Stock Options and Chief Executive Officer Compensation†

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1 Introduction

Over the past decade there has been an explosion in the use of equity-based compensation (especially stock options) for top executives (e.g., Murphy, 1999; Ittner, Lambert, and Larcker, 2003). Despite the growing popularity of stock options, there is considerable academic and professional debate regarding the relative costs and benefits of equity-based compensation. Some observers view these plans as providing high-powered incentives that align the interests of employees with shareholders and help attract and retain scarce managerial and technical talent. However, critics claim that options give away too much value by diluting the interests of shareholders. Perhaps based on this claim, some companies are dropping their stock option in favor of restricted stock (e.g., Carter, Lynch, and Tuna (forthcoming); Frederic W. Cook & Co., 2006).

One especially pointed academic critique is that stock options are an inefficient mechanism for compensating executives relative to restricted stock. (e.g., Meulbroek, 2001; Hall and Murphy, 2002). Similarly, Dittmann and Maug (forthcoming) conclude that stock options should almost never be part of the compensation contract for actual CEOs. In contrast, Kadan and Swinkels (2006) develop and test an agency model where stock options dominate restricted stock when non-viability (or bankruptcy) risk is zero. Aseff and Santos (2005) also suggest that option grants are a powerful instrument for providing incentives to the agent. Thus, there is considerable debate in the prior research about the desirability of using stock options for compensating senior-level executives.

The purpose of this paper is to further investigate the optimal use of stock options in compensation contract for chief executive officers (CEOs). We first develop an agency model that mimics the real world contracting problem between shareholders and the CEO. Some of the important features of our model are that the CEO's compensation contract is limited to fixed salary, at-the-money stock options, and restricted stock, the 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, outside wealth consists of a fixed portion and a portfolio of pre-existing stock options and stock with a stochastic payoff, and agent exerts effort affects all the moments of the lognormal distribution of stock price. We then employ numerical methods to solve this bi-level optimization problem for the optimal CEO compensation contract for a sample of firms in *Fortune 500* during the time period from 2000 to 2004.

Our analysis produces three important results. First, in marked contrast to the conclusions by Meulbroek (2001), Hall and Murphy (2002) and Dittmann and Maug (forthcoming), we find that stock options are an important part of the optimal CEO compensation contract. Second, consistent with Aseff and Santos (2005), restricting the compensation contract to fixed salary, at-the-money stock options, and restricted stock produces roughly the same expected payoff to owners as the unrestricted second-best compensation contract. This result suggests that simple observed compensation contracts are robust. Finally, 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. For these CEOs, the choice of compensation contract is essentially the amount of fixed salary that is necessary to satisfy the outside reservation wage.

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 develop our numerical optimization approach in Section 3. Section 4 discusses our sample and measurement choices. Our results are presented in Section 5. Section 6 provides sensitivity and validation analyses. 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. For example, Meulbroek (2001) argues that risk averse and undiversified executives do not place enough value on the risky payout they will receive from an option to justify the cost given up by shareholders (and implicitly the incentives the option will provide). However, Meulbroek (2001) does not model the incentive effect of the stock option and this makes it problematic for her to assess the net benefit to shareholders from using a stock options. Similarly, using the certainty equivalent approach of Lambert, Larcker, and Verrecchia (1991), Hall and Murphy (2002) conclude that restricted stock (which is an option with an exercise price of zero) dominates options with non-zero exercise prices. However, their numerical results are also based on a "partial equilibrium" analysis that does not formally incorporate the cost of the option, the value to the employee, or the incentives provided by the options into an optimization program. Since the incentives are a key reason for the use of equity-based contracts, it is impossible to make substantive conclusions about the relative desirability of stock options or restricted stock unless incentives are actually part of the modeling analysis.

In contrast to Meulbroek (2001) and Hall and Murphy (2002), Kadan and Swinkels (2006) analyze and provide some empirical tests of a fully specified optimization 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).[1] Their formulation departs from the traditional agency model by incorporating a minimum payment constraint or limited liability

[1]Feltham and Wu (2001) also develop a fully specified optimization model that includes stock options or restricted stock. They find that restricted stock dominates (does not necessarily dominate) option-based contracts that when the agent affects only the mean (both the mean and the variance) of the outcome, However, their model structure and solution technique exhibit several problematic features such as a mean-variance approximation to the agent's expected utility which is unlikely to be accurate when the agent's payoff is skewed with stock option contracts, reliance on the first-order condition approach that is inappropriate for this setting, and unconstrained salary for the agent.

