The Optimal Design of Stock Options: A Loss-aversion Approach*

Ernst Maug† Oliver Spalt‡

May 13, 2008

Abstract

We analyze optimal strike prices in the context of a principal agent-model with loss aversion and calibrate the model to a cross-section of US CEOs. We find that for the majority of CEOs options with strike prices close to the current stock price would be optimal and that the inefficiency of observed contracts compared to those prescribed by the model is small. Our cross-sectional results also predict that optimal compensation contracts would be less diverse across firms than observed contracts. We also investigate if the inefficiencies from pay-setting detected by the model are related to measures of the quality of corporate governance and find only weak evidence for this.

JEL Classifications: G30, M52

Keywords: Stock Options, Executive Compensation, premium options, Loss Aversion

*We thank Stefan Hirth and seminar participants at the University of Aarhus for helpful comments. We are grateful to the collaborative research center SFB 504 "Rationality Concepts, Decision Making and Economic Modeling" for financial support.

†Corresponding author. University of Mannheim, D-68131 Mannheim, Germany. Email: maug@bwl.uni-mannheim.de, Tel: +49 621 181 1952.

‡University of Mannheim, D-68131 Mannheim, Germany. Email: spalt@bwl.uni-mannheim.de, Tel: +49 621 181 1973.

The Optimal Design of Stock Options: A Loss-aversion Approach

Abstract

We analyze optimal strike prices in the context of a principal agent-model with loss aversion and calibrate the model to a cross-section of US CEOs. We find that for the majority of CEOs options with strike prices close to the current stock price would be optimal and that the inefficiency of observed contracts compared to those prescribed by the model is small. Our cross-sectional results also predict that optimal compensation contracts would be less diverse across firms than observed contracts. We also investigate if the inefficiencies from pay-setting detected by the model are related to measures of the quality of corporate governance and find only weak evidence for this.

JEL Classifications: G30, M52

Keywords: Stock Options, Executive Compensation, premium options, Loss Aversion

1 Introduction

In this paper we investigate the gap between the recommendations of academics as well as practitioners on one side and common practice in most countries on the other side with respect to the design of executive stock options. Common sense concurs with economic theory that two types of options would be particularly desirable, namely premium options and indexed options. Yet, premium options and indexed options are rarely observed in practice, and most options are granted at the money. We build a simple efficient-contracting model where we analyze optimal strike prices and then calibrate the model to a sample of CEOs. We show that there is in fact little mystery here: Companies could reduce their compensation costs by less than 0.5% if they replaced at the money options with premium options, so setting strike prices optimally is a secondary consideration from the point of view of designing efficient pay packages.

The case for premium options rests on the notion that CEOs and senior executives should only be rewarded for the value they help to generate. Consider a typical option grant with a maturity of 10 years, where options are typically exercised after about 7 years. If the stock price appreciates by 7% p.a., then the expected price in 7 years will be 61% above the current price, so at the money options – by far the most common type of option issued in the U.S. – provide the CEO with a significant windfall profit. By contrast, for a typical firm in our sample, a premium option, struck at the expected stock price in 7 years, would cost the firm almost 30% less than an otherwise identical at the money option.[1] If we adjust for the fact that premium options provide less incentives, by increasing the number of premium options, then the firm could still save 12% by replacing at the money options with premium options.[2] Given that the typical CEO in our sample has option grants worth about $11 million, this is a substantial component of compensation costs, which the boards of directors and their

[1] We use the following parameters: normalize the price and strike price to 100, set the dividend yield to zero, a risk-free rate of 4%, maturity of 7 years and a volatility of 40%. Then the Black-Scholes value of the option is 48.73. With a strike-price of 161 (the expected stock price after 7 years) the Black-Scholes value drops to 34.63.

[2] In this example, we define incentives in terms of pay-performance sensitivity. The value of the CEO's options change for a small change in the stock price by $n_o N(d1)$, where n_o is the number of options granted and $N(d1)$ is the option delta. The option delta is 0.79 for at the money options and 0.64 for premium options. Hence, the number of options has to be increased by a factor of 1.248 to keep pay-performance sensitivity constant.

compensation committees should be concerned about. The argument for indexed options follows a similar line of reasoning and argues that CEOs should be paid only for performance and not for luck.[3] We do not investigate indexed options in this paper and argue in the conclusion why we expect that the logic of our analysis in this paper carries over to the case of indexed options as well.

Two views have emerged that explain the gap between observed practice and recommendations based on the argument outlined above. The *rent-extraction view* takes the absence of indexed options and premium options as evidence for the hypothesis that managers capture the pay-setting process and extract unearned rents.[4] The *efficient-contracting view* holds that this reading of the evidence is one-sided. In particular, it is not clear why the U.S., which is held to be the country with the best developed corporate governance practices, should deviate furthest from the best practice for setting executive pay.[5]

The debate between these two views suffers from the fact that there is no accepted model of efficient contracting that can serve as a normative benchmark and that can also accommodate the use of stock options as part of the optimal contract. The standard principal-agent model with effort aversion, lognormal stock prices, and CRRA-preferences, which was conventionally used in the literature, cannot accommodate stock options.[6] Our analysis here relies on the loss-aversion model introduced in Dittmann, Maug, and Spalt (2007), which yields combinations of stock and options that correspond broadly to the proportions observed in practice. Our contribution to the literature is that we are the first to analyze optimal strike prices in an efficient-contracting model that can endogenously generate positive option holdings and positive base salaries.

We apply the model to a sample of 724 U.S. CEOs. We calibrate the model individually and compute the optimal strike price for each CEO. We present comparative static analyses for a representative CEO as well as for the whole sample, where we also vary our assumptions

[3] See for example, Rappaport (1999) and Bebchuk and Fried (2004).

[4] Bertrand and Mullainathan (2001), Bebchuk and Fried (2004), particularly pp. 142-146.

[5] See Aggarwal, Erel, Stulz, and Williamson (2007) for a recent cross-country study on corporate governance quality.

[6] To the best of our knowledge the earliest use of this model for the analysis of compensation contracts is Lambert, Larcker, and Verrecchia (1991). The model was used for the analysis of optimal strike prices by Hall and Murphy (2000, 2002). Dittmann and Maug (2007) show that this model cannot accommodate stock options and that it generally predicts concave contracts.

about the reference wage in the loss-aversion model. We find that premium options are optimal for higher values of the reference wage but not for the lower values suggested by the results in Dittmann, Maug, and Spalt (2007). We find that premium options are optimal for volatile firms and for firms that rely heavily on options as a form of incentive compensation. We then compare the costs to shareholders of contracts with optimal strike prices according to the model with the costs of observed contracts. The savings from setting strike prices optimally are always small, even for those parameterizations where premium options become optimal for most companies.

The savings from switching from the observed contracts to the contracts prescribed by the model also admit another interpretation, where we adopt the model as a normative benchmark and regard the savings from recontracting as a measure of the inefficiency of pay-setting. According to the rent-extraction view, these savings should be related to indicators of the quality of corporate governance. We find that the CEO's pay slice, suggested by Bebchuk, Cremers, and Peyer (2007) as a measure of CEO power, is consistently related to the savings from recontracting. There is also weak evidence that savings are higher in firms with higher agency costs, such as R&D intensive firms and firms with high Tobin's Q. The governance index of Gompers, Ishii, and Metrick (2003) has no predictive power. While there is some evidence that internal governance is statistically significant, the economic significance is small. Hence, there is no evidence from our approach to suggest that there are large inefficiencies in the structure of CEO compensation contracts.

