=1}^{M} \tilde{y}_i a_i\right) \quad \text{(IC)}$$

$$E\left[U(\alpha + \beta_1 P + \beta_2 \max\{P-K,0\}) \mid \left(\textstyle\sum_{i=1}^{M} y_i a_i\right)\right] - D\left(\textstyle\sum_{i=1}^{M} y_i a_i\right) \geq U \quad \text{(IR)}$$

$$\alpha \geq 0 \quad \text{(LL)}$$

$$\beta_1, \beta_2 \geq 0 \quad \text{(SS)}$$

$$\beta_1 + \beta_2 \leq N \quad \text{(TS)}$$

$$e_M^T y = 1$$

$$y_i \in \{0,1\} \text{ for all i = 1,…,M}$$

Program (#3) has Q nonlinear variables (where Q is the number of stock price outcomes for each action), M binary variables, one linear constraint, and (M+1) nonlinear constraints. Since the agent will choose one, and only one action, the number of possible combinations on the binary vector y is only M. Thus, we can solve M nonlinear programs, where $y_i = 1$ (for i = 1,…,M) and the other $y_i = 0$. Among those M solutions, we then select the feasible solution with the largest value of the objective function.

Rather than solving the program #3 using a mixed-integer nonlinear program solver such as MINLP (Fletcher and Leyffer, 1999) or BARON (Sahinidis and Tawarmalani,

[17]In order to ease the notation in the text, these programs do not include agent wealth. The inclusion of wealth is a simple extension to the programs.

2004), we follow Su and Judd (2006) and transform our problem into the following MPEC formulation, which we refer to as program (#4):

$$\max_{\alpha,\beta_1,\beta_2,\delta} imize \sum_{i=1}^{M} \delta_i E\left[NP - \left(\alpha + \beta_1 P + \beta_2 \max\{P-K,0\}\right) | a_i\right]$$

$$\text{subject to} \quad 0 \le \delta_j \perp \sum_{i=1}^{M} \delta_i \left(E\left[NP - \left(\alpha + \beta_1 P + \beta_2 \max\{P-K,0\}\right) | a_i\right] - D(a_i)\right)$$

$$-\left(E\left[NP - \left(\alpha + \beta_1 P + \beta_2 \max\{P-K,0\}\right) | a_j\right] - D(a_j)\right) \ge 0 \quad \text{for j = 1,…,M} \quad \text{(IC)}$$

$$\sum_{i=1}^{M} \delta_i \left(E\left[NP - \left(\alpha + \beta_1 P + \beta_2 \max\{P-K,0\}\right) | a_i\right] - D(a_i)\right) \ge U \qquad \text{(IR)}$$

$$\alpha \ge 0 \qquad \text{(LL)}$$

$$\beta_1, \beta_2 \ge 0 \qquad \text{(SS)}$$

$$\beta_1 + \beta_2 \le N \qquad \text{(TS)}$$

$$\sum_{i=1}^{M} \delta_i = 1$$

In general, this program has only (M + Q) variables and M complementarity constraints with one linear constraint and one nonlinear constraint. The complementary constraints require that if an (IC) constraint is not active (binding), then its multiplier must be zero. If the particular (IC) constraint is active, then $\delta_i = 1$ and $\delta_{-i} = 0$, for that particular action, and we solve the corresponding non-linear program.

One advantage of this formulation is that it enables more flexibility in the choice of nonlinear programming solvers. This enables us to check the robustness of our solutions (by comparing solutions from different solvers such as KNITRO and SNOPT).

4.3 Scaling Constants

One common issue in numerical analysis concerns the choice of scaling for the objective functions and constraints. Since the agent's utility is defined over consumption of both flow compensation and wealth, it is necessary to scale these figures in order to produce a utility number that is "reasonable" for numerical analysis. For example, if the risk aversion parameter is equal to two, the utility of \$100 million dollars of non-stochastic flow compensation and wealth is $\frac{1}{(1-2)}(\$100{,}000{,}000)^{(1-2)}$ = $-1 \text{ x}10^{-8}$, which is very close to zero from a computational perspective. Further, the agent's marginal utility is $(\$100{,}000{,}000)^{-2} = 1\text{x}10^{-18}$, which is numerically indistinguishable from zero for conventional levels of precision.

In order to mitigate these types of numerical issues, we deflate the agent's monetary consumption (both pre-existing wealth and flow compensation) by 129,000,000, which is approximately the median value of total wealth for the CEO's in our sample.[18] This scaling serves to "shift" the agent back on the utility function where both the (1) overall expected utility from consumption is a smaller value (but larger in absolute value) and (2) marginal utility of consumption is a larger value (e.g., the agent's marginal utility in the example above would be $(\$100{,}000{,}000/\$129{,}000{,}000)^{-2} = 1.6641$). Since utility is a scale-free construct, this approach is empirically valid.

A more critical scaling parameter is the multiplier for the agent's disutility of effort. We assume that the disutility function, D(a), is equal to a scaling parameter (λ) multiplied by the square of effort, or $\lambda \cdot a^2$. Since the agent's utility is additively separable in monetary consumption and disutility of effort, this multiplier scales the agent's disutility of effort to ensure that it is of the same "order of magnitude" as the utility from

[18] The estimated total wealth for the executives in our sample is the sum of fixed wealth, value of their stock holdings, and the Black-Scholes value of their various option holdings. Although many papers show that a risk averse executive values an employee stock option at less than its Black-Scholes value (e.g., Lambert, Larcker, and Verrecchia, 1991), this should provide a reasonable approximation for computing a scaling multiplier.

consumption. We estimate this multiplier by determining the value of λ that will result in the observed compensation contract for the median firm in our sample. Specifically, we assume that the agent takes an action of 29 (i.e., the action that yields expected returns equal to the hypothetical firm's cost-of-capital) and then solve for the multiplier for which the principal would select a contract that is most similar to the median contract values observed in the data.[19] A crucial point to emphasize is that the arbitrary consumption multiplier (i.e., 129,000,000) also affects the calculation of the disutility multiplier because the disutility multiplier is calculated using the scaled median values for our sample. However, this preserves the relative unscaled values of the marginal utility from consumption and the marginal disutility of effort.

5. Numerical Results

5.1 First Best Solution

The benchmark first best solution is computed using program #2 after removing the IC constraint. In this solution, the agent's salary will equal the sum of the disutility of effort and the right-hand-side of the IR constraint.[20] Since the function translating agent effort into μ is based on a four-year expected return, the compensation paid to the agent is also for a four-year time period. The optimal level of effort ranges from 70 to 227 and the payoff to the principal ranges from \$2.3 to \$403 billion (Table 2).[21] With the exception of United Technologies, the expected payoff to the principal when there are no incentive

[19] This approach for solving for the disutility multiplier assumes that our model represents the actual contracting process between the principal and agent.

[20] The compensation portion of the right-hand-size of the IR constraint is expressed as four times the median salary, number of stock options, and number of shares of restricted stock for CEOs in the 2000 Fortune 500 for relevant three-digit SIC.

[21] We allow the effort in the first best case to be above 100. For values above 100, we assume that the slope of the function linking effort to μ is the same as the slope between 31 and 100.

problems exceeds the observed market capitalization. The mean (median) discount between the first best expected payoff to the principal and the observed market capitalization is 41.25 (42.12) percent of beginning market capitalization.

5.2 Unconstrained Second Best Solution

The results for the second best solution with an unconstrained compensation contract are computed using the basic approach described in program #4. The two key changes incorporated into program # 4 for the unconstrained solution are that a compensation contract consisting of a cash payment for each stock price outcome is substituted for the salary, stock option, and restricted stock contract and agent wealth is included in the agent's problem. As expected, the agent's effort choice and expected payoff to the principal for the unconstrained second best solution are substantially below the corresponding first-best values (Table 3).[22] Assuming the model in program #3 is an appropriate representation of the real world, the differences in expected payoff to the principal between Tables 2 and 3 provide an estimate of the economic size of moral hazard for our sample. The dollar estimates range from $453 million to $204.6 billion with a mean (median) of $28.44 ($9.69) billion dollars. These individual company results are consistent with the average company results in Margiotta and Miller (2000) and Aseff and Santos (2005).

The typical shape of the optimal unconstrained contract is illustrated in Figure 2 for Archer Daniels Midland and Paccar. The unconstrained compensation function is convex for low stock prices and becomes concave at higher stock prices. These contracts provide

[22] The results for Deere and Conagra are "corner solutions" in Table 3 (i.e., agent effort is equal to 100). If 100 is the maximum amount of effort that can be provided by the agent, this outcome is not problematic. However, it seems more reasonable to find an interior solution, and this requires some additional assumptions about the functional form of the production after an effort level of 100.

zero payment to the agent until the observed stock is fairly close to the optimal expected stock price. In this region, the contract is highly convex (e.g., for Archer Daniels Midland, a stock price change from $12 to $13 produces an increase in fixed payment from $0 to $178 million). This part of the contract is very similar to an option, and thus we should expect to see stock options in observed compensation arrangements. The payment is also zero at very high observed stock prices. This occurs because the principal is likely to infer that these high outcomes are due to a high random outcome (i.e., "good luck") as opposed to the agent providing a high level of effort.