(e.g., Innes, 1990) and a positive probability that stock price is equal to zero or what they term as "non-viability risk". Using the first order approach (FOA) to represent the agent's problem, Kadan and Swinkels (2006) find that stock options dominate restricted stock when non-viability risk is zero.[2] Using a sample of firms from *ExecuComp*, they also find that the probability of bankruptcy (as a measure of non-viability) risk is positively related to the use of restricted stock. Since the probability of non-viability risk is likely to be low for most firms, the results in Kadan and Swinkels (2006) imply that stock options should be part of the optimal CEO compensation contract.[3]

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. Thus, Aseff and Santos (2005) show that stock options are an important component of the observed executive compensation contracts.

Finally, Dittmann and Maug (forthcoming) consider an agency model with a variety of

[2]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.

[3]This hypothesis is somewhat at odds with the general observation that young technology firms (with a high probability of bankruptcy) aggressively use stock options, as opposed to restricted stock, in the executive compensation programs (e.g., Ittner, Lambert, and Larcker, 2003).

realistic features and use 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 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 very small in expectation. Thus, it is not surprising that stock options do not enter the "optimal" contract in the analysis by Dittmann and Maug (forthcoming). Second, their analysis relies on the ability of the FOA to construct a measure for the incentives imposed on the agent. 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.

This brief literature review illustrates that there is considerable controversy regarding the use of stock options in executive compensation plans. In order to provide some insight into the optimal use of stock options, we develop an agency model that mimics the real world contracting problem between shareholders and the CEO. We also incorporate a number of the structural features from Aseff and Santos (2005), Kadan and Swinkels (2006), and Dittmann and Maug (forthcoming) into our model.

3 Agency Model

3.1 Basic Model Structure

We assume that the traditional moral hazard model is an appropriate representation of the contracting problem involving shareholders and the CEO. Our model is based on a traditional single period agency setting with a risk neutral principal and a risk and effort averse agent.[4] 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.[5]

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 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

[4]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.

[5]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.

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):

$$\begin{aligned}
&\underset{(\alpha,\beta_1,\beta_2,a)}{\text{maximize}} && \mathbb{E}[NP - (\alpha + \beta_1 P + \beta_2 \max\{P-K,0\})|a] \\
&\text{subject to} && a \in \underset{\tilde{a}}{\text{argmax}}\,\{\mathbb{E}[U(\alpha + \beta_1 P + \beta_2 \max\{P-K,0\})|\tilde{a}] - D(\tilde{a})\} && (IC) \\
& && \mathbb{E}[U(\alpha + \beta_1 P + \beta_2 \max\{P-K,0\})|a] - D(a) \geq \underline{U} && (IR) \\
& && \alpha \geq 0 && (LL) \\
& && \beta_1,\, \beta_2 \geq 0 && (SS) \\
& && \beta_1 + \beta_2 \leq N && (TS)
\end{aligned}$$

where N is the number of shares outstanding,[6] 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

[6] 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.

the agent's disutility of effort, and $\underline{U}$ 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-existing wealth into the optimization, the principal's problem is characterized by the following maximization program (#2).

$$\begin{aligned}
\underset{(\alpha,\beta_1,\beta_2,a)}{\text{maximize}} \quad & \mathbb{E}[(N-S)P - \mathit{Compensation} - \mathit{Options}|a] & \\
\text{subject to} \quad & a \in \underset{\tilde{a}}{\operatorname{argmax}} \{\mathbb{E}[U(\mathit{Wealth} + \mathit{Compensation})|\tilde{a}] - D(\tilde{a})]\} & (IC') \\
& \mathbb{E}[U(\mathit{Wealth} + \mathit{Compensation})|a] - D(a) \geq \underline{U}' & (IR') \\
& \alpha \geq 0 & (LL) \\
& \beta_1,\ \beta_2 \geq 0 & (SS) \\
& \beta_1, +\beta_2 + \beta_3 + \beta_4 + \beta_5 \leq N & (TS')
\end{aligned}$$

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

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

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 ($K1$, $K2$, and $K3$) are the number (exercise price) of options in each category.[7] The payoff for the pre-existing option is defined as follows:[8]

$$Options = \beta_3 \max\{P - K_1, 0\} + \beta_4 \max\{P - K_2, 0\} + \beta_3 \max\{P - K_3, 0\}.$$

$Wealth$ is sum of the agent's pre-existing fixed wealth, shares, and stock options. $\underline{U}'$ is the agent's reservation utility for both wealth and compensation and is defined as follows:

$$\underline{U}' = \mathbb{E}[U(Wealth + External\,Wage)]$$

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 Concerts Regarding to the First Order Approach

The analytical and numerical analyses reviewed in Section 2 rely on the validity of the FOA in 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. Moreover, the sufficient conditions found in the literature are highly

[7] The three categories are options granted last period, exercisable options, and unexercisable options. This choice is related to the data that are available for developing model parameters (e.g., Core and Guay, 2002).