The reason why our results are different from those in the simple numerical example above is that our model looks at all components of the compensation package. Recontracting then does not just lead to a redesign of the option component of the contract in which a given number of options with low strike prices is replaced with more options that have higher strike prices. Instead, contemporaneous with a change in the strike price, the optimal portion of incentives from options and shares is adjusted (to meet the incentive compatibility constraint), and the base salary is changed accordingly (to meet the CEO's participation constraint).

We develop our analytic approach in the next Section 2. Section 3 describes the data set used in our empirical analysis and Section 4 contains our main results. Section 5 provides some robustness checks and Section 6 concludes.

2 The analytic approach

We develop an efficient-contracting model to analyze optimal strike prices on the basis of the loss-aversion model in Dittmann, Maug, and Spalt (2007).[7] The strategy is to calibrate the model and numerically derive optimal contracts for each individual CEO in a large cross-sectional data set. In solving for the optimal contract, we endogenize the number of shares, the number of options, the base salary, and the strike price of the option. We can thus explicitly analyze how a change in one contract parameter influences the optimal choice of the other parameters.

2.1 The model

The model is a version of the static hidden action principal-agent model (Holmström, 1979). At time $t = 0$ a risk-neutral firm makes a take-it-or-leave-it offer of a contract to a loss-averse and effort-averse CEO. The CEO accepts the contract if it provides her with at least the same value (net of effort costs) as her exogenous outside opportunity.[8] If the CEO accepts the contract, she can exert non-contractible and costly effort, which enhances the expected value of the firm at time $t = T$. Any uncertainty about the firm value is resolved at time T and the CEO is paid according to the contract.

The non-contractibility of CEO effort introduces a trade-off for the firm between efficient risk-sharing and providing the CEO with an incentive to exert effort by making her pay contingent on firm value.[9] Under standard technical assumptions, the optimal contract can be shown to be a monotonically increasing function of the time T firm value P_T.

To make this model operational, we assume specific functional forms for the technology,

[7] The exposition of the model in this paper will focus on the essential parts. For further details and some methodological choices (such as using risk-neutral valuation or the validity of the first-order approach) see the detailed discussion in Dittmann, Maug, and Spalt (2007). For details on risk-neutral pricing see also Dittmann and Maug (2007) and Cai and Vijh (2005).

[8] We do not use the term "utility" here because we are working in a loss-aversion framework.

[9] This is strictly true for risk-averse CEOs. The argument also holds empirically for the loss-averse CEOs in our set-up, since all are effectively risk averse in the sense that their certainty equivalent for the observed contract is lower than the expected value of the contract.

admissible contracts, and CEO preferences. For the **technology**, we assume that the value of the firm at time $t = T$, denoted by P_T, is lognormally distributed and that CEO effort, denoted by e, shifts the mean of the distribution of stock prices:

$$P_T(u,e) = P_0(e) \exp\left\{ \left(r_f - \frac{\sigma^2}{2} \right) T + u\sqrt{T}\sigma \right\} \ , \quad u \sim N(0,1) \ , \tag{1}$$

where r_f is the risk-free rate of interest, σ is the annualized standard deviation of stock returns, u is a standard normal random variate, and $P_0(e) = e^{-r_f T} E[P_T]$ is a strictly increasing and concave function.[10] To guarantee internal consistency of our approach, we use risk-neutral pricing throughout. Hence, the stock price is expected to appreciate annually at the risk-free rate. Note that in any rational-expectations equilibrium, P_0 is equal to the market value of equity at the effort level e^* chosen by the manager under the observed contract. We assume rational expectations, so $P_0(e^*)$ is equal to the observed market capitalization of the firm.

Admissible contracts are denoted by $w(P_T)$ and specify the pay-off to the CEO at time T as a function of firm value. As is standard in the literature, we restrict ourselves to stylized linear contracts that consist of stock, options, and base salary

$$w(P_T) = \phi e^{r_f T} + n_S P_T + n_O \max(P_T - K, 0), \tag{2}$$

where ϕ denotes fixed salary (which in our formulation we assume to be paid at $t = 0$), n_S is the number of shares, expressed as a fraction of all shares outstanding, n_O is the number of stock options (where the number of shares outstanding is normalized to one), and K is the strike price of the option. We use the superscript "d" to denote observed contract parameters ("data") and superscript "$*$" to denote optimal contract parameters chosen by our model.

Regarding **preferences**, CEOs are assumed to be loss averse, so they evaluate outcomes of risky gambles relative to a reference point (Kahneman and Tversky, 1979 and Tversky and

[10] For ease of the exposition, we will submerge reference to u and e. We also do not include dividend yields here. Dividend yields will, however, be integrated into our numerical implementation.

Kahneman, 1992). Following the literature, we assume the following parametric form:

$$V\left(w\left(P_T\right)\right)=\begin{cases}\left(w\left(P_T\right)-w^R\right)^{\alpha} & if \quad w\left(P_T\right)\geq w^R\\ -\lambda\left(w^R-w\left(P_T\right)\right)^{\beta} & if \quad w\left(P_T\right)<w^R\end{cases}, \text{ where } 0<\alpha,\beta<1 \text{ and } \lambda\geq 1. \tag{3}$$

Here w^R is the reference point and outcomes above the reference point are coded as gains and outcomes below the reference point are coded as losses. The reference point is assumed to be exogenous in what follows.[11] The parameters α and β determine the curvature of the value function over the gain space and the loss space, respectively. CEOs are risk averse over gains and risk seeking over losses. Finally, $\lambda \geq 1$ is the coefficient of loss aversion, which governs the steepness of the value function over losses. For values of $\lambda > 1$ the aversion to losses of all sizes is higher than the attraction to equal-sized gains.

In the absence of clear guidance from the literature, we assume that the reference point w^R is based on last year's pay package. More specifically we assume

$$w_t^R\left(\theta\right)=\phi_{t-1}+\theta\cdot MV(n_{t-1}^S,n_{t-1}^O,P_t). \tag{4}$$

Hence, the reference point equals last year's base salary plus θ times the market value of the share and option portion of last year's contract evaluated at today's stock price. For $\theta = 0$, the reference point equals last year's base salary, while for $\theta = 1$, the reference point equals the risk-neutral value of last year's contract evaluated today.

We do not incorporate probability weighting. This is primarily a technical assumption to keep the underlying theoretical model tractable. However, there is also some research from decision scientists which suggests that individuals can "learn their way out" of distorting probabilities (van de Kuilen and Wakker, 2006, van de Kuilen, 2008). For loss aversion, on the other hand, there is strong evidence that professional traders are not less, and, if anything, more loss averse than inexperienced subjects (Haigh and List, 2005, Coval and Shumway, 2005). Hence there seems to be at least some support for the assumptions used here that CEO loss aversion is a stable effect for most professionals, whereas probability weighting may not be.

[11] For a treatment of endogenous reference points see for example de Meza and Webb (2007).