Finally, the fixed payments to the agent are substantially larger than the typical flow compensation for CEOs (even after considering that the payments in Figure 2 are for a four year period). Although these payments to the agent are large (about $200 to $500 million), the expected payoff to the principal is also extremely large for high levels of agent effort (approximately $11 billion for both companies). In this case, the principal is only paying between three and six percent of the change in expected value of the firm to the agent. This magnitude is consistent with the Haubrich (1994) critique of the Jensen and Murphy (1990) challenge to the agency model.

These results provide some insights into the recent movement of executives from public companies to private equity firms (e.g., Thornton, 2006; Guerrera, 2006). It may be possible for private equity firms to implement something like the unconstrained second best contract because there are no external constituencies to satisfy or they have a more analytical economic approach to contract design. If this is the case, our model provides a rational economic explanation for compensation payments to private equity partners on the order of several hundred million dollars.

5.3 Constrained Second Best Solution

The constrained second best contract (consisting of salary, at-the-money stock options, and restricted stock) results are computed using the approach in program #4 and the results are presented in Table 4. As expected, the optimal agent effort is less than or equal to the effort level observed in the unconstrained contract case. Similar to Aseff and Santos (2005), on average, we find that there is generally only a modest loss in expected payoff to the principal when the constrained contract is used rather than the more complicated unconstrained second best contract. For our sample, the mean (median) loss caused by using a constrained contract is $1,103 ($55) million. However, the loss for Intel is $15.54 billion with the shift from the unconstrained to constrained compensation contract. For Intel, it is not possible to motivate a high level of agent effort using the constrained compensation contract (and given the level and composition of agent wealth).

The components of the second best constrained contract also vary considerably across firms. There are three cases where the salary, number of at-the-money stock options, and restricted share are trivial in magnitude (Hewlett Packard, United Technologies, and Harley Davidson). For these companies, flow pay has minimal incentives effects and serves primarily to satisfy the agent's IR constraint and agent incentives are primarily produced by the pre-existing exogenous wealth.[23] For four companies (Rohm & Haas, Smithfield Foods, General Mills, and Deere) the optimal constrained compensation contract is essentially all fixed salary. In these companies, additional equity incentives are too costly for principal and salary is used either to satisfy the agent's (IR) constraint

[23] We confirmed this point by computing the agent's effort choice after constraining flow pay to zero. For Hewlett Packard, United Technologies, and Harley Davidson, the agent's effort choice and expected payout to the principal are the same as reported in Table 4.

and/or mitigate the agent's risk aversion. Another feature of companies with a very large salary component in flow pay is that they tend to exhibit small values of systematic risk (Beta). The absence of stock options and restricted stock in the flow pay is a result of the low expected benefit in the production function from using equity incentives to increase agent effort (up to action 30). Although the production technology for these companies is likely to be convex after moving beyond action 30, the expected benefit to the principal needs to be very high in order to compensate the agent for the substantial disutility incurred at high levels of effort.

In contrast to the conclusions by Hall and Murphy (2002) and Dittman and Maug (2007), there are seven companies where the optimal number of stock options in the CEO compensation contract is very large and 14 cases where the optimal number of restricted shares is trivial. In some cases, the optimal constrained second best grant of at-the-money stock options to the CEO is approximately one to two million options per year. Thus, stock options dominate restricted stock for most companies after the incentive effects of stock options are explicitly considered in the analysis (the problem in Hall and Murphy, 2002) and incentives are correctly modeled (the limitation in Dittman and Maug, 2007).

Assuming that our constrained optimization model is representative of the real world economic environment, the results in Table 4 provide an estimate for the degree to which the CEO earns "excess" compensation (i.e., more than the required external reservation wage). Our measure of excess compensation is the additional fixed compensation that the agent would have to receive from an outside alternative employer to obtain the same expected utility as under the optimal constrained second-best contract.

It is important to note that this measure does not imply that the agent is extracting wealth from the principal because the observed constrained second best contract is optimal for motivating the agent.

The excess compensation results are presented in Table 5. For five companies the excess compensation is small (less than $100,000) because the IR constraint is almost binding for these companies.[24] However, for six companies the excess compensation is fairly large (greater than $10 million). Overall, the mean (median) excess compensation over a four year period is $30.5 ($3.1) million dollars.

6. Preliminary Empirical Results

Core and Guay (1999) conclude that companies adjust their equity grants to executives based on the equity incentives inherent in the executives' pre-existing portfolio of wealth. This is an important result because in order to select the compensation contract for the agent the principal should consider the entire portfolio of wealth held by the agent. Thus, we should observe more stock and option grants to executives with low levels of incentives associated with their portfolio of wealth. From an empirical perspective, the fundamental problem is how to measure the construct of "low levels of incentives."

The key measurement assumptions in Core and Guay (1999) are that executive incentives can be validly measured using the partial derivative of the executives wealth with respect to stock price (i.e., the traditional "delta" for stock and options) and the

[24] In general, the IR constraint is not binding in our model because the limited liability constraint stops the principal from "paying" the agent a negative salary.

"optimal" value of this measure can be computed using the systematic portion of the empirical function linking observed incentives to firm size, industry, investment opportunity, and other similar economic determinants. Since Core and Guay (1999) do not have an explicit model for determining equity incentives, they assume that relative differences between the observed and the expected level of equity incentives computed from the average of all other firms.

Rather than relying on such a relative measurement approach, the results from program #4 can be used to determine whether observed grants of stock and options are consistent with the predictions from our model. This is a very different methodological approach than Core and Guay (1999) because we have firm-specific (and absolute) predictions for equity grants that are based on equilibrium optimizing behavior by both the principal and agent. In addition, we do not rely on the arbitrary use of the stock and option "delta" because this risk neutral measure of incentives is unlikely to exhibit construct validity when an executive is risk averse and where stock and options motivate the executive to change the distribution of stock prices.

In Table 6, we compare the actual and second best optimal compensation contracts for our sample. If firms incorporate pre-existing incentives produced by agent wealth into their computation of current period stock and option grants, we should observe a positive correlation between the actual and optimal equity grants. Although somewhat unsophisticated, we "combine" the equity grants into a single figure by adding the number of restricted shares to 0.6 times the number of stock options.[25] The Pearson and Spearman bivariate correlations between the combined actual and optimal grants are

[25] The 0.6 factor for the stock options is the average "delta" for a new at-the-money stock option grants. (Core and Guay, 2002). The implicit "delta" for stock is equal to unity.

-0.192 and -0.210 ($p > 0.10$, two-tail). These results are not consistent with the Core and Guay (1999) interpretation that equity grants are used to manage optimal equity incentive levels. An alternative explanation is that our agency model does not adequately capture the economic contractual setting between the principal and agent. Nevertheless, the predictions from our model are based on an explicit optimization model, whereas the relative measurement approach in Core and Guay (1999) is largely heuristic in nature.

Although the optimal second best constrained contract is presented in Table 4, it is also interesting to estimate the agent effort and expected payoff to the principal using the actual compensation paid to the CEO during the subsequent four years (2002-2005). In particular, we use the actual compensation contract as an input into our model and then compute the induced agent effort and expected payoff to the principal. The results of these computations are presented in Table 7. Although the contracts are different than the constrained second best contract, for seven of the companies the agent's effort choice is the same with the observed flow compensation (although the expected payoff to the principal is lower). With the exception of Archer Daniels Midland, the effort levels for the observed contract are lower than those for the constrained second best contract.

The other interesting output from these computations is that we can also compute the expected value of the μ parameter of the lognormal price distribution induced by the observed compensation contract. If our model captures the important features of the contracting environment and compensation contract have an important impact on firm performance, we should observe a positive association between expected and actual firm performance. In Figure 4, we plot the average monthly excess returns (controlling for the four Fama-French factors) over the four year time period from 2002 to 2005 versus the predicted performance induced by the actual contract.[26] An ordinary least squares analysis reveals that the slope coefficient is 0.050 ($p < 0.05$, two-tail), intercept is 0.010 ($p < 0.01$, two-tail), and the R^2 (adjusted R^2) is equal to 8.41% (6.33%). These results are consistent with our expectations and provide some validation of our agency model (and the associated functional forms and parameter estimates).

7. Summary and Conclusions

In this paper, we develop and analyze a moral hazard agency model based on observed characteristics of executives, typical compensation plans, and stylized features of the contracting environment. Some of these features are (i) a compensation contract that consists of fixed salary, number of at-the-money stock options, and number of restricted shares, (ii) fixed salary that is great than or equal to zero (i.e., limited liability), (iii) power utility for the agent, (iv) pre-existing wealth which we show plays an important role, and (v) a production function where agent effort affects all the moments of the distribution of stock price. We believe that this model structure captures many of the important observed features of the real-world contracting between owners (i.e., principals) and executives (i.e., agents).

Given the constraints and distributional assumptions of our model, it is not possible to develop a closed form mathematical solution to the principal's problem. Therefore, we solve our model using numerical optimization methods. We represent our model using discrete actions by the agent, discrete stock prices, and continuous compensation contract

[26] These results are generated for a sample of 46 firms that were members of the 2000 Fortune 500 and had the same CEO over the time period from 2001 to 2005 and no missing data.

parameters. The use of discrete actions allows us to employ the solution techniques of Grossman and Hart (1983).