[8] 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.

specialized (e.g., convexity of the distribution function condition and monotone likelihood ratio property) and can easily fail in the economic setting in the papers discussed in Section 2 as well as our model. Thus, it is important to verify the validity of the FOA before proposing a solution strategy.

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.[9]

3.3 Solution Strategy

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) and avoid the reliance on the validity of the FOA. The Grossman and Hart (1983) approach also facilitates finding of a globally optimal solution for the compensation contract.[10]

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

[9] 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.

[10] 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.

inequalities:

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

for each of the agent's $i = 1, \ldots, M$ 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)[11]:

$$\begin{aligned}
&\underset{(\alpha,\beta_1,\beta_2,y)}{\text{maximize}} \quad \mathbb{E}\left[NP - (\alpha + \beta_1 P + \beta_2 \max\{P-K,0\})|\left(\sum_{i=1}^{M} y_i a_i\right)\right] \\
&\text{subject to} \\
&y \in \underset{\tilde{y}:\tilde{y}_i\in\{0,1\},\sum\tilde{y}_i=1}{\text{argmax}} \quad \left\{\mathbb{E}\left[U(\alpha + \beta_1 P + \beta_2 \max\{P-K,0\})|\left(\sum_{i=1}^{M} \tilde{y}_i a_i\right)\right] - D(\sum_{i=1}^{M} \tilde{y}_i a_i)\right\} \\
&\mathbb{E}\left[U(\alpha + \beta_1 P + \beta_2 \max\{P-K,0\})|\left(\sum_{i=1}^{M} y_i a_i\right)\right] - D(\sum_{i=1}^{M} y_i a_i) \geq \underline{U} \\
&\alpha \geq 0 \\
&\beta_1,\ \beta_2 \geq 0 \\
&\beta_1 + \beta_2 \leq N \\
&e_M^{\mathrm{T}} y = 1 \\
&y_i \in \{0,1\} \quad \text{for all } i = 1, \ldots, M.
\end{aligned}$$

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.

[11] 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.

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 (nonconvex) programs, where $y_i = 1$ (for $i = 1, \ldots, M$) 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, 2004), we follow Su and Judd (2006) and transform our problem into the following MPEC formulation, which we refer to as program (#4):

$$
\begin{aligned}
\underset{(\alpha,\beta_1,\beta_2,\delta)}{\text{maximize}} \quad & \sum_{i=1}^{M} \delta_i \, \mathbb{E}\left[NP - (\alpha + \beta_1 P + \beta_2 \max\{P-K,0\})|a_i\right] \\
\text{subject to} \quad & 0 \leq \delta_j \perp \{\sum_{i=1}^{M} \delta_i \cdot (\mathbb{E}\left[U(\alpha + \beta_1 P + \beta_2 \max\{P-K,0\})|a_i\right] - D(a_i)) \\
& - (\mathbb{E}\left[U(\alpha + \beta_1 P + \beta_2 \max\{P-K,0\})|a_j\right] - D(a_j))\} \geq 0 \\
& \sum_{i=1}^{M} \delta_i \, \mathbb{E}\left[U(\alpha + \beta_1 P + \beta_2 \max\{P-K,0\})|a_i\right] - D(a_i) \geq \underline{U} \\
& \alpha \geq 0 \\
& \beta_1, \, \beta_2 \geq 0 \\
& \beta_1 + \beta_2 \leq N \\
& \sum_{i=1}^{M} \delta_i = 1
\end{aligned}
$$

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 nonlinear 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 Sample and Measurement Choices

4.1 Sample

Our sample consists of 16 firms in the *Fortune 500* where there was no CEO turnover during the time period from 2000 to 2004. These selection criteria obviously reduce our ability to generalize our results. We impose these criteria because we use the four-year period from 2001 to 2004 to compare the model results to actual CEO compensation and assess the validity of our model.[12] Despite our modest sample size, we believe that our sample is sufficient for providing insight into the use of stock options in CEO compensation contracts for individual companies.

The descriptive statistics for our sample are presented in Table 1 (Panel A). Since we are selecting firms from the *Fortune 500*, it is not surprising that the mean (median) firm has very large with a market capitalization of $36,021 million ($9,920 million).

4.2 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)

[12] It is also necessary to use a sample much smaller than studies such as Dittmann and Maug (forthcoming) because the computational time required to solve our bi-level optimization is on the order of several hours per company.