2.2 Analyzing optimal contracts

It is our aim to analyze optimal strike prices in a model where they have to be jointly determined with base salaries, the number of shares, and the number of stock options. Following Dittmann and Maug (2007) and the treatment in Dittmann, Maug, and Spalt (2007), we use the set-up developed in the previous section to show that the optimal structure of compensation contracts can be derived numerically for individual CEOs based on observable contracts. We proceed under the null hypothesis that observed contracts $w^d(P_T)$ are indeed optimal. Then it should not be possible to replace $w^d(P_T)$ by a contract $w^*(P_T)$ that gives the same value and incentives to the CEO and costs less to the firm. Formally, both, the firm and the CEO would agree to replace $w^d(P_T)$ with a new contract $w^*(P_T)$ that solves

$$\min_{\{\phi, n_S, n_O, K\}} \pi(w(P_T)) \equiv \phi + n_S P_0 + n_O BS_0(K) \tag{5}$$

such that

$$\int V[w^*(P_T)] f(P_T) dP_T \geq \int V\left[w^d(P_T)\right] f(P_T) dP_T \tag{6}$$

$$\int V[w^*(P_T)] \frac{\partial f(P_T)}{\partial P_0} dP_T \geq \int V\left[w^d(P_T)\right] \frac{\partial f(P_T)}{\partial P_0} dP_T \tag{7}$$

$$\phi \geq -W_0, \ n_S \geq 0, \ n_O \geq 0. \tag{8}$$

The cost of the contract to the company, $\pi(w(P_T))$, is approximated by the value a risk-neutral investor would pay for the contract. This value is given in (5). In our model the value of stock options is given by their Black-Scholes value, which we denote by BS.

Since the CEO is not allowed to hedge the risk imposed on her by the stock and options in her contract, the value of the contract to the CEO depends on the CEO's preferences. By equation (6), the new contract has to provide at least the same expected value to the CEO as the old one.

Incentives are the sensitivity of the CEO's expected utility with respect to the observed market value P_0. Equation (7) states that the algorithm should only consider contracts where the effort incentives of the CEO are at least as high as those under the observed contract $w^d(P_T)$. For a risk-neutral CEO ($\alpha = \beta = \lambda = 1$), this definition of incentives becomes the widely-studied pay-performance sensitivity.

We further assume that stock options and shares in the contract are bounded by zero, which means that the CEO cannot write options on her company and that she cannot short her company's stock. We allow for negative base salaries, which can be interpreted as the CEO investing in her own company from her own non-firm-related wealth. A conservative lower bound on ϕ is thus her total outside wealth W_0. There are no negative base salaries in observed contracts. We argue, however, that a good model should endogenously generate positive base salaries. Imposing $\phi \geq 0$ does not change anything material as we show in Section 5.

Given our assumptions about technology, admissible contracts, and CEO preferences, and given the fact that we can observe actual CEO pay contracts, we can numerically solve program (5) to (8) for individual CEOs. The solution to the program is a tuple $(\phi^*, n_S^*, n_O^*, K^*)$, consisting of the optimal base salary, the optimal numbers of shares and options, and the optimal strike price of the option.

The optimal contracts generated by the model can then be compared to observed contracts $\left(\phi^d, n_S^d, n_O^d, K^d\right)$. We define total savings as the reduction in expected compensation costs to the firm from switching from observed to optimal contracts as:

$$\text{Total savings } \equiv \frac{\pi\left(w^d\left(P_T\right)\right) - \pi\left(w^*\left(P_T\right)\right)}{\pi\left(w^d\left(P_T\right)\right)}. \tag{9}$$

If total savings are positive, $w^d(P_T)$ has an inefficient structure and cannot be optimal. Clearly, we do not expect a contract suggested by a highly stylized model to conform to contracts observed in reality. However, we use the savings from (9) as a metric for the difference between observed contracts and optimal contracts suggested by the model. It is these savings, which our numerical procedure maximizes.

Solving program (5) to (8) is numerically demanding because it involves searching over four dimensions (ϕ, n_S, n_O, K). Our numerical routine reliably solves problems with up to three parameters.[12] We therefore solve for (ϕ^*, n_S^*, n_O^*) using a minimization routine *given* a strike price K, and then let K vary over a grid of strike prices. For sufficiently fine grids

[12] We use a sequential quadratic programming method implemented in the Matlab routine "fmincon."

this approach is equivalent to the one-step search over four dimensions.[13] We define our grid relative to the actual market value of the firm according to

$$K \equiv \psi P_0. \tag{10}$$

In our benchmark specification we use steps of 0.125 for $\psi \in [0, 4]$. Hence, we solve 33 optimization problems for each CEO.

If premium options are indeed optimal, then we should expect $\psi^* > 1$ for most CEOs in our sample. If in addition, actual pay contracts are grossly inefficient, savings from (9) should be substantial. We will test these implications on our dataset.

3 Data

3.1 Observed contracts

We identify all CEOs in the ExecuComp database who are CEO at least from January 2004 to December 2005. We restrict ourselves to CEOs in order to avoid multiple observations from one firm that are likely to be correlated. We also delete all CEOs who were executives in more than one company in either 2004 or 2005. We estimate the CEOs' contracts in 2005. We also evaluate their contracts for 2004 separately in order to construct the reference wage for 2005. We set P_0 equal to the market capitalization at the end of 2004 and take the dividend yield d, the stock price volatility σ^2, and the proportion of shares owned by the CEO n_S from the 2004 data, while the fixed salary ϕ is calculated from 2005 data.[14] The numbers of shares and options, n_S and n_O, include the CEO's total holdings of stock-based compensation, and not just the most current grant of stock and options. This is important because Hall and Liebman (1998) have shown that almost all incentives for CEOs come from their holdings of stock and options and not merely from current grants.

We estimate the option portfolio held by the CEO from 2004 data using the procedure proposed by Core and Guay (2002). We then map this option portfolio into one representative

[13] The fineness of the grid is bounded by the available computing power. Solving the model for our sample of 724 CEOs takes about 8 hours for one single value of K.

[14] ϕ is the sum of the following four ExecuComp data types: Salary, Bonus, Other Annual, and All Other Total. We do not include LTIP (long-term incentive pay), as these are typically not awarded annually.

option by first setting the number of options n_O equal to the sum of the options in the option portfolio. Then we determine the strike price K and the maturity T of the representative option such that n_O representative options have the same market value and the same Black-Scholes option delta as the estimated option portfolio. We take into account the fact that most CEOs exercise their stock options before maturity by multiplying the maturity of the individual options in the estimated portfolio by 0.7 before calculating the representative option (see Huddart and Lang, 1996, and Carpenter, 1998). The maturity T determines the contracting period and the risk-free rate r_f is the U.S. government bond rate from January 2005 with maturity closest to T. After deleting 4 CEOs with stock volatility exceeding 250% and 2 companies with a dividend yield greater than 20% the raw data set contains 913 CEOs.

We estimate the portion of each CEO's wealth that is not tied up in securities of his or her company from historical data for a subsample of 496 CEOs who have a history of at least five years (as executive of any firm) in the ExecuComp database. We cumulate the CEO's income from salary, bonus, and other compensation payments, add the proceeds from sales of securities, and subtract the costs from exercising options. For this subsample, the median ratio of non-firm wealth to the risk-neutral value of the CEO's pay package (including fixed salary, stock and options) is 0.34. We therefore estimate each CEO's non-firm wealth W_0 by calculating the risk-neutral value of the CEO's pay package and then set W_0 equal to 34% of this value. This procedure introduces some noise into the estimation of wealth.[15] However, we will show below that for the majority of CEOs and optimal contracts, the lower bound on base salaries are not binding, which is why we are not concerned about small measurement errors in wealth.[16]

3.2 Preference parameters

To specify the preference parameters in equation (3), we use the experimental evidence in Tversky and Kahneman (1992) and set $\lambda = 2.25$, $\alpha = 0.88$, and $\beta = 0.88$. To specify the

[15] It is therefore not different from (or indeed likely to be more accurate than) other procedures such as, for example, Hall and Knox (2004) who estimate wealth as the greater of six times annual compensation or $3 million.