For our sample of firms, we find that the economic cost of moral hazard is quite large (i.e., the difference in expected dollar payoff to owners between the first-best and second-best solution). Constraining the compensation contract to fixed salary, at-the-money stock options, and restricted stock (as opposed to an unrestricted compensation contracts) produces roughly the same expected payoff to owners in most cases. This result is consistent with Aseff and Santos (2005) and suggests that simple observed compensation contracts can be fairly close to the optimal contract. Similar to Core, Guay, and Verrecchia (2003), for some companies, the incentive effects of fixed salary, at-the-money stock options, and restricted stock are dominated by the level and composition of CEO wealth. We also find that the optimal compensation contract frequently includes large quantities of stock options. These numerical results are at odds with the conclusions by Hall and Murphy (2002) and Dittman and Maug (2007).

Finally, we provide some preliminary empirical analyses for a sample the 2000 Fortune 500 firms. We find little evidence that actual equity grants are similar to our computed optimal equity grants. Since one of the primary economic determinants of equity grants in our model is the level and composition of executive wealth, the absence of a correlation between observed and optimal grants suggests that our firms are not considering executive wealth for this important decision. This result is inconsistent with the prior conclusions by Core and Guay (1999). We also find that the firm performance predicted using our model and the observed compensation payments is able to explain some of the actual excess stock price performance of our firms.

Our analytical and empirical results are subject to a variety of limitations related to the specific assumptions used in our model. First, we rely on a lognormal distribution of stock prices and our model captures only the risk-return tradeoff inherent in this specific distribution. Although this is a somewhat standard assumption in the finance literature, there are other reasonable ways to describe the impact on the agent's effort choice on the distribution of stock price outcomes. Second, our choice of the production function assumes that the agent's productivity is a specific piecewise linear function of both the firm's cost of capital and the analyst long-term price forecasts. It is important to assess the sensitivity of our results to alternative production technologies. Third, our model includes only a single action that leads to a change in the distribution of stock price. The role of accounting information and accounting-based compensation contracts (e.g., annual bonus or performance plans) is ignored. Fourth, we assume that the power utility function (with a coefficient of relative risk aversion of two) describes the executives' preferences for monetary consumption and that a quadratic cost function describes the agent's disutility for effort. Finally, our analysis is conducted in a single period setting. This requires us to abstract away from undoubtedly important features of real world contracting settings, such as the early exercise of stock options (and thus their time value), inter-temporal effort allocation, and consumption smoothing.

References

Antle, R. and A. Smith. 1985. Measuring executive compensation: methods and an application. Journal of Accounting Research 23: 296-325.

Araujo, A. and H. Moreira. 2001. A general lagrangian approach for non-concave moral hazard problems. Journal of Mathematical Economics 35: 17-39.

Aseff, J. and M. Santos. 2005. Stock options and managerial optimal contracts. Economic Theory 26: 813-837.

Core, J. and W. Guay. 1999. The use of equity grants to manage optimal equity incentive levels. Journal of Accounting and Economics 28: 151-184.

Core, J. and W. Guay. 2002. Estimating the value of stock option portfolios and their sensitivities to price and volatility. Journal of Accounting Research 40: 613-640.

Core, J., W. Guay, and R. Verrecchia. 2003. Price versus non-price performance measures in optimal CEO compensation contracts. The Accounting Review, 78: 957-981.

Dittmann, I. and E. Maug. 2007. Lower salaries and no options? On the optimal structure of executive pay. Journal of Finance.

Friend, I. and M. Blume. 1975. The demand for risky assets. American Economic Review: 901-922.

Ferrall, C. and B. Schearer. 1999. Incentives and transactions costs with firms: estimating an agency model using payroll data. Review of Economic Studies. 66: 309-338.

Fletcher, R. and S. Leyffer, 1999. User manual for MINLP_BB. Department of Mathematics, University of Dundee, UK.

Grossman, S. and O. Hart. 1983. An analysis of the principal-agent problem. Econometrica 51: 7-45.

Guo, M. and H. Ou-Yang. 2006. Incentives and performance in the presence of wealth effects and endogenous risk. Journal of Economic Theory. 129: 150-191.

Guerrera, F. 2006. Private equity woos top talent. Financial Times (August 29).

Haubrich, J. 1994. Risk aversion, performance pay, and the principal-agent problem. Journal of Political Economy 102: 258-276.

Hall, B., and K. Murphy. 2002. Stock options for undiversified executives. Journal of Accounting and Economics 33: 3-42.

Innes, R., 1990. Limited liability and incentive contracting with ex-ante action choices, *Journal of Economic Theory* 52: 45-67.

Ittner, C., R. Lambert, and D. Larcker. 2003. The structure and performance consequences of equity grants to employees of new economy firms. Journal of Accounting and Economics 34: 89-127.

Jensen, M. and K. Murphy. 1990. Performance pay and top-management incentives. Journal of Political Economy 98: 225-264.

Jewitt, I. 1988. Justifying the first-order approach to the principal-agent problems. Econometrica 56: 1177-1190.

Kadan, O. and J. Swinkels. 2006. Stock or options? Moral hazard, firm viability, and the design of compensation contracts. Working paper. John M. Olin School of Business, Washington University in St. Louis.

Kocherlakota, N. 1990. On tests of representative consumer asset pricing models. Journal of Monetary Economics 26: 285-304.

Lambert, R., D. Larcker, and R. Verrecchia. 1991. Portfolio considerations in valuing executive stock options. Journal of Accounting Research 29: 129-149.

Litzenberger, R. and E. Ronn. 1986. A utility-based model of common stock price movements. Journal of Finance 41: 67-92.

Lucas, D. 1994. Asset pricing with undiversifiable risk and short sales constraints: deeping the equity risk puzzle. Journal of Monetary Economics 34: 325-342.

Margiotta, M. and R. Miller. 2000. Managerial compensation and the cost of moral hazard. International Economic Review 41: 669-719.

Masson, R. 1971. Executive motivations, earnings, and consequent equity performance. Journal of Political Economy 79: 1278-1292.

O'Reilly, C. and B. Main. 2005. Setting the CEO's pay: economic and psychological perspectives. Working paper. Graduate School of Business, Stanford University.

Prendergast, C. 1999. The provision of incentives in firms. Journal of Economic Literature 27: 7-63.

Prendergast, C. 2002. The tenuous trade-off between risk and incentives. Journal of Political Economy 110: 1071-1102.

Rogerson, W. 1985. The first-order approach to principal-agent problems. Econometrica 53: 1357-1368.

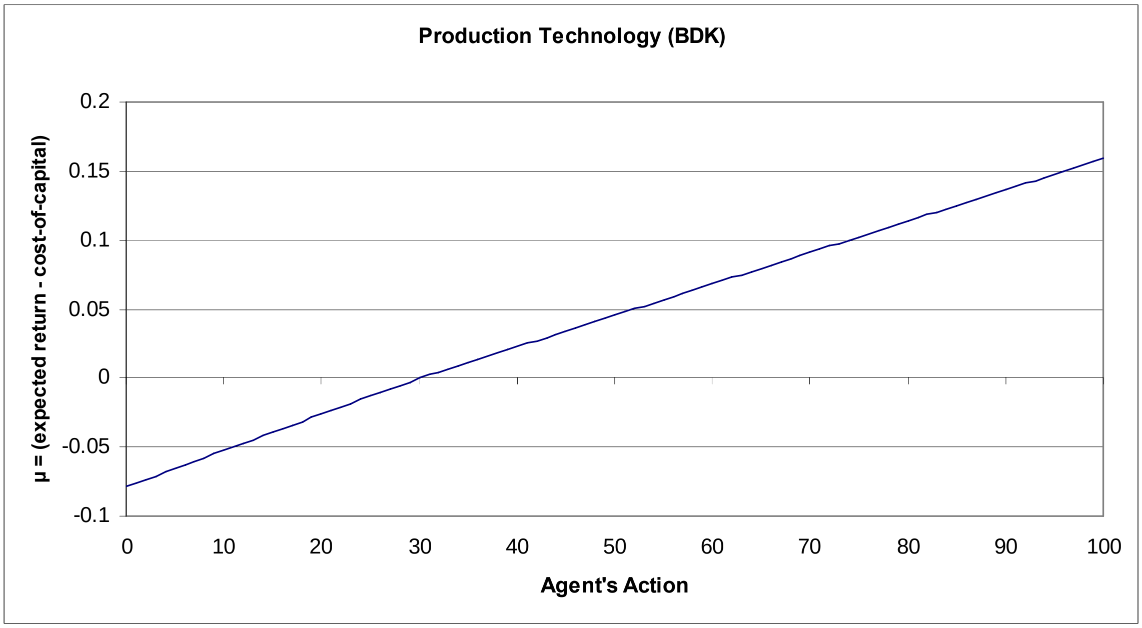
Sahinidis, N. V. and M. Tawarmalani, 2004. BARON 7.2: Global optimization of mixed-integer nonlinear programs, user's manual, available at: http://www.gams.com/dd/docs/solvers/baron.pdf

Su, C. and K. Judd. 2005. Computation of moral-hazard problems. Working paper. CMS-EMS J.L. Kellogg Graduate School of Management, Northwestern University.

Thornton, E. 2006. Going private: Hotshot managers are fleeing public companies for money, freedom, and glamour of private equity. BusinessWeek online (Feburary 27).