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").[13] 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.[14] 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.[15] We assume that the agent's action impacts only the μ parameter (i.e., we assume that σ^2, 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 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

[13] 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."

[14] 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.

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

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,[16] 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 most recent year for all CEO's in the *Fortune 500*.[17] 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

[16]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).

[17]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.

the risk-free rate less the cost-of-capital) and the agent experiences no associated disutility of effort.

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 $\frac{1}{1-2}(\$100,000,000)^{1-2} = -10^{-8}$, which is very close to zero from a computational perspective. Further, the agent's marginal utility is $(\$100,000,000)^{-2} = 10^{-18}$, 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

[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.

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 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 Results

5.1 Unconstrained Second Best Solution

The results for the second best solution with an unconstrained compensation contract are computed using the basic structure of program # 4. The two key changes incorporated into program # 4 for the unconstrained solution are that the compensation contract consists of a cash payment for each stock price outcome (as opposed to a salary, stock option, and restricted stock contract) and agent wealth is included in the problem. 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

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

becomes concave at higher stock prices. These contracts provide 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.

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 (compute more precisely) 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.

5.2 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.[20] 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 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

[20]We confirmed this point by computing the agent's effort choice after constraining flow pay to *zero*.

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 Meulbroek (2001), Hall and Murphy (2002), and Dittman and Maug (forthcoming), 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, forthcoming).

6 Extensions

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.[21] 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).

[21] 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.

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 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 optimal compensation contract frequently includes large quantities of stock options. These numerical results are at odds with the conclusions by Meulbroek (2001), Hall and Murphy (2002), and Dittmann and Maug (forthcoming). Constraining the compensation contract to fixed salary, at-the-money stock options, and restricted stock (as opposed to an unrestricted compensation contracts) also 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. Finally, 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 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.

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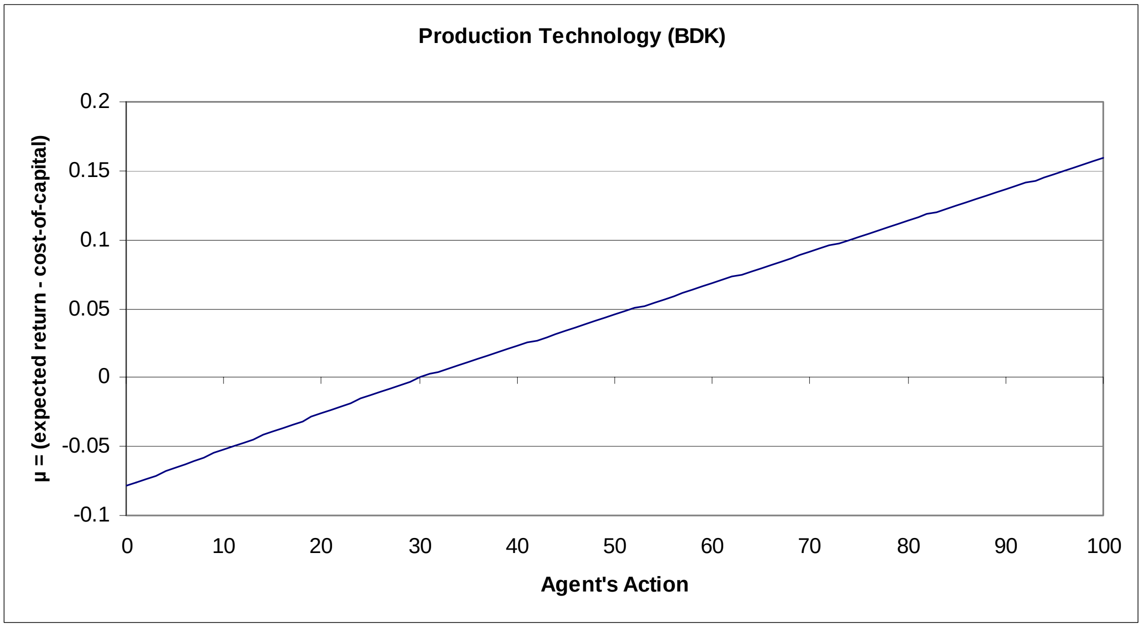
Figure 1