[16] Unlike for models with constant relative risk aversion utility functions, loss aversion does not imply a relationship between wealth and the attitude to risk from compensation, so measurement errors of wealth are less important for our model.

reference wage, we use results from Dittmann, Maug, and Spalt (2007), in which the model used here is calibrated to the cross-section of a subset of our 913 CEOs, where it is shown that the model fits the data well for $\theta = 0.1$. We then perform robustness checks to demonstrate that our results are not sensitive to this choice of the reference wage.

3.3 Measures of agency costs and managerial discretion

In order to test the hypothesis that inefficient structures of executive compensation contracts are systematically related to agency costs or managerial discretion, we use a range of different indicators. As a first set of measures, we hypothesize that managerial power and agency costs are likely to be higher in firms where a substantial part of the value is tied up in growth options. We use Tobin's Q, which we define as market value of equity (Compustat data item 25 $\times$ data item 199) plus the book value of assets (data item 6) minus book equity (data item 60 + data item 74), as well as expenses for research and development (R&D, data item 43) as our proxies for growth options. All variables are scaled by the book value of assets.

A second hypothesis is that managers can more easily divert cash if it is abundant (Jensen, 1986). Moreover, excess cash flow could be a sign of organizational slack, which is also likely to be associated with contractual inefficiencies. We use cash flow shortfall as a measure of cash flow available to management and define it as common plus preferred dividends (data item 19 + data item 21) plus cash flow from investing activities (data item 311) less cash flow from operating activities (data item 308). Again, all variables are scaled by the book value of assets. We argue that this internally generated cash is controlled by insiders and not accessible to outsiders which makes it valuable as a measure of managerial discretion.[17]

A third set of measures are measures of governance problems. Bebchuk, Cremers, and Peyer (2007) provide evidence that governance problems regarding contracting about compensation are related to the *CEO pay slice*. This measure is defined as the percentage of total compensation of the top 5 managers paid to the CEO. They define this as "the relative importance of the CEO within the top executive team in terms of ability, contribution,

[17] See also Core and Guay (2001) and Bergman and Jenter (2007) for similar uses of this measure.

or power."[18] Hence, we would expect contractual inefficiencies detected in our model to be positively correlated to the CEO pay slice, which we compute using the total compensation ("TDC1") reported in ExecuComp for the top 5 executives.[19] As another measure of potential governance problems, we use the corporate governance index proposed by Gompers, Ishii, and Metrick (2003), the "GIM-Index", from Andrew Metrick's website.

Lastly, we control for size. It may be easier for managers to entrench themselves in larger firms. At the same time, larger firms may be under particular scrutiny from institutional investors, analysts, and the press, and they are more likely to rely on the services of specialized pay consultants. We therefore have no strong prior about the sign of the relation between assets and contractual inefficiency. We use the log of lagged total book assets in our regressions to control for size.

By using the method of Core and Guay (2002), we look at total holdings of stock and options at time $t = 0$ (2005 in our implementation), which are made up of the current tranche of stock and options and several tranches received in the past. To reflect this in our agency and managerial discretion controls, we take three-year averages for all these variables. We also winsorize all variables at the 1% and the 99% level. For the GIM-Index, which is only available biannually, we take the average of the 2002 and 2004 values.

3.4 Descriptive statistics

From the raw data set with 913 companies, we drop 142 financial companies (SIC code 6000 to 6999) and 43 observations for which at least one variable (assets, Q, cash flow shortfall, or one of their components) was missing. Of the remaining 724 companies we have a value for the CEO pay slice for 607 companies, the GIM-Index for 597 companies, and R&D for 424 companies.

Table 1 presents descriptive statistics. In Panel A, the median CEO in the sample holds 0.31% of the shares and stock options on 1.05% of the shares. The fixed salary for 2005 (including most bonus components) is about 1.5 million dollars and the total value of the contract (including all current holdings of stock and stock options) is 27.4 million dollars.

[18] Bebchuk, Cremers and Peyer (2007), p. 1.

[19] We disregard all firms with less than 5 reported executives and use only the top 5 highest paid officers for companies that report compensation for more than 5 officers.

Table 1: Descriptive statistics. The table shows descriptive statistics for our dataset of 724 managers who were CEO in 2005. Stock and options are the total number of shares and options the CEO holds at the beginning of the year, normalized by firm value. Moneyness and maturity report the strike price and maturity of a hypothetical option grant with the same value and option delta as the actual option portfolio held by the CEO. Stock volatility and dividend yield are taken directly from ExecuComp. Tobin's Q is defined as market value of equity plus book assets minus book equity all over assets. Cash flow shortfall is common plus preferred dividends plus cash flow from investing activities less cash flow from operating activities all over assets. All dollar amounts are given in thousands.

	Mean	Std. Dev.	10% Quantile	Median	90% Quantile	N
Panel A: Observed contracts						
Stock	1.93%	5.12%	0.03%	0.31%	4.34%	724
Options	1.45%	1.58%	0.15%	1.05%	3.21%	724
Fixed Salary	$2,209	$2,698	$558	$1,503	$4,108	724
BS-value of options	$23,694	$43,806	$1,103	$11,036	$52,925	724
Value of Contract	$166,033	$1,751,514	$4,939	$27,352	$153,591	724
Firm Value	$9,243,453	$29,800,000	$357,345	$1,983,262	$17,300,000	724
K^d / P_0	69.22%	21.45%	38.73%	70.17%	99.11%	724
Maturity	4.59	1.23	3.39	4.48	6.04	724
Stock Volatility	45.65%	22.17%	24.70%	39.10%	78.30%	724
Dividend Yield	0.96%	1.36%	0.00%	0.40%	2.80%	724
Panel B: Agency and Managerial Discretion Proxies						
3-year avg. of $Assets_{t-1}$	$6,830,569	$17,300,000	$263,397	$1,490,352	$15,500,000	724
3-year avg. of Tobin's Q_{t-1}	1.86	1.06	1.04	1.53	3.18	724
3-year avg. of Cash flow $shortfall_{t-1}$	-1.83%	6.87%	-9.02%	-2.11%	5.46%	724
3-year avg. of CEO pay slice	39.14%	8.96%	27.84%	39.13%	50.92%	607
3-year avg. of $R\&D_{t-1}/Assets_{t-1}$	4.76%	5.65%	0.00%	2.50%	12.60%	424
Avg. over GIM-Index 2002 and 2004	9.46	2.52	6.00	9.00	13.00	597

The market value of equity is about 2 billion dollars for the median firm. These variables are skewed and means are considerably larger than medians. The moneyness of the observed contract, K^d/P_0, is 0.7, which reflects the fact that stock prices tend to appreciate over our sample period. Panel B shows three-year averages of the agency and managerial discretion proxies. Total book assets of the median firm in the sample is about 1.5 billion dollars and Tobin's Q is 1.53. Cash flow shortfall is negative, which means that the median firm spends less cash on dividends and investments than its net cash flow from operations. The median CEO pay slice is 39.1% and expenses for research and development amount to 2.5% of book assets for the median firm. The median value for the GIM-Index is 9, which is the same as in the sample used by Gompers, Ishii, and Metrick (2003). Our sample is thus not biased towards either better or worse governed firms.