Figure 1

Production Technology of the Relation Between Agent Effort and μ of the Returns/Price Distribution



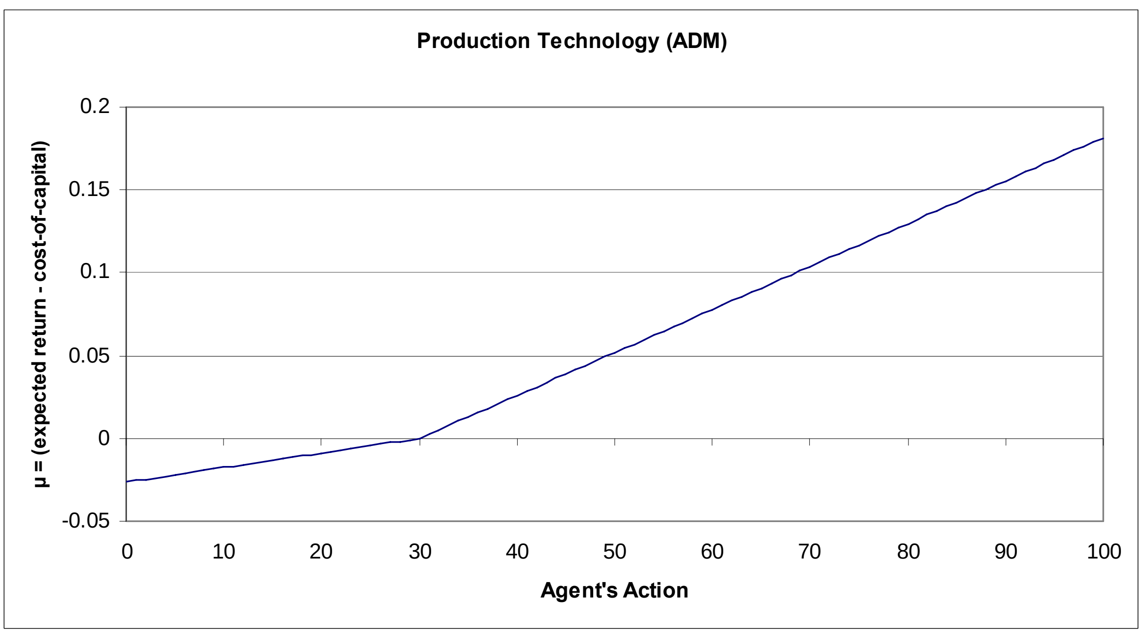
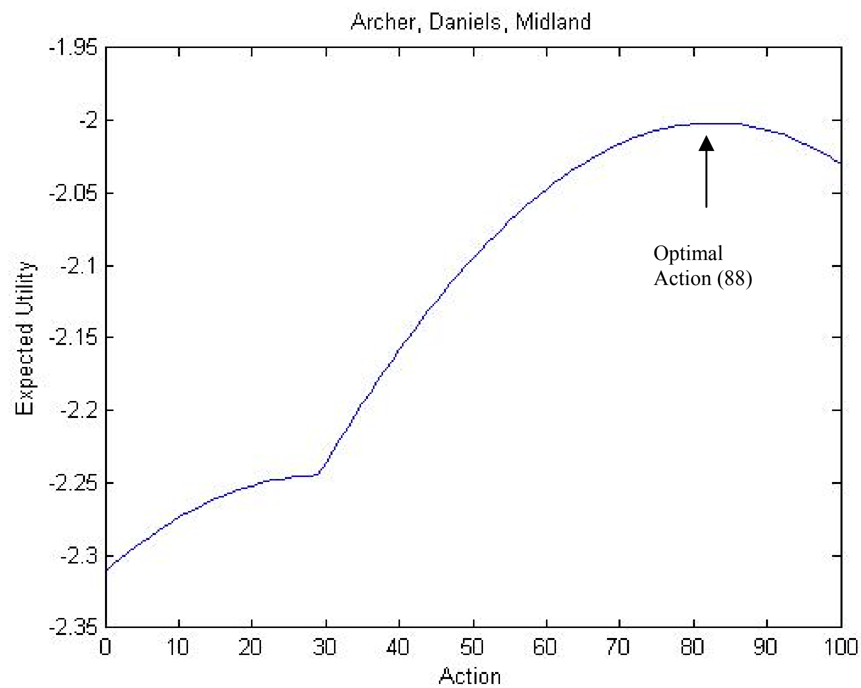


Figure 2
Agent Effort and Expected Utility for the Optimal Restricted Compensation Contract



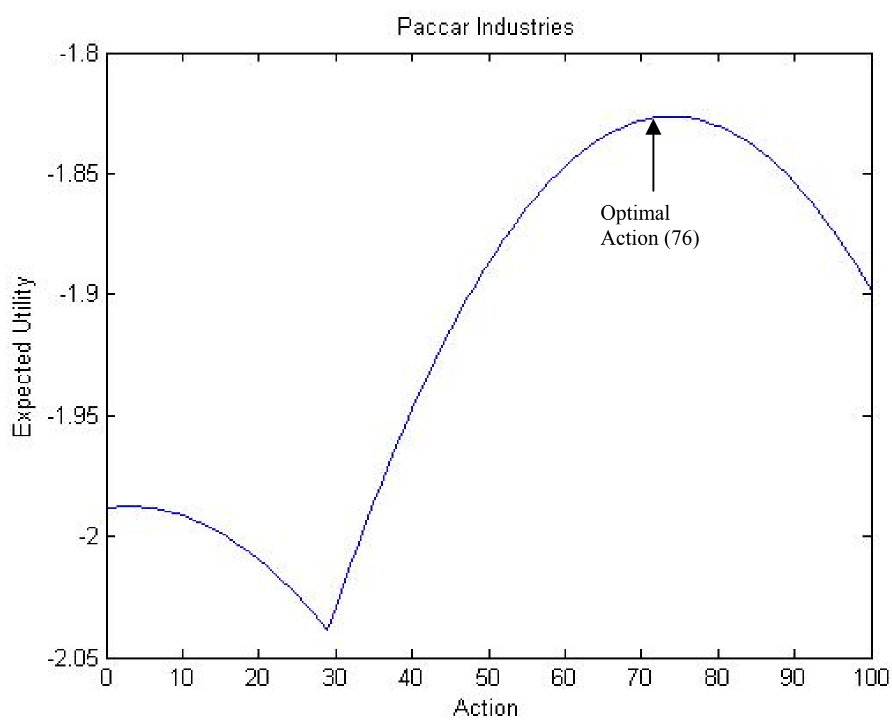
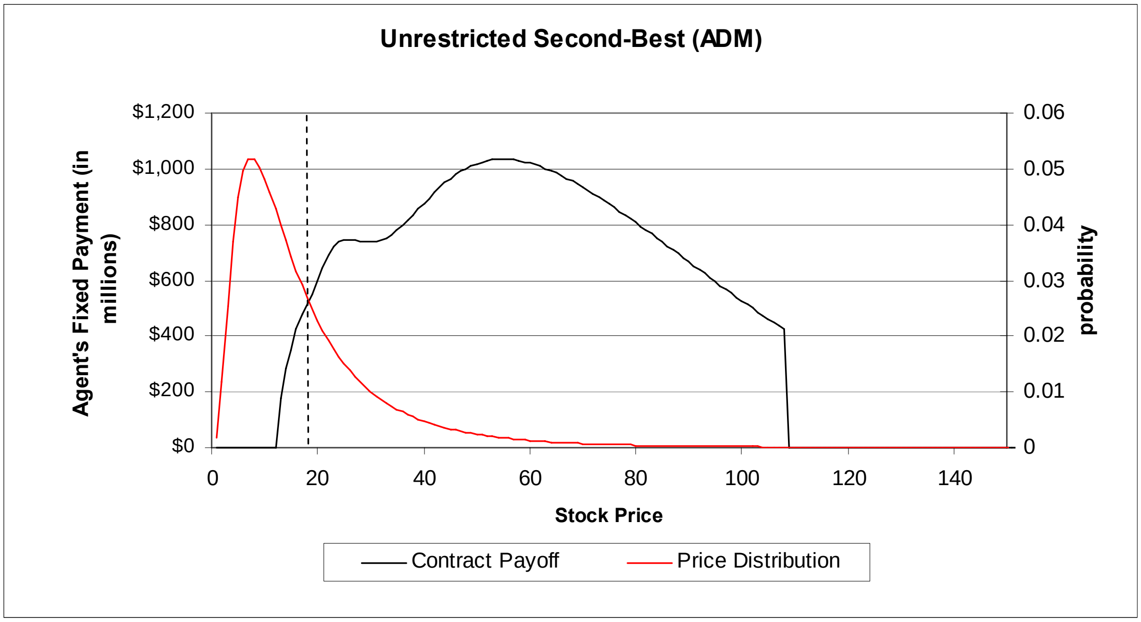