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



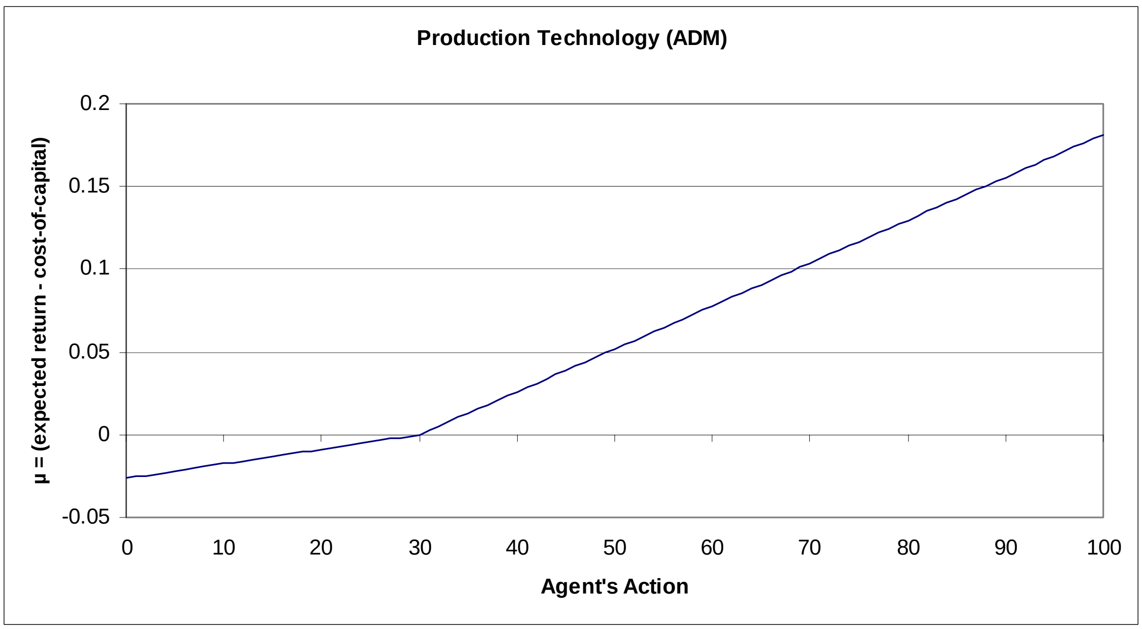
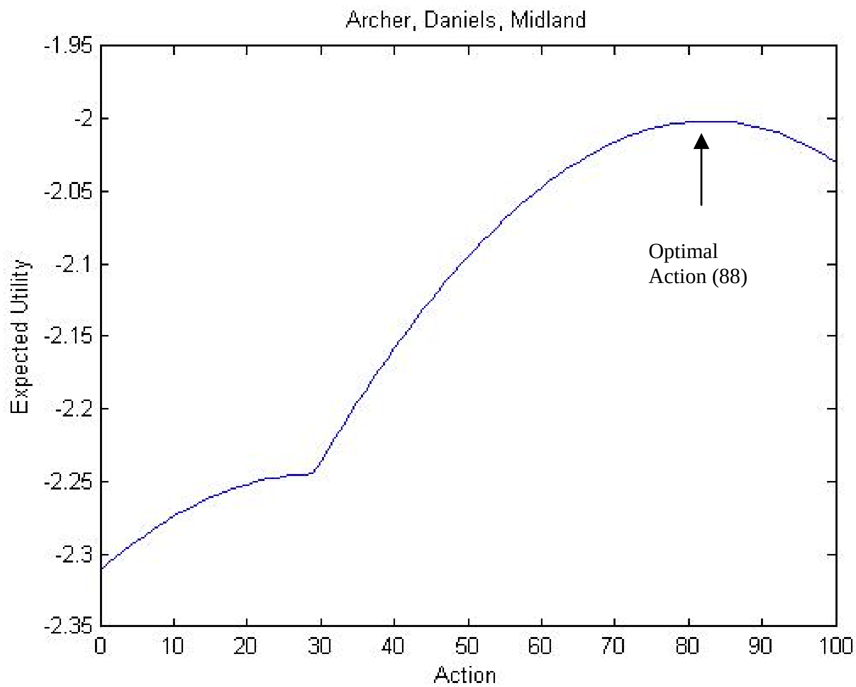


Figure 2
Agent Effort and Expected Utility for the
Optimal Restricted Compensation Contract