4 Results

4.1 Are premium options optimal?

We analyze the optimality of premium options by solving program (5) to (8) over a grid of candidate strike prices for each CEO. Optimal contracts from this procedure give the same incentives and value to the CEO as the observed contract. Effectively, we are analyzing the optimal structure of the contract the firm would offer if it could renegotiate the entire contract of the CEO including all holdings of stock-based pay granted in the past. If premium options are optimal, then the optimal strike price in the renegotiated contract should be above the current stock price.

Figure 1 shows a histogram of the resulting optimal strike prices, K^*, scaled by firm value, P_0, across our sample of CEOs.[20] Optimal strike prices cluster heavily at or slightly below the current stock price, and for a large majority of CEOs, K^* is smaller than P_0. The distribution is skewed to the right with only a minority of strike prices above the current stock price. Hence, there is no support from our model for the view that premium options are generally optimal. To the contrary, if our model is correct, Figure 1 suggests that at the money options are optimal for the average company.

[20] We lose 19 CEOs (2.6 percent of our sample) because of numerical problems.

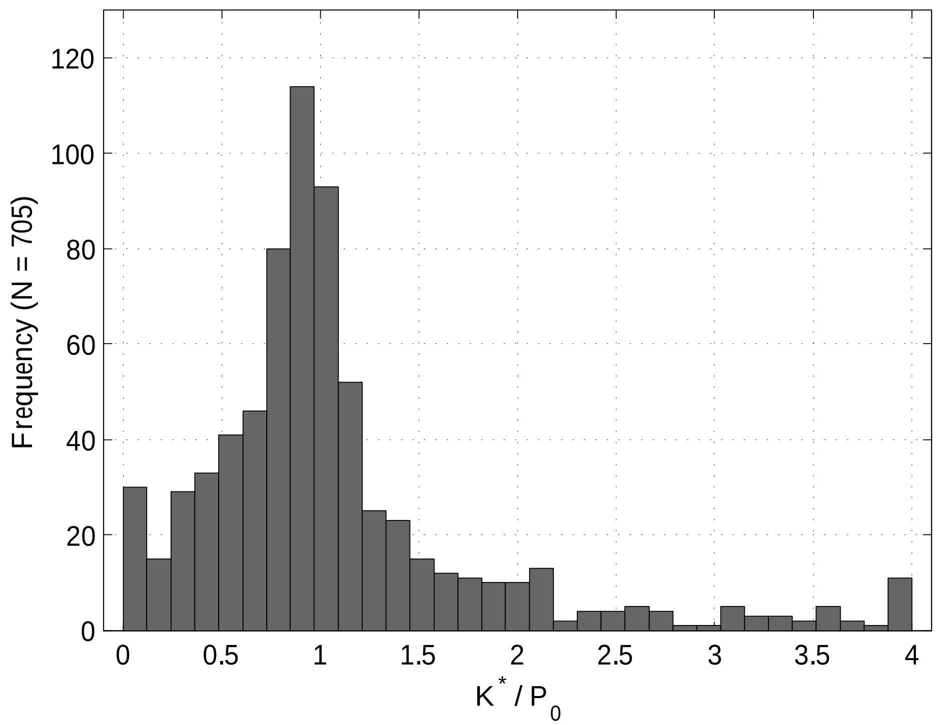

Figure 1: This figure shows a histogram of individually optimal strike prices K^* relative to the actual market value of the firm P_0 across all CEOs in the sample.

Table 2 further analyzes the evidence from Figure 1. Panel A shows that the median strike price is at 87.5% of the current strike price and that the average is slightly higher at 105.3%. Almost 70% of firms should grant options with strike prices not higher than P_0.[21]

While there is strong evidence that premium options are not optimal for most companies, they seem to be optimal for some. In general, Figure 1 suggests some dispersion in optimal strike prices. We therefore ask why we do not see more dispersion in strike prices across observed contracts. Panel B of Table 2 provides a potential answer. The savings that a firm could generate by replacing the observed contract with the optimal contract are small. On average, firms could save only 0.79%, or about $218,000 of the $27.35 million granted to the median CEO. The median firm could save as little as 0.17%. These savings can be broken down into two components. The first component are the savings the firm could realize

[21] The model predicts all-share contracts for a small number (about 7 percent) of CEOs and companies. Interestingly, this includes Warren Buffett at Berkshire Heathaway, who neither holds options in the predicted, nor in the observed contract.

Table 2: Optimal strike prices and savings. The table shows the distribution of optimal strike prices when the model is individually optimized for all CEOs in the sample. P_0 is the observed stock price. K^* is the derived optimal strike price. The table also reports total savings the firm can generate by switching from observed contract to derived optimal contract. "Savings with at the money options" is the component of total savings that could be realized by optimizing over stocks, options and fixed salaries for observed strike prices. "Savings from endogenous strike price" are incremental savings that can be realized by endogenizing the strike price. Number of observations: 705.

	Mean	Std. Dev.	10% Quantile	Median	90% Quantile
Panel A: Optimal strike prices					
K^* / P_0	105.3%	77.5%	25.0%	87.5%	200.0%
Percent with K^* not larger than P_0	68.2%	-	-	-	-
Panel B: Potential savings					
Total savings	0.79%	1.35%	0.01%	0.17%	2.51%
Savings with at the money options	0.46%	1.12%	0.00%	0.06%	1.22%
Savings from endogenous strike price	0.34%	0.61%	0.00%	0.03%	1.25%

by adjusting only the structure of the contract (base salary, stock, and options) without also adjusting the strike prices of the options (we call this component "savings from at the money options"). These savings would be on average 0.46%, which is about 60% of the total savings with endogenous strike price. The second component are the incremental savings from endogenizing the strike price. We find that on average savings of only 0.34%, or $93,000 for the median CEO, can properly be attributed to premium options. As a consequence, the costs of implementing a contract with a tailor-made strike price are very likely to outweigh the benefits in terms of more efficient contracts. Examples for such costs include direct costs for compensation consultants and indirect costs related to negotiating the magnitude of the premium.

4.2 Comparative static analysis

In our model optimal strike prices cannot be considered independently of the other contract parameters. Changing the strike price also induces a change in all other contract parameters, because the CEO has to be kept at her reservation value while maintaining incentives. In

Table 3: Representative CEO. This table presents the characteristics of the observed contract of the representative CEO in our sample. The CEO is representative on the dimensions: firm volatility, moneyness of the options, base salary, and incentives from options as a fraction of total incentives.

Name: Hans Helmerich	*ExecuComp execid: 462*
Company: HELMERICH & PAYNE INC	*ExecuComp permid: 5581*
Stock	0.53%
Options	1.95%
Fixed Salary	$1,376
Value of Contract	$21,627
Firm Value	$1,447,267
K^d / P_0	71.57%
Maturity	4.00
Stock Volatility	40.60%
Dividend Yield	1.12%

particular, tougher performance goals through higher strike prices will have to come with some form of additional compensation, because increasing the strike price of options reduces their value to the CEO. We explore these trade-offs by analyzing the comparative statics of our model.

To demonstrate the workings of the model we will make use of a representative CEO in our sample. The representative CEO is chosen to match as closely as possible the medians of firm volatility, base salary, moneyness of the options, and incentives granted by options as a fraction of total incentives. Incentives from options ("IncOpt") are calculated on a risk-neutral basis as

$$IncOpt = \frac{n_O N(d_1)}{n_O N(d_1) + n_S e^{dT}}, \tag{11}$$

where $N(d_1)$ is the Black-Scholes delta of the option. There is exactly one CEO in our sample who is in the third quintile of each of these four variables (volatility, base salary, moneyness, and IncOpt). We provide statistics of this "representative" CEO in Table 3.