Figure 3

Optimal Unrestricted Second Best Contracts for the Optimal Action



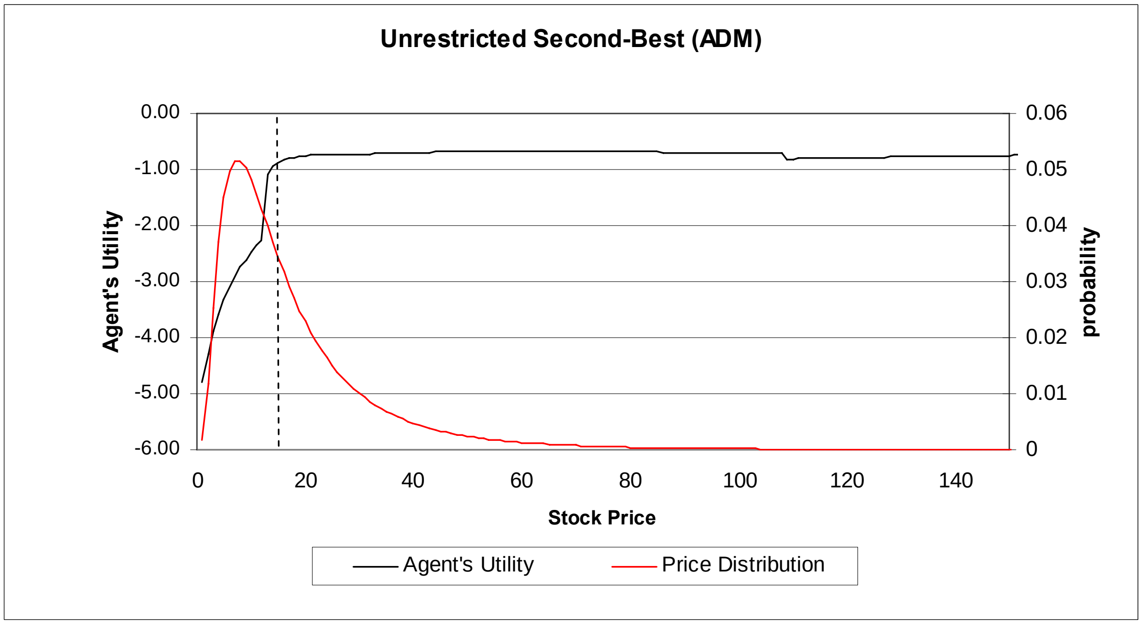
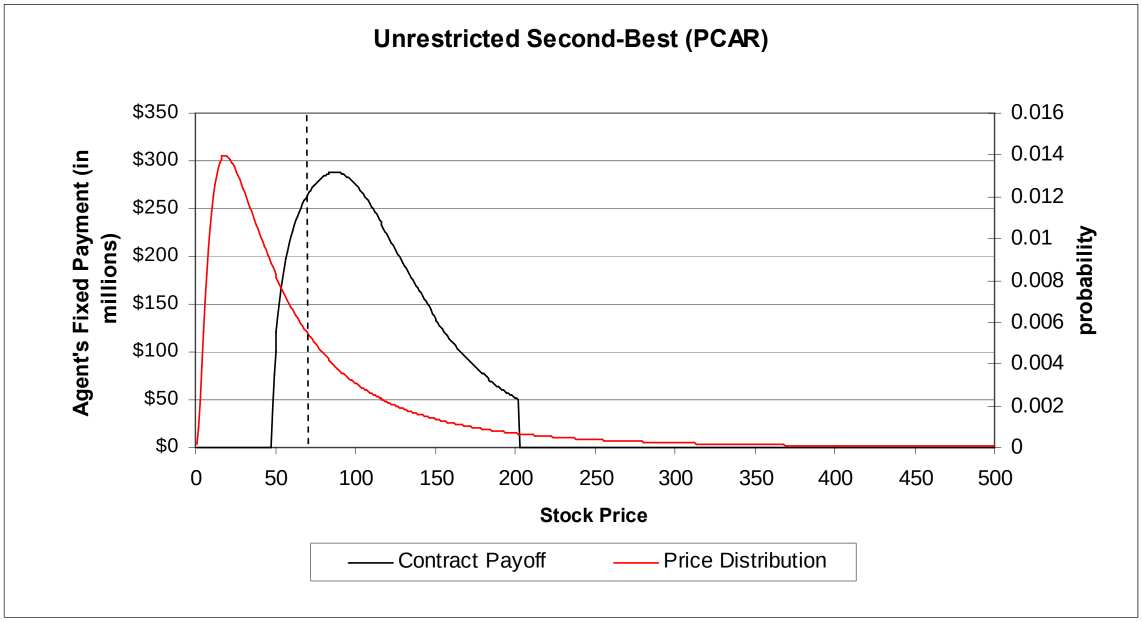
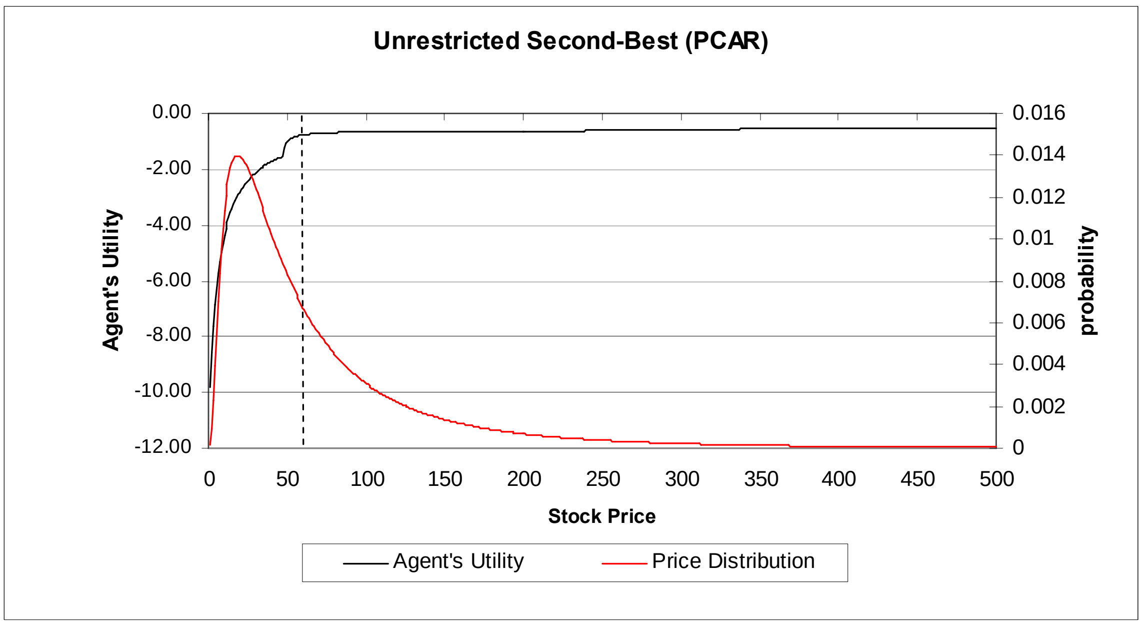


Figure 3 (continued)

Optimal Unrestricted Second Best Contracts for the Optimal Action





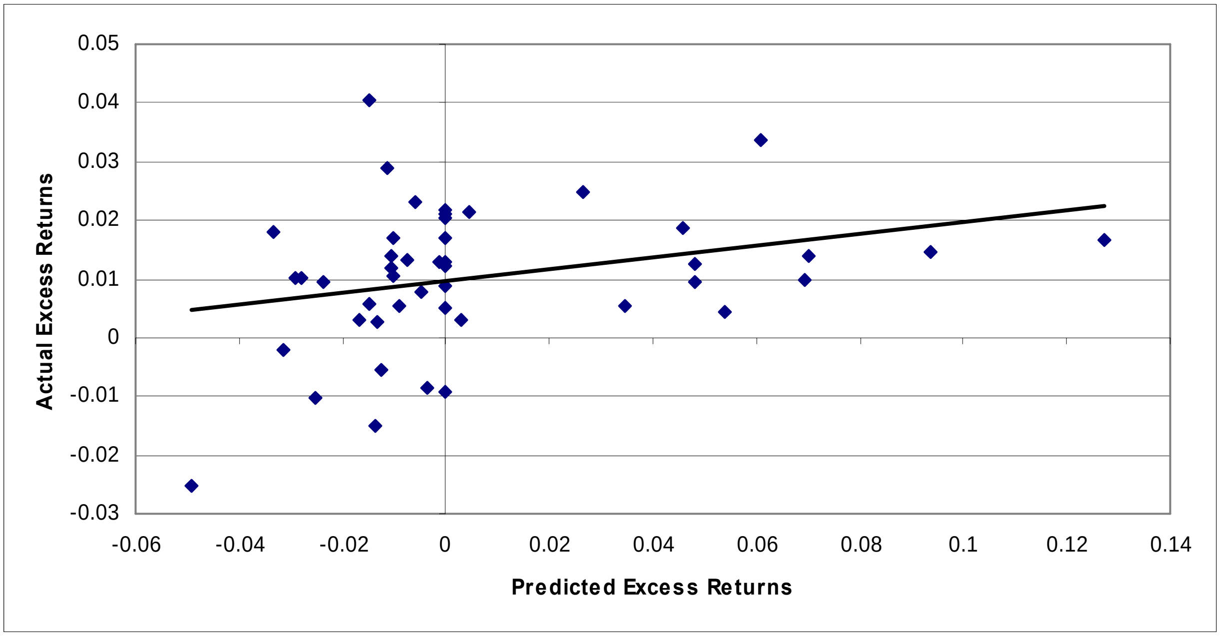
The dotted line is the expected stock price of $18.08 ($75.60) resulting from agent effort of 88 (75) for ADM (PCAR).

Figure 4

Plot of Actual Excess Return versus Predicted Excess Return

The sample consists of all firms in the 2000 Fortune 500 that had the same CEO over the time period from 2001 to 2004 were (n = 46)

OLS Fit: Actual Excess Return = 0.010+ 0.050 Predicted Excess Return



The actual excess return is the average monthly alpha estimated over 48 months (2001 to 2004) after controlling for the four Fama-French factors).