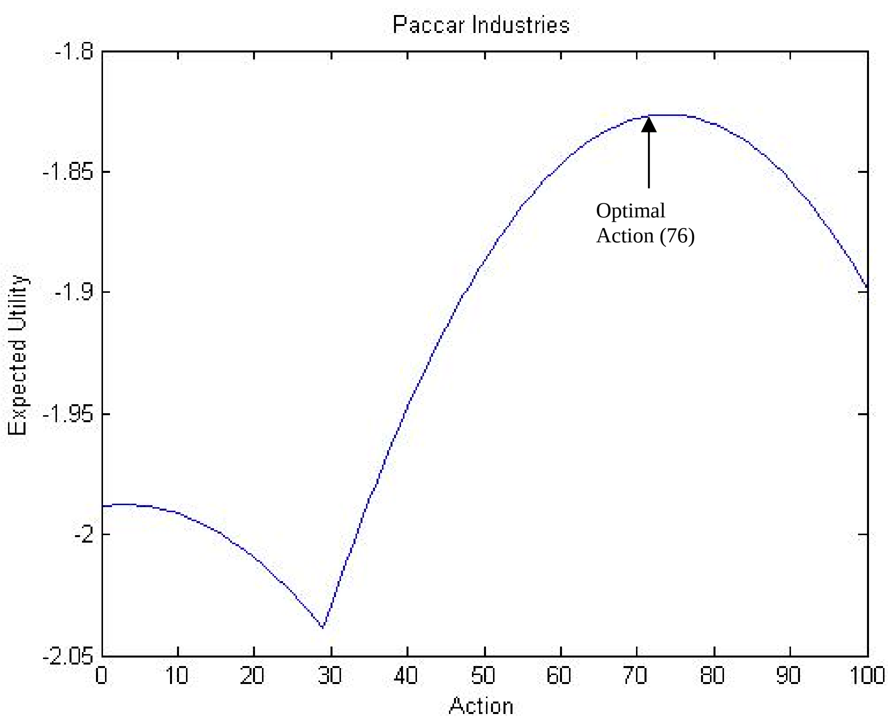
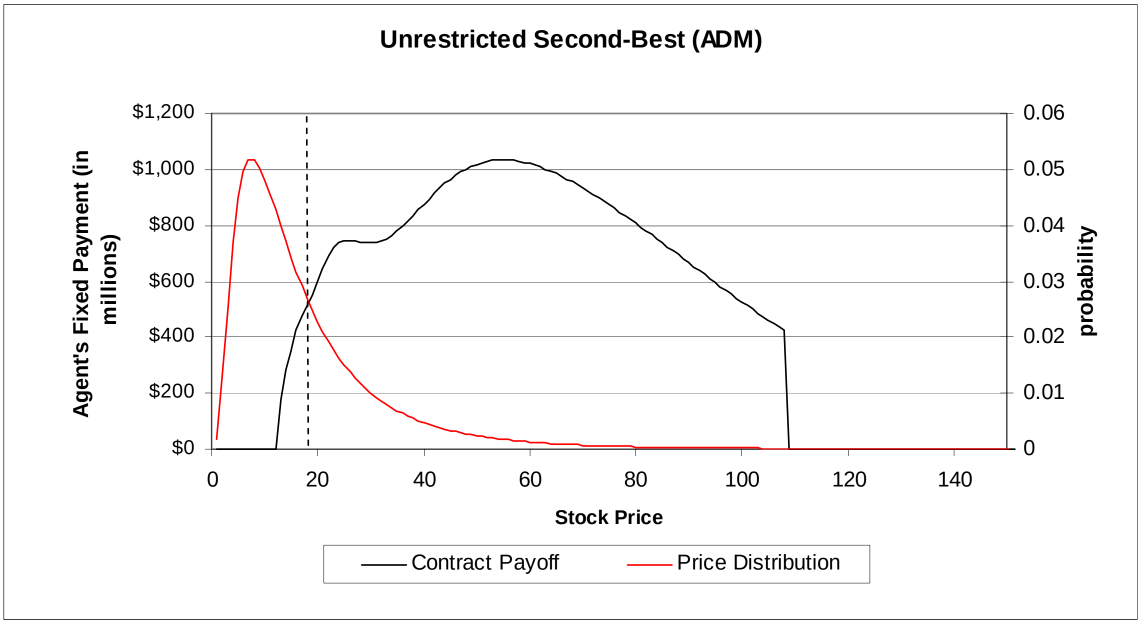