The representative CEO is below the median CEO in terms of the value of the contract and his base salary compared to the respective sample medians, and has somewhat higher-powered incentives.

We first conduct a comparative static analysis for the representative CEO. Using only one CEO allows us to use a finer grid for our strike prices and we choose 100 equally spaced

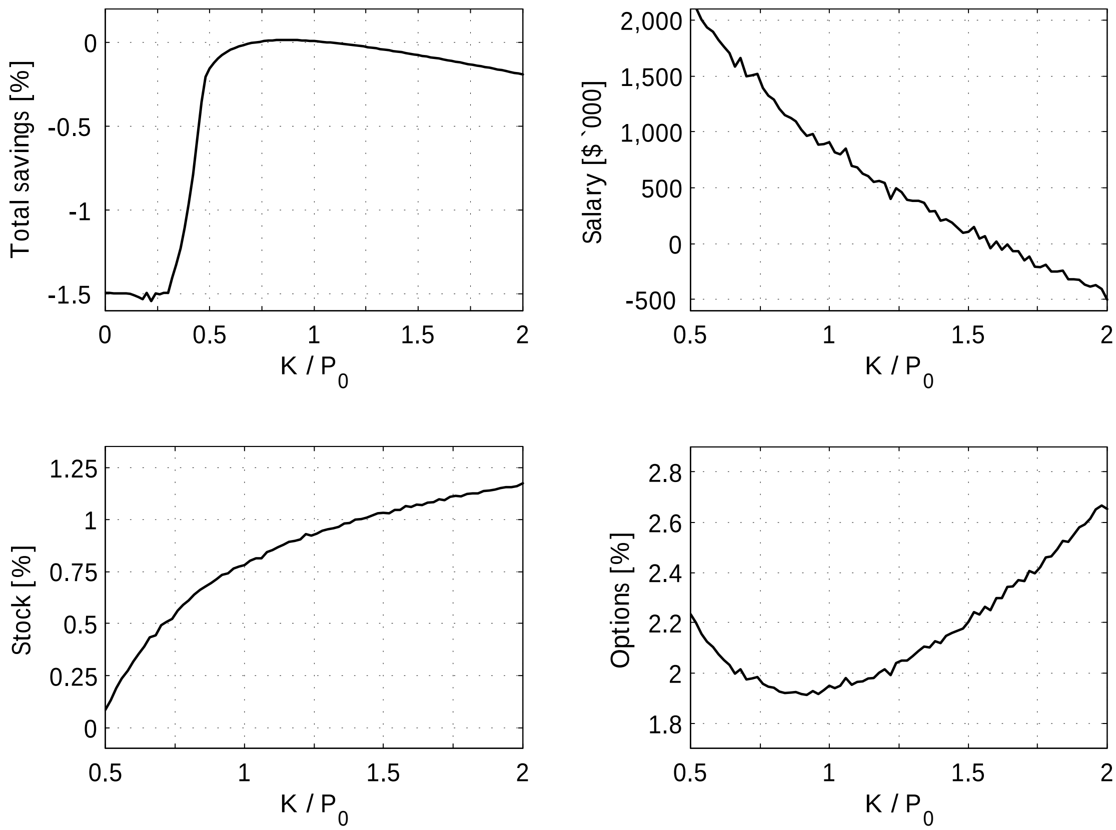

Figure 2: This figure shows how total savings, base salary, shares, and options predicted by the model change with a change in the strike price for the representative CEO in our sample (see Table 3 for parameters). The observed strike price is at $K^d/P_0 = 0.72$. The optimal strike price is at $K^*/P_0 = 0.88$.

values for K/P_0 between zero and two. Figure 2 shows total savings and predicted base salaries, stock, and options at each candidate strike price K/P_0. The top left plot presents the total savings at each candidate strike price. There is a unique value of $K/P_0 = 0.88$ that maximizes savings. This value is slightly above the observed strike price, which is 0.72. For $0.72 \leq K/P_0 \leq 1.08$, there exist contracts with positive savings, outside this interval no contract can make both the firm and the CEO better off, thus reinforcing our claim that our model is consistent with observed strike prices being optimal.

Base salaries (top right plot) are always declining and predicted share holdings (bottom left) are always increasing as K/P_0 increases. For values of $K/P_0 \geq 0.9$ we see that predicted stock option holdings (bottom right) are increasing. This is intuitive: increasing the strike price decreases incentives per option because it reduces the probability to see the options

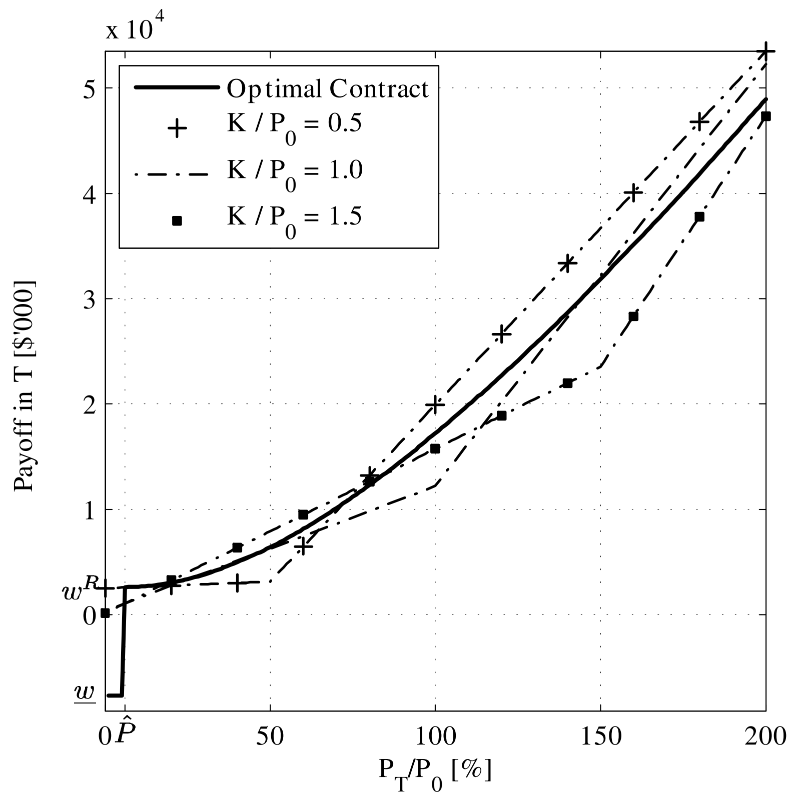

Figure 3: This figure shows the optimal contract for the non-linear loss-aversion model and the optimal linear contract for three different values of K/P_0 for the representative CEO in our sample (see Table 3 for parameters).

in the money at maturity. Hence, to keep the CEO at the incentive level of the observed contract, the number of options has to increase. Simultaneously, since stock options with higher strike prices are riskier, shares get relatively more attractive in terms of providing incentives per unit of risk. Hence, there is a substitution effect between shares and options, which is why increasing the strike price leads to both higher stock and higher option holdings. Finally, the CEO has to be kept at her reservation value, and more shares and options are granted with higher strike prices of the option, so the base salary has to be lower to satisfy the participation constraint.