The predicted excess return is the value of the μ parameter of the lognormal price distribution from the action induced (using program #4) from the actual salary, shares, and at-the-money stock options granted to the CEO during the fiscal years 2001 - 2004

Table 1

Panel A: Descriptive Statistics for the Sample Companies

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	DOV	**BDK**	**ROH**	**LYO**	**QCOM**	**SFD**	**GIS**	**ADM**	**CAG**	**DE**	**HPQ**	**PCAR**	**INTC**	**UTX**	**ITW**	**HDI**
Shares Outstanding	203.30	80.74	220.05	117.56	1,496.85	104.17	284.86	631.68	537.30	234.66	1,932.55	172.19	6,718.00	941.37	303.00	302.10
Price per Share	38.63	38.56	35.63	16.00	71.31	34.25	42.36	9.81	20.85	36.81	46.50	50.00	31.06	75.25	59.06	37.63
Market Capitalization	7,853	3,113	7,841	1,881	106,740	3,568	12,067	6,197	11,203	8,638	89,863	8,609	208,661	70,838	17,895	11,368
Sigma	0.384	0.506	0.554	0.568	0.907	0.470	0.217	0.383	0.373	0.486	0.625	0.483	0.705	0.421	0.389	0.440
Beta	1.08	1.31	0.85	0.72	0.64	0.34	0.10	0.44	0.24	0.78	1.49	0.04	0.74	1.07	1.10	1.08
Cost-of-capital	11.74%	13.11%	10.33%	9.59%	9.06%	7.27%	5.87%	7.89%	6.66%	9.94%	14.20%	5.45%	9.68%	11.67%	11.85%	11.70%
High VL Forecast	24.44%	29.01%	13.19%	13.43%	29.68%	21.13%	14.74%	26.03%	21.34%	26.45%	23.77%	21.18%	24.75%	8.26%	26.45%	14.65%
Slope 1	0.00217	0.00262	0.00170	0.00145	0.00127	0.00068	0.00021	0.00088	0.00047	0.00157	0.00299	0.00007	0.00148	0.00214	0.00220	0.00215
Slope 2	0.00181	0.00227	0.00041	0.00055	0.00295	0.00198	0.00127	0.00259	0.00210	0.00236	0.00137	0.00225	0.00215	-0.0005	0.00209	0.00042

Shares outstanding is the number of shares outstanding at the end of the 2001 fiscal year in millions. ***Price per share*** is the market price per share of common stock at the end of the 2001 fiscal year. ***Market capitalization*** is the number of shares outstanding multiplied by the price per share in millions. ***Sigma*** is the annualized standard deviation of daily returns over the 2001 fiscal year. ***Beta*** is computed from the Capital Asset Pricing Model (CAPM) using the monthly return series over the 60 months prior to the end of the 2001 fiscal year end. ***Cost-of-capital*** is the company-specific discount rate calculated using the Capital Asset Pricing Model (CAPM) with a risk-free rate of 5.24% and a market-risk premium of 6%. ***High VL Forecast*** is annualized return implied by the Value Line high long-term target price. ***Slope 1*** and ***Slope 2*** are the slopes of the production function that translates the agent's action (in the set {0, 1, …, 100}) to the μ parameter of the lognormal price distribution. ***Slope 1*** is the slope between actions 0 and 30 where mu ranges between the risk-free rate and the firm's cost-of-capital. ***Slope 2*** is the slope between actions 30 and 100 where mu ranges between the firm's cost-of-capital and the annual return implied by the high Value Line price forecast.

Company Names:

DOV – Dover Corp.	CAG – Conagra Foods Inc.
BDK – Black & Decker Corp.	DE – Deere & Co.
ROH – Rohm & Haas Co.	HPQ – Hewlett Packard Co.
LYO – Lyondell Chemical Co.	PCAR – Paccar Inc.
QCOM – Qualcomm Inc.	INTC – Intel Corp.
SFD – Smithfield Foods Inc.	UTX – United Technologies Corp.
GIS – General Mills Inc.	ITW – Illinois Tool Works Inc.
ADM – Archer Daniels Midland Co.	HDI – Harley Davidson Inc.

Table 1 (continued)

Panel B: Descriptive Statistics for the Sample Executives

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	DOV	**BDK**	**ROH**	**LYO**	**QCOM**	**SFD**	**GIS**	**ADM**	**CAG**	**DE**	**HPQ**	**PCAR**	**INTC**	**UTX**	**ITW**	**HDI**
Fixed Wealth	28.21	38.59	16.42	31.03	26.24	95.86	24.02	26.50	15.06	14.20	40.28	11.66	40.61	40.38	24.59	28.07
Shares of Stock	758.06	908.85	189.52	678.65	51910.56	6237.89	2353.27	4143.41	779.74	312.34	879.40	2099.84	5121.42	8577.55	748.62	1865.52
New Options	85.28	1000.00	91.10	535.46	800.00	600.00	785.81	525.00	300.00	79.09	1280.04	156.13	200.00	650.00	450.00	165.00
New Strike	39.00	42.78	41.44	12.91	41.75	13.22	38.70	11.91	21.00	41.47	53.81	18.56	61.19	31.25	55.88	33.59
Unexercisable Options	315.10	275.00	0.00	308.93	5162.67	0.00	1917.41	209.16	282.92	66.83	1151.86	227.32	2328.00	2100.00	305.00	270.50
Unexercisable Strike	30.45	38.45	0.00	16.00	42.09	0.00	34.96	9.81	20.85	36.81	44.16	50.00	18.94	73.79	50.83	13.61
Exercisable Options	368.11	1335.00	89.52	186.67	11953.44	400.00	1762.76	76.62	532.97	224.69	383.95	304.03	2496.00	7080.00	675.61	928.39
Exercisable Strike	18.64	18.66	34.34	16.00	37.70	34.25	26.49	9.81	20.85	35.90	44.16	50.00	4.06	46.26	37.09	7.10
Reservation Utility	-2.1218	-1.8037	-3.9142	-2.5761	-1.6996	-0.6994	-0.9264	-2.2470	-3.4014	-3.9936	-1.9953	-2.4725	-1.6306	-0.5216	-2.0351	-1.6404
Wealth Only Reservation Utility	-2.6771	-2.1621	-6.4672	-3.4893	-1.9352	-0.7451	-1.0460	-2.7244	-4.9746	-6.3451	-2.3921	-3.5304	-1.7990	-0.5658	-2.5396	-1.9789

Fixed wealth is the executive's total non-stochastic wealth (in $ millions) which is estimated as five times the sum of the 2000 salary and bonus payment, plus an estimated SERP payment which is calculated as the present value of 60% of the 2000 salary and bonus paid out over 15 years starting five years into the future. ***Shares of stock*** is the total number of shares of stock and restricted stock held by the executive as of the end of the 2001 fiscal year (in thousands). ***New options*** is the number of options (in thousands) granted in the prior year (i.e., fiscal year 2000). ***New strike*** is the exercise price of the options granted in the prior year (i.e., fiscal year 2000). If there was more than one grant in the prior year, ***new strike*** is a blended strike price calculated as the strike price of the total number of options that would produce an equivalent value to the total Black-Scholes value of all grants. ***Unexercisable options*** is the number of unexercisable options (in thousands) reported on the proxy statement for the end of the 2001 fiscal year. ***Unexercisable strike*** is the estimated average exercise price of the unexercisable options using the Core and Guay (1998) one-year approximation approach. ***Exercisable options*** is the number of exercisable options (in thousands) reported on the proxy statement for the end of the 2001 fiscal year. ***Exercisable strike*** is the estimated average exercise price of the exercisable options using the Core and Guay (1998) one-year approximation approach. ***Reservation utility*** is the agent's expected utility over the pre-existing wealth (consisting of fixed wealth, shares of stock, new options, unexercisable options, and exercisable options) and four times the most recent (i.e., fiscal year 2000) median industry compensation assuming the executive exerts an action of zero and incurs no disutility of effort.