Figure 3

Optimal Unrestricted Second Best Contracts for the Optimal Action



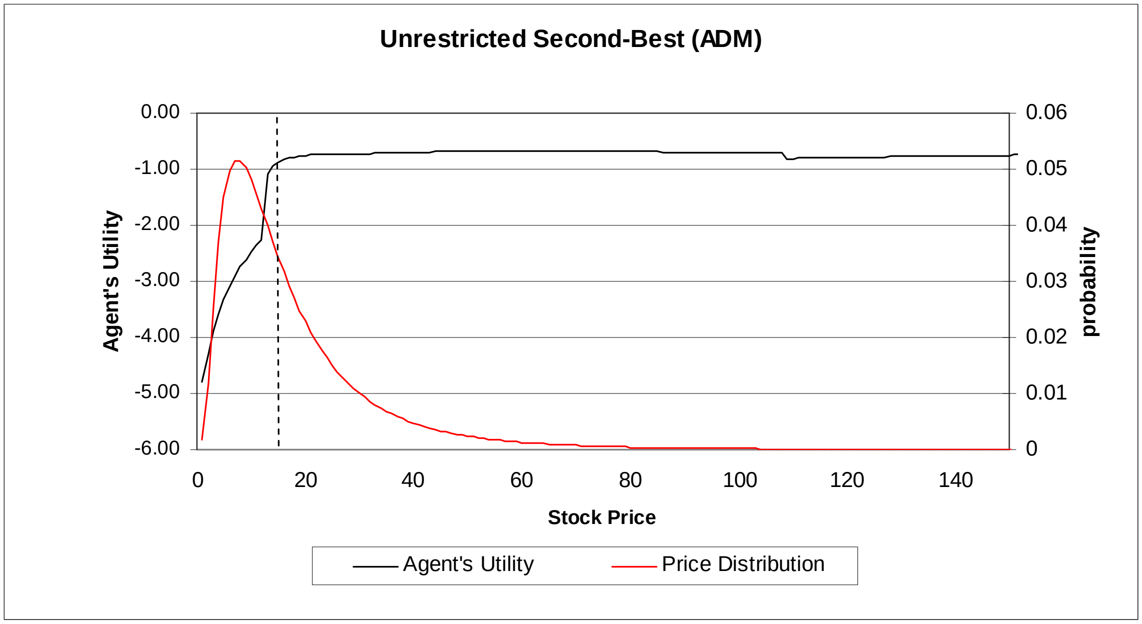
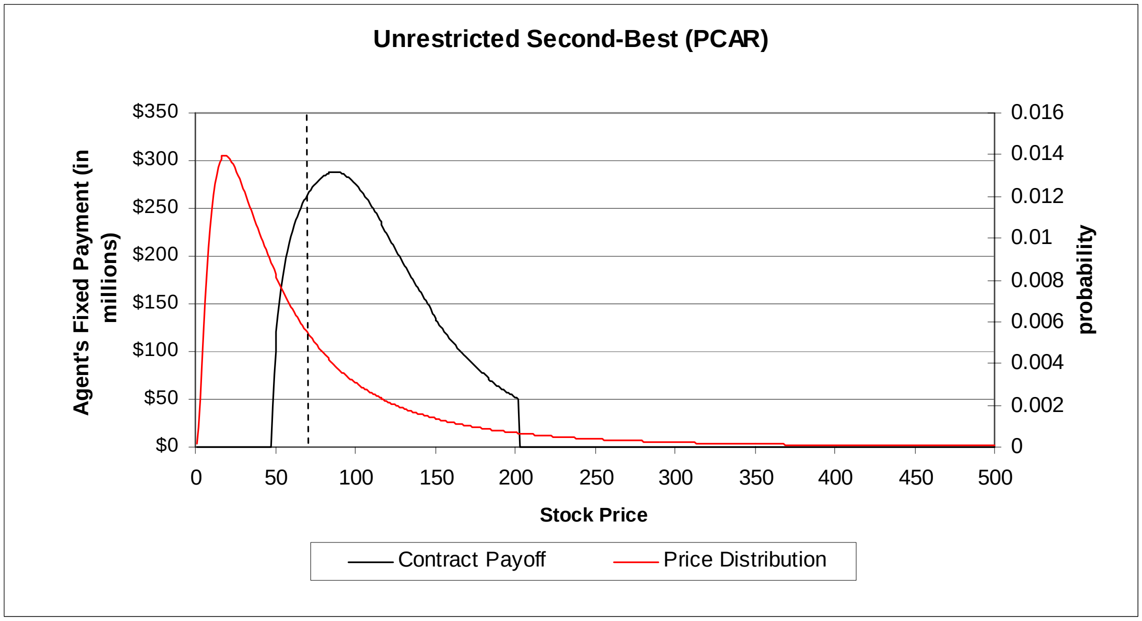
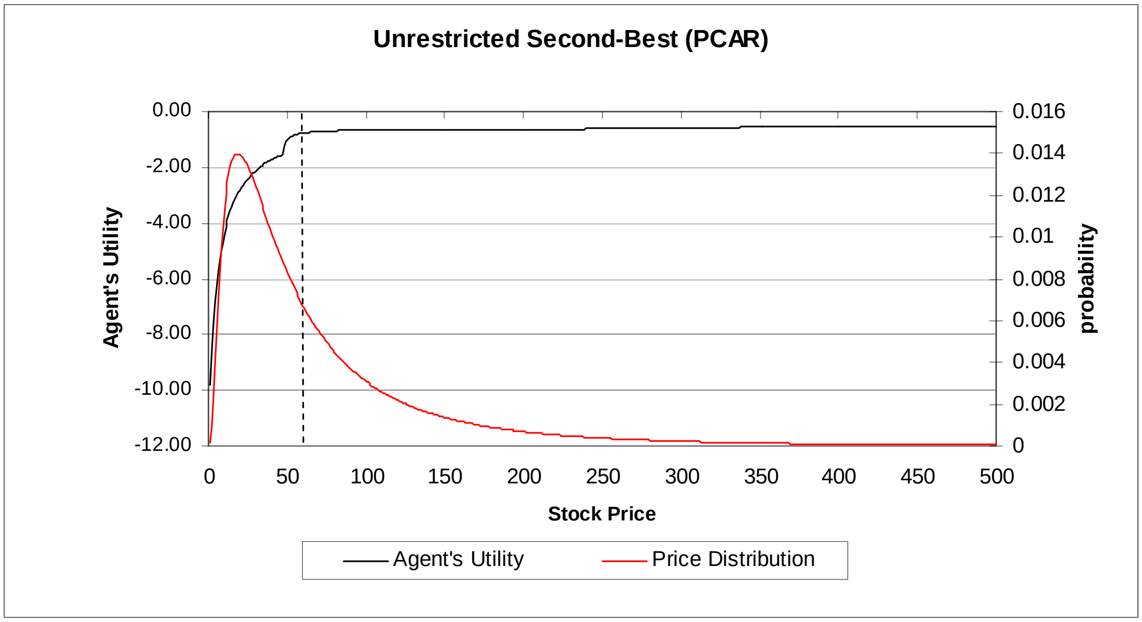