For values of $K/P_0 < 0.9$ predicted stock option holdings are decreasing with the strike price. To understand this we show in Figure 3 the optimal non-linear contract for our representative CEO (solid line), which was derived in Dittmann, Maug, and Spalt (2007). The horizontal axis depicts the stock price at maturity relative to the current stock price and the vertical axis is the total pay-off from the pay package at maturity. Above a unique cut-off value, the optimal non-linear contract is monotonically increasing and convex.[22] The optimal linear contract we derive by solving program (5) to (8) tries to approximate the non-linear contract as closely as possible over the relevant range of possible realizations of the stock price at maturity.[23] Figure 3 shows this for three different linear contracts, which are optimal conditional on the candidate strike prices $K/P_0 = 0.5$, $K/P_0 = 1$ and $K/P_0 = 1.5$, respectively. Increasing the strike price to stock price ratio from 1 (dashed line) to 1.5 (dashed line with diamonds) leads to more options, more stock, and lower base salaries. Decreasing the ratio from 1 to 0.5 (dashed line with plus-sign) decreases predicted stock holdings, increases bases salary, and increases predicted options, consistent with Figure 2.

We have restricted the range for which we present base salaries, stock, and options in Figure 2 and show only values of $K/P_0 \geq 0.5$. The reason is that for very low strike prices the option delta $N(d_1)$ approaches unity and stock options become effectively like restricted stock. For the representative CEO, $N(d_1)$ is 0.92 at $K/P_0 = 0.5$ and our numerical routines cannot reliably distinguish between stock and options for lower strike prices. The algorithm can still reliably compute total savings, which approach those for an all-stock contract for lower strike prices.

We check the validity of the conclusions reached for a single representative CEO for the whole sample. Table 4 shows total savings and mean and median contract parameters if we uniformly set the ratio of strike price to stock price K/P_0 to the same value for the entire cross-section of CEOs. We report the percentage of firms for which our lower bounds on base salary, stock and options are binding, as well as the percentage of firms with negative predicted base salaries.

Savings are highest when strike prices are at or slightly above the current stock price, consistent with what was observed in Figure 1. Savings get smaller for both, higher and lower strike prices, and they are even negative, for the median firm, for options that are far in the money. Savings are negative whenever it is not possible to find an optimal contract at the given strike price that satisfies both the participation constraint and the incentive constraint

[22] As was shown in Dittmann, Maug, and Spalt (2007), the optimal non-linear contract becomes eventually concave. This concave region is not empirically relevant for the representative CEO over the range considered here. Still, for sufficiently high share prices, optimal stock option holdings might decrease again.

[23] The expected value of the stock at maturity is 109.77, the median is 78.94, and the mode is 66.94.

Table 4: Cross-sectional comparative static results. This table shows means and medians for base salaries, stock, and stock options of the optimal contract for the same strike price (scaled by the stock price) across the sample. The table also reports the percentage of observations for which the lower bound on base salary ($\phi \geq -W_0$), stock ($n_S \geq 0$), and stock options ($n_O \geq 0$) is binding, as well as the percentage of firms with negative predicted base salary. This table includes 503 firms for which all 33 optimizations were successful. Of the original 705 firms, 118 firms are lost because one optimization was unsuccessful, 46 are lost because two optimizations were unsuccessful, and 38 because more than two optimizations were unsuccessful.

K / P_0	phi = $-W_0$	phi < 0	$n_S = 0$	$n_O = 0$	Total savings		Salary		Stock		Options	
					Mean	Median	Mean	Median	Mean	Median	Mean	Median
0.25	0%	44%	2%	17%	0.06%	-0.01%	-$5,301	-$1,571	2.16%	0.82%	1.41%	0.32%
0.50	0%	21%	1%	14%	0.36%	0.04%	$2,579	$405	2.23%	0.69%	1.48%	0.77%
0.75	0%	16%	0%	10%	0.61%	0.12%	$4,671	$1,462	2.36%	0.75%	1.50%	0.87%
1.00	0%	14%	0%	10%	0.69%	0.17%	$4,940	$1,443	2.48%	0.82%	1.54%	0.90%
1.25	0%	16%	0%	10%	0.72%	0.16%	$4,584	$1,318	2.57%	0.85%	1.61%	0.97%
1.50	0%	18%	0%	9%	0.72%	0.14%	$4,187	$1,178	2.68%	0.93%	1.66%	1.03%
1.75	0%	20%	0%	10%	0.71%	0.11%	$3,528	$986	2.72%	0.98%	1.82%	1.13%
2.00	0%	22%	0%	10%	0.69%	0.08%	$3,207	$871	2.77%	1.03%	1.97%	1.20%
2.25	0%	25%	0%	9%	0.67%	0.07%	$2,730	$749	2.81%	1.07%	2.15%	1.31%
2.50	0%	29%	0%	10%	0.64%	0.04%	$2,405	$630	2.85%	1.12%	2.34%	1.40%
2.75	0%	33%	0%	10%	0.62%	0.04%	$2,018	$522	2.89%	1.17%	2.54%	1.49%
3.00	0%	37%	0%	10%	0.59%	0.02%	$1,661	$455	2.92%	1.21%	2.78%	1.64%
3.25	0%	40%	0%	9%	0.56%	0.01%	$1,383	$403	2.95%	1.24%	3.01%	1.76%
3.50	0%	42%	0%	9%	0.54%	0.00%	$912	$340	2.98%	1.26%	3.26%	1.88%
3.75	0%	44%	0%	10%	0.51%	0.00%	$339	$301	3.01%	1.26%	3.53%	1.93%
4.00	0%	45%	0%	10%	0.48%	0.00%	$409	$206	3.03%	1.27%	3.87%	2.06%

and costs less to the firm than the observed contract. Effectively, by stipulating a certain strike price rather than solving for it, we impose an additional constraint on program (5) to (8) that can sometimes not be satisfied by the observed contract.

Over most of the range considered here, higher strike prices are associated with both a higher number of shares and a higher number of options. Base salaries increase with the strike price for strike prices below the current stock price and decrease for higher strike prices. For both very low and very high strike prices, the percentage of CEOs who should receive negative base salaries (invest into their own company) increases. Note that the lower bounds on the contract parameters rarely bind and that our model generates interior solutions.

4.3 Which companies should use premium options?

We now turn to the question which companies should use premium options. We conduct two types of regressions to investigate which company characteristics and which characteristics of the CEO explain the optimal moneyness of the options. First, we run a logit regression of an indicator function for premium options predicted by our model, on all observed contract characteristics. The indicator is one if $K^* > P_0$ and zero else. Columns (1) and (2) of Table 5 present results. Second, we use the relative premium $\left(K^* - K^d\right)/P_0$ itself as an independent variable (columns (3) and (4)).

In regression (1), premium options are positively associated with observed option holdings and negatively associated with observed stock holdings. Column (2) adds the fraction of incentives granted through options, $IncOpt$, as an additional regressor. $IncOpt$ is highly significant and positively related to premium options. Introducing $IncOpt$ also changes the sign on both stock and option holdings, which may well be due to collinearity of $IncOpt$ with observed stock holdings (Spearman's $\rho = 0.79$) and its negative correlation with option holdings ($\rho = 0.34$). Running specification (2) without shares and options as independent variables leaves the sign and significance of $IncOpt$ unchanged. Moneyness (K^d/P_0), which was insignificant before, becomes significant when controlling for incentives. In both regressions, firm volatility is significantly positive, indicating that premium options are predicted predominantly for riskier firms. Since high volatility firms are also firms with a substantial upside potential for stock options payoffs, they lose less incentives from granting stock options

Table 5: Regression of predicted premium on observed contract parameters. The table shows the result of a logit regression of an indicator of a predicted premium option ($K^* > P_0$) and a median regression of the difference between the observed and predicted strike price scaled by the current market value of the firm on observed contract parameters. The interest rate is the U.S. government bond rate from January 2005 with maturity closest to the maturity of the representative options of each CEO. Maturity (T) is the calculated maturity of the representative option. IncOpt is the fraction of incentives that come from stock options and is calculated as in equation (11). P-values are given in parentheses. Coefficients are multiplied by 1,000. Number of observations: 705.