Table 2

First-Best Solutions

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	DOV	BDK	ROH	LYO	QCOM	SFD	GIS	ADM	CAG	DE	HPQ	PCAR	INTC	UTX	ITW	HDI
Optimal Action	162	145	212	158	144	82	102	169	210	227	159	176	143	70	160	132
Mu	0.238	0.260	0.074	0.070	0.334	0.103	0.091	0.358	0.374	0.552	0.175	0.326	0.242	-0.020	0.348	0.043
Salary	697	358	211	133	43	321	615	1,035	1,221	875	1,126	566	947	328	799	259
Shares	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Options	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Strike	38.63	38.56	35.63	16	71.31	34.25	42.36	9.81	20.85	36.81	46.5	50	31.06	75.25	59.06	37.63
Scaled Objective	145.44	53.90	75.34	17.82	963.97	35.65	127.83	189.84	367.55	344.10	1087.86	179.21	3127.25	485.93	429.60	100.57
Participation	-2.1218	-1.8037	-3.9113	-2.5758	-1.7000	-0.6994	-0.9264	-2.2470	-3.4014	-3.9936	-1.9953	-2.4725	-1.6306	-0.5216	-2.0351	-1.6404
Objective	18,762	6,953	9,719	2,299	124,353	4,599	16,490	24,490	47,414	44,389	140,334	23,118	403,416	62,686	55,418	12,973
Mean Price Dist.	100.03	108.98	47.83	21.15	271.22	51.81	61.01	41.03	93.19	334.86	93.71	183.94	81.75	69.55	237.85	44.67
Median Price Dist.	74.54	65.31	25.89	11.11	52.30	33.32	55.52	30.60	70.59	208.83	42.90	115.44	30.28	48.83	175.74	30.34
Variance Price Dist.	8,014	21,195	5,520	1,176	1,905,049	3,806	772	1,345	6,453	176,186	33,112	52,054	42,030	4,978	47,057	2,330
Skewness Price Dist.	0.034	0.059	0.176	0.431	0.542	0.102	0.024	0.083	0.035	0.017	0.140	0.031	0.285	0.059	0.015	0.101
Kurtosis Price Dist.	25.93	120.59	244.21	302.24	564531.64	73.98	4.02	25.81	22.94	91.54	797.46	87.58	3751.24	40.02	27.62	50.55

Optimal action is the non-negative integral action value taken by the agent. ***Mu*** is the value of the μ parameter of the lognormal price distribution under the ***optimal action***. ***Salary*** is the amount of the fixed payment to the agent (in $ millions) in the optimal contract. ***Shares*** is the number of shares of the firm (in thousands) granted to the agent in the optimal contract. ***Options*** is the number of at-the-money call options on the firm's stock (in thousands) granted to the agent in the optimal contract. ***Strike*** is the exercise price (in $) of the at-the-money call options granted to the agent in the optimal contract. ***Scaled Objective*** is the value of the principal's objective function at the optimal contract. ***Participation*** is the value of the agent's participation (i.e., (IR)) constraint at the optimal contract, which is the agent's expected utility at the optimal contract. ***Objective*** is the value of the principal's objective function (in $ millions) for the optimal contract scaled by the scaling multiplier (i.e., 129,000,000). This can be interpreted as the payoff to the principal (i.e., total firm value), net of the compensation paid to the agent and the value of the agent's pre-existing equity holdings. ***Mean Price Dist.*** is the expected value of the price distribution following the agent's action induced by the optimal contract. ***Median Price Dist.*** is the median value of the price distribution following the agent's action induced by the optimal contract. ***Variance Price Dist.*** is the variance of the price distribution following the agent's action induced by the optimal contract. ***Skewness Price Dist.*** is the normalized third central moment of the price distribution following the agent's action induced by the optimal contract. This measures the degree of asymmetry in the distribution and values greater (less) than zero indicates positive (negative) skewness. ***Kurtosis Price Dist.*** is the normalized fourth central moment of the price distribution (minus three) following the agent's action induced by the optimal contract.

Table 3

Unconstrained Second-Best Solutions

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	DOV	BDK	ROH	LYO	QCOM	SFD	GIS	ADM	CAG	DE	HPQ	PCAR	INTC	UTX	ITW	HDI
Optimal Action	74	58	29	29	7	5	6	88	100	100	31	75	38	18	89	29
Mu	0.082	0.066	0.000	0.000	-0.028	-0.016	-0.005	0.153	0.147	0.201	0.003	0.103	0.019	-0.024	0.162	0.000
Scaled Objective	81.99	28.85	58.68	14.30	445.31	24.07	90.53	85.29	155.68	137.77	633.68	92.48	1541.21	481.45	247.01	86.78
Participation	-1.946	-1.676	-3.914	-2.576	-0.398	-0.582	-0.926	-1.924	-3.401	-3.994	-1.515	-1.765	-1.079	-0.363	-1.662	-1.586
Objective	10,576	3,722	7,570	1,845	57,445	3,106	11,678	11,003	20,083	17,773	81,745	11,930	198,816	62,107	31,864	11,195
Mean Price Dist.	53.55	50.18	35.63	16.00	63.75	32.10	41.55	18.08	37.51	82.17	47.01	75.60	33.56	68.48	112.81	37.63
Median Price Dist.	39.90	30.07	19.29	8.40	12.29	20.64	37.81	13.48	28.41	51.25	21.52	47.45	12.43	48.07	83.35	25.56
Variance Price Dist.	2,296	4,494	3,064	673	105,249	1,461	358	261	1,046	10,610	8,334	8,794	7,085	4,826	10,586	1,654
Skewness Price Dist.	0.064	0.127	0.236	0.570	2.307	0.164	0.035	0.188	0.086	0.070	0.280	0.074	0.694	0.060	0.031	0.120
Kurtosis Price Dist.	25.93	120.59	244.21	302.24	564,531.64	73.98	4.02	25.81	22.94	91.54	797.46	87.58	3,751.24	40.02	27.62	50.55

Optimal action is the non-negative integral action value taken by the agent. ***Mu*** is the value of the μ parameter of the lognormal price distribution under the ***optimal action***. ***Scaled objective*** is the value of the principal's objective function at the optimal contract. ***Participation*** is the value of the agent's participation (i.e., (IR)) constraint at the optimal contract, which is the agent's expected utility at the optimal contract. ***Objective*** is the value of the principal's objective function (in $ millions) for the optimal contract scaled by the scaling multiplier (i.e., 129,000,000). This can be interpreted as the payoff to the principal (i.e., total firm value), net of the compensation paid to the agent and the value of the agent's pre-existing equity holdings. ***Mean Price Dist.*** is the expected value of the price distribution following the agent's action induced by the optimal contract. ***Median Price Dist.*** is the median value of the price distribution following the agent's action induced by the optimal contract. ***Variance Price Dist.*** is the variance of the price distribution following the agent's action induced by the optimal contract. ***Skewness Price Dist.*** is the normalized third central moment of the price distribution following the agent's action induced by the optimal contract. This measures the degree of asymmetry in the distribution and values greater (less) than zero indicates positive (negative) skewness. ***Kurtosis Price Dist.*** is the normalized fourth central moment of the price distribution (minus three) following the agent's action induced by the optimal contract.

Table 4

Constrained Second-Best Solutions

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	DOV	BDK	ROH	LYO	QCOM	SFD	GIS	ADM	CAG	DE	HPQ	PCAR	INTC	UTX	ITW	HDI
Optimal Action	73	56	29	27	7	4	6	83	100	100	29	75	22	18	88	29
Mu	0.079	0.060	0.000	-0.003	-0.028	-0.017	-0.005	0.138	0.147	0.198	0.000	0.103	-0.010	-0.024	0.157	0.000
Salary	0	0	10,948	631	185	15,264	9,030	200	4,105	5,361	947	0	761	884	0	28
Shares	0	0	7	1,123	86	0	0	85	74	0	1	0	273	17	0	1
Options	10,003	4,575	4	5,910	430	0	0	16,573	1	0	2	4,020	1,171	0	5,688	2
Strike	38.63	38.56	35.63	16	71.31	34.25	42.36	9.81	20.85	36.81	46.5	50	31.06	75.25	59.06	37.63
Scaled Objective	80.82	28.08	58.67	13.78	445.23	23.89	90.50	81.61	155.66	136.43	629.54	92.15	1420.78	481.43	242.90	86.78
Participation	-2.0064	-1.7873	-3.9090	-2.5197	-0.3970	-0.5378	-0.9264	-2.0016	-3.4013	-3.9931	-1.9944	-1.8194	-1.2561	-0.3609	-1.6406	-1.5847
Objective	10,426	3,622	7,569	1,778	57,435	3,082	11,674	10,528	20,080	17,600	81,211	11,887	183,280	62,105	31,335	11,195
Mean Price Dist.	52.92	49.11	35.63	15.82	63.75	32.01	41.55	17.04	37.51	81.25	46.50	75.60	29.80	68.48	110.61	37.63
Median Price Dist.	39.43	29.43	19.29	8.30	12.29	20.59	37.81	12.70	28.41	50.67	21.29	47.45	11.04	48.07	81.72	25.56
Variance Price Dist.	2,243	4,304	3,064	657	105,249	1,453	358	232	1,046	10,372	8,153	8,794	5,585	4,826	10,176	1,654
Skewness Price Dist.	0.0643	0.1302	0.2360	0.5769	2.3069	0.1643	0.0352	0.1993	0.0860	0.0705	0.2827	0.0745	0.7818	0.0597	0.0316	0.1197
Kurtosis Price Dist.	25.93	120.59	244.21	302.24	564,531.64	73.98	4.02	25.81	22.94	91.54	797.46	87.58	3,751.24	40.02	27.62	50.55

Optimal action is the non-negative integral action value taken by the agent. ***Mu*** is the value of the μ parameter of the lognormal price distribution under the ***optimal action***. ***Salary*** is the amount of the fixed payment to the agent (in $ thousands) in the optimal contract. ***Shares*** is the number of shares of the firm (in thousands) granted to the agent in the optimal contract. ***Options*** is the number of at-the-money call options on the firm's stock (in thousands) granted to the agent in the optimal contract. ***Strike*** is the exercise price (in $) of the at-the-money call options granted to the agent in the optimal contract. ***Scaled objective*** is the value of the principal's objective function at the optimal contract. ***Participation*** is the value of the agent's participation (i.e., (IR)) constraint at the optimal contract, which is the agent's expected utility at the optimal contract. ***Objective*** is the value of the principal's objective function (in $ millions) for the optimal contract scaled by the scaling multiplier (i.e., 129,000,000). This can be interpreted as the payoff to the principal (i.e., total firm value), net of the compensation paid to the agent and the value of the agent's pre-existing equity holdings. ***Mean Price Dist.*** is the expected value of the price distribution following the agent's action induced by the optimal contract. ***Median Price Dist.*** is the median value of the price distribution following the agent's action induced by the optimal contract. ***Variance Price Dist.*** is the variance of the price distribution following the agent's action induced by the optimal contract. ***Skewness Price Dist.*** is the normalized third central moment of the price distribution following the agent's action induced by the optimal contract. This measures the degree of asymmetry in the distribution and values greater (less) than zero indicates positive (negative) skewness. ***Kurtosis Price Dist.*** is the normalized fourth central moment of the price distribution (minus three) following the agent's action induced by the optimal contract.