Figure 3 (continued)

Optimal Unrestricted Second Best Contracts for the Optimal Action





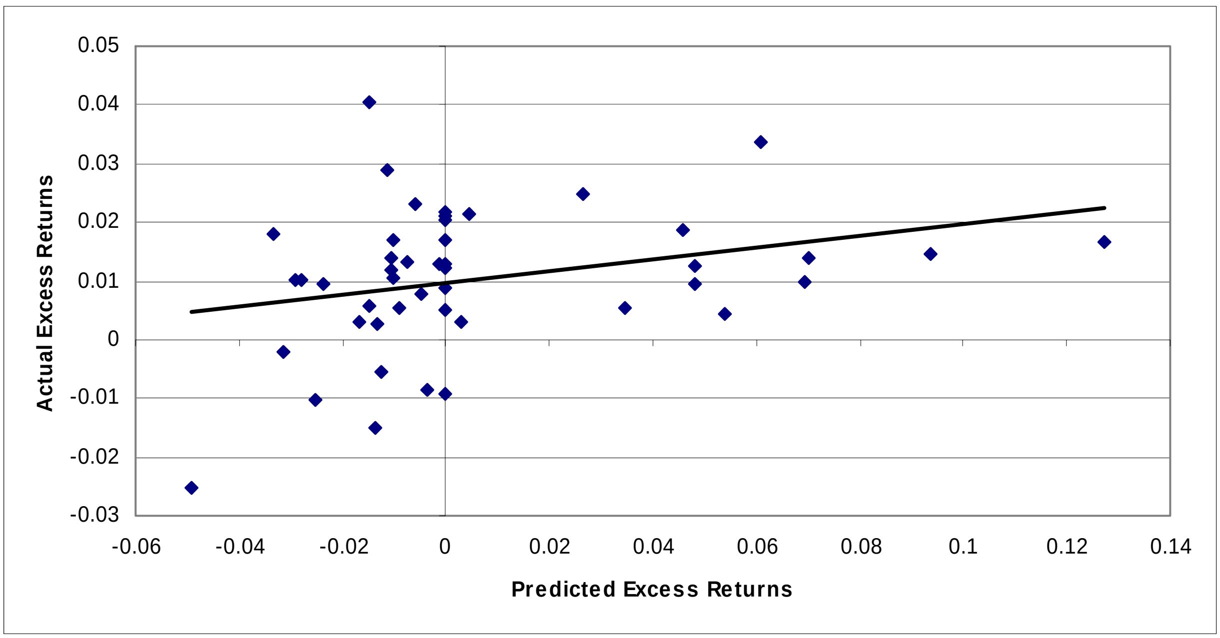
The dotted line is the expected stock price of $18.08 ($75.60) resulting from agent effort of 88 (75) for ADM (PCAR).

Figure 4

Plot of Actual Excess Return versus Predicted Excess Return

The sample consists of all firms in the 2000 <u>Fortune</u> <u>500</u> 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.