Table 5

"Excess" CEO Compensation for the Constrained Second Best Solution

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	DOV	**BDK**	**ROH**	**LYO**	**QCOM**	**SFD**	**GIS**	**ADM**	**CAG**	**DE**	**HPQ**	**PCAR**	**INTC**	**UTX**	**ITW**	**HDI**
Salary	0	0	10,948	631	185	15,264	9,030	200	4,105	5,361	947	0	761	884	0	28
Shares	0	0	7	1,123	86	0	0	85	74	0	1	0	273	17	0	1
Options	10,003	4,575	4	5,910	430	0	0	16,573	1	0	2	4,020	1,171	0	5,688	2
Strike	38.63	38.56	35.63	16.00	71.31	34.25	42.36	9.81	20.85	36.81	46.50	50.00	31.06	75.25	59.06	37.63
Participation	-2.0064	-1.7873	-3.9090	-2.5197	-0.3970	-0.5378	-0.9264	-2.0016	-3.4013	-3.9931	-1.9944	-1.8194	-1.2561	-0.3609	-1.6406	-1.5847
Reservation Utility	-2.1218	-1.8037	-3.9142	-2.5761	-1.6996	-0.6994	-0.9264	-2.2470	-3.4014	-3.9936	-1.9953	-2.4725	-1.6306	-0.5216	-2.0351	-1.6404
Excess Compensation	3,497	653	44	1,120	249,050	55,436	7	7,039	1	4	31	18,727	23,585	110,077	15,241	2,762

Salary is the amount of the fixed payment to the agent (in $ thousands) in the optimal contract. ***Shares*** is the number of shares of the firm (in thousands) granted to the agent in the optimal contract. ***Options*** is the number of at-the-money call options on the firm's stock (in thousands) granted to the agent in the optimal contract. ***Strike*** is the exercise price (in $) of the at-the-money call options granted to the agent in the optimal contract. ***Scaled objective*** is the value of the principal's objective function at the optimal contract. ***Participation*** is the value of the agent's participation (i.e., (IR)) constraint at the optimal contract, which is the agent's expected utility at the optimal contract. ***Reservation utility*** is the agent's expected utility over his pre-existing wealth (consisting of fixed wealth, shares of stock, new options, unexercisable options, and exercisable options) and four times the most recent (i.e., fiscal year 2000) median industry compensation assuming the executive exerts an action of zero and incurs no disutility of effort. ***Excess Compensation*** is the certainty equivalent (in $ thousands) of additional compensation that the agent would have to receive from his outside alternative to obtain the same expected utility as under the optimal constrained second-best contract.

Table 6

Comparison of Actual (Four-Year Aggregate) to the Second Best Optimal Compensation

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	DOV	BDK	ROH	LYO	QCOM	SFD	GIS	ADM	CAG	DE	HPQ	PCAR	INTC	UTX	ITW	HDI
Actual Salary	9,159	25,200	7,300	7,102	9,851	27,651	9,724	11,176	18,957	12,257	23,928	11,328	8,612	16,411	12,073	16,527
Actual Shares	0	38.6	32.8	76.4	0	0	108.5	343.7	200.6	116.7	35.2	0	0	0	194.6	0
Actual Options	827	875	898	1,871	2,160	1,400	2,100	1,105	1,055	1,073	3,250	449	2,769	2,490	823	585
Optimal Salary	0	0	10,948	631	185	15,264	9,030	200	4,105	5,361	947	0	761	884	0	28
Optimal Shares	0	0	7	1,123	86	0	0	85	74	0	1	0	273	17	0	1
Optimal Options	10,003	4,575	4	5,910	430	0	0	16,573	1	0	2	4,020	1,171	0	5,688	2

Actual Salary is the amount of the expected fixed payment to the agent (in $ thousands) and is computed as the sum of salary, bonus, other compensation, and the target long-term incentive from performance share plans. *Actual* ***Shares*** is the number of shares of the firm (in thousands) granted to the agent in the optimal contract. *Actual* ***Options*** is the number of at-the-money call options on the firm's stock (in thousands) granted to the agent in the optimal contract. The actual numbers are the same as rows one to three in Table 5. *Optimal S****alary*** is the amount of the fixed payment to the agent (in $ thousands) in the optimal contract. ***Optimal Shares*** is the number of shares of the firm (in thousands) granted to the agent in the optimal contract. ***Optimal Options*** is the number of at-the-money call options on the firm's stock (in thousands) granted to the agent in the optimal contract. The optimal numbers are the same as the rows three to five in Table 4.

Table 7

Solutions Using the Actual (Four-Year Aggregate) Contract

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	DOV	**BDK**	**ROH**	**LYO**	**QCOM**	**SFD**	**GIS**	**ADM**	**CAG**	**DE**	**HPQ**	**PCAR**	**INTC**	**UTX**	**ITW**	**HDI**
Salary	9,159	25,200	7,300	7,102	9,851	27,651	9,724	11,176	18,957	12,257	23,928	11,328	8,612	16,411	12,073	16,527
Stock	0	38.6	32.8	76.4	0	0	108.5	343.7	200.6	116.7	35.2	0	0	0	194.6	0
Options	827	875	898	1,871	2,160	1,400	2,100	1,105	1,055	1,073	3,250	449	2,769	2,490	823	585
Action	48	31	29	25	6	4	6	56	62	83	29	56	19	16	52	29
Mu	0.034	0.005	0.000	-0.006	-0.029	-0.017	-0.005	0.070	0.069	0.127	0.000	0.061	-0.015	-0.028	0.048	0.000
Scaled Objective	69.14	23.11	58.60	13.91	443.59	23.68	90.35	62.94	113.99	106.02	628.91	79.92	1399.38	473.33	164.33	86.60
Participation	-1.957	-1.326	-4.080	-2.599	-0.371	-0.503	-0.883	-1.795	-2.367	-3.024	-1.394	-1.600	-1.153	-0.339	-1.528	-1.270
Objective	8,919	2,981	7,559	1,795	57,223	3,055	11,655	8,119	14,704	13,677	81,130	10,309	180,519	61,059	21,199	11,171
Mean Price Dist.	44.34	39.27	35.63	15.63	63.43	32.01	41.55	12.98	27.50	61.27	46.50	63.73	29.27	67.31	71.55	37.63
Median Price Dist.	33.04	23.53	19.29	8.21	12.23	20.59	37.81	9.68	20.83	38.21	21.29	40.00	10.84	47.26	52.87	25.56
Variance Price Dist.	1,575	2,752	3,064	642	104,182	1,453	358	135	562	5,898	8,153	6,249	5,390	4,663	4,258	1,654
Skewness Price Dist.	0.077	0.163	0.236	0.584	2.319	0.164	0.035	0.262	0.117	0.094	0.283	0.088	0.796	0.061	0.049	0.120
Kurtosis Price Dist.	26	121	244	302	564,532	74	4	26	23	92	797	88	3,751	40	28	51

Salary is the expected fixed payment to the agent (in $ millions) during the fiscal years 2002 – 2005 and is computed as the sum of salary, bonus, other compensation, and the target long-term incentive from performance share plans. ***Shares*** is the number of shares of the firm (in thousands) granted to the agent during the fiscal years 2002 - 2005. ***Options*** is the number of at-the-money call options on the firm's stock (in thousands) granted during the fiscal years 2002 - 2005. ***Action*** is the non-negative integral action value induced by the observed contract. ***Mu*** is the value of the μ parameter of the lognormal price distribution under the ***induced action***. ***Objective*** is the value of the principal's objective function from the observed contact and the induced action. ***Participation*** is the value of the agent's participation (i.e., (IR)) constraint from the observed contract and the induced action. ***Scaled objective*** is the value of the principal's objective function (in $ millions) for the observed contract and the induced action scaled by the scaling multiplier (i.e., 129,000,000). This can be interpreted as the payoff to the principal (i.e., total firm value), net of the compensation paid to the agent and the value of the agent's pre-existing equity holdings. ***Mean Price Dist.*** is the expected value of the price distribution following the agent's action induced by the observed contract. ***Median Price Dist.*** is the median value of the price distribution following the agent's action induced by the observed contract. ***Variance Price Dist.*** is the variance of the price distribution following the agent's action induced by the observed contract. ***Skewness Price Dist.*** is the normalized third central moment of the price distribution following the agent's action induced by the observed contract. This measures the degree of asymmetry in the distribution and values greater (less) than zero indicates positive (negative) skewness. ***Kurtosis Price Dist.*** is the normalized fourth central moment of the price distribution (minus three) following the agent's action induced by the observed contract.