	Dependent variable			
	$\mathbf{I}_{K^* > P0}$		$(K^*-K^d) / P_0$	
Independent variable	(1)	(2)	(3)	(4)
Stock	**-80.68** ***	**10.52** ***	**-4.45** ***	**-0.11**
	(0.00)	(0.01)	(0.00)	(0.68)
Options	**18.77** **	**-22.61** ***	**3.15** ***	**-0.92**
	(0.01)	(0.01)	(0.00)	(0.13)
Base salary	**0.00**	**0.00**	**0.00**	**0.00** **
	(0.43)	(0.15)	(0.80)	(0.03)
Firm volatility$_{t-1}$	**2.30** ***	**2.72** ***	**0.25** ***	**0.59** ***
	(0.00)	(0.00)	(0.00)	(0.00)
Dividend yield$_{t-1}$	**-38.61** ***	**-37.13** ***	**-4.56** ***	**-2.48** ***
	(0.00)	(0.00)	(0.00)	(0.00)
Interest rate	**-30.96**	**-189.36**	**9.56**	**3.98**
	(0.82)	(0.28)	(0.69)	(0.80)
Maturity	**0.11**	**0.43**	**-0.01**	**0.00**
	(0.64)	(0.17)	(0.76)	(0.96)
K^d / P_0	**0.71**	**1.21** **	**-0.73** ***	**-0.80** ***
	(0.12)	(0.03)	(0.00)	(0.00)
IncOpt		**8.14** ***		**1.16** ***
		(0.00)		(0.00)
Pseudo R-squared	0.19	0.37	0.15	0.32

*** Significant at 1% level; ** significant at 5% level; * significant at 10% level.

Table 6: Cross-sectional variation of contracts. The table shows the means, medians and interquartile ranges of important contract characteristics. It also shows the median change between observed and optimal value when the variable of interest was in the first or the fifth quintile, respectively, of its distribution over all observed contracts. IncOpt is the fraction of incentives that come from stock options and is calculated as in equation (11). The change in IncOpt, moneyness, share holdings, and options are calculated as difference between optimal and observed value. Changes in base salary are defined as percentage changes relative to observed base salaries.

Variable	Mean		Median		Interquartile range		Median change if observed value in…	
	Observed	Optimal	Observed	Optimal	Observed	Optimal	Quintile 1	Quintile 5
K / P_0	69.15%	105.32%	70.11%	87.50%	31.29%	50.00%	43.67%	-6.43%
IncOpt	56.74%	64.42%	73.00%	62.85%	41.47%	24.36%	28.49%	-22.94%
Base salary	$2,204	$4,857	$1,491	$1,324	$1,586	$2,136	25.61%	-38.39%
Stock	1.79%	1.61%	0.31%	0.56%	0.86%	1.00%	0.13%	-0.85%
Options	1.47%	1.96%	1.07%	1.17%	1.38%	1.84%	0.03%	0.22%

with high strike prices.

The distribution of $\left(K^* - K^d\right)/P_0$ is very skewed, so we use median regressions in specifications (3) and (4).[24] The results are consistent with the results from the logit model. However, the coefficient on moneyness is now negative and highly significant. In specification (4), stock and stock options become insignificant when *IncOpt* is included in the regression, consistent with *IncOpt* capturing the information about incentives in the number of shares and options, respectively. The results from specifications (3) and (4) suggest that firms with options far in the money should increase strike prices in order to re-incentivize the CEO. They also suggest that firms that grant incentives primarily through stock options should decrease this fraction by increasing strike prices.

The regressions in Table 5 have to be interpreted with caution because the observations for each firm are already at an internal optimum. In order to support the conclusions from the previous regressions, we also look at the cross-sectional variation of contract parameters in Table 6. The table shows that our model predicts a relatively homogenous mix of incentives from options and shares across executives. The median firm should decrease incentives

[24] Using OLS regressions does not materially affect our results.

from stock options, while on average firms should increase option incentives. Overall, the distribution of incentives from options is less dispersed for optimal contracts than for observed contracts, and on average about 60% of incentives should be granted by stock options. The last columns show that firms with the highest option incentives in observed contracts should reduce these incentives, while the firms with the lowest option incentives in observed contracts should increase them. The same tendency for extreme firms to revert back to the median is also observed for the moneyness of options. A possible interpretation is that changes in the environment have moved the parameter K/P_0 away from the optimum. Since stock prices tended to increase over the period we consider, we would expect the predicted change to be larger for firms with low moneyness than for firms with high moneyness, which is consistent with the last column in Table 6.

Our model thus prescribes a more homogenous mix of incentives between stock and options across CEOs. Our results are therefore more consistent with a "one size fits all"-approach to compensation, where firms use at the money strike prices and adjust stock and option holdings in line with those of the median company.

4.4 Governance implications

If the difference between observed contracts and optimal contracts from the model reflects inefficiencies in pay-setting, then we should see a relationship between these and measures of agency costs and managerial discretion.

We run median regressions of total savings on Tobin's Q, cash flow shortfall, the fraction of total top 5 compensation that goes to the CEO ("CEO pay slice"), research and development, and the corporate governance index proposed by Gompers, Ishii, and Metrick (2003). We control for firm volatility, dividend yield, and firm size. We run median regressions to address concerns about outliers in the savings variable and the independent variables. We also include industry dummies based on 30 Fama-French industries.

Table 7 shows that savings generated by our model are indeed systematically related to measures of agency problems and managerial power. Savings are higher in firms with higher Q, higher free cash flows, higher CEO pay slice, and higher R&D spending. All coefficients on these variables are statistically significant, although economic significance is small, as was

Table 7: Agency costs and contractual inefficiency. Median regression of total savings on stock volatility, dividend yield, and proxies for agency costs and managerial discretion. Tobin's Q, assets, cash flow shortfall, and research and development (R&D) are three-year averages. CEO pay slice is the fraction of pay to top 5 executives that goes to the CEO. GIM-Index is an average over the years 2002 and 2004. Industry dummies are based 30 Fama-French industries for all specifications. P-values are reported in parentheses. All coefficients are multiplied by 1,000.

	Dependent variable: Log (1 + savings)					
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)
Firm volatility$_{t-1}$	**12.32** ***	**11.97** ***	**9.60** ***	**12.62** ***	**18.09** ***	**11.84** ***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Dividend yield$_{t-1}$	**-9.62**	**-7.98**	**-11.42**	**-10.77**	**-41.21**	**3.89**
	(0.55)	(0.47)	(0.33)	(0.34)	(0.22)	(0.59)
Log of Assets$_{t-1}$	**0.02**	**-0.06**	**-0.05**	**-0.10**	**0.42** **	**0.04**
	(0.85)	(0.47)	(0.61)	(0.27)	(0.03)	(0.49)
Log of Tobin's Q$_{t-1}$	**1.68** ***			**1.20** ***		
	(0.00)			(0.00)		
Cash flow shortfall$_{t-1}$		**-7.36** ***		**-10.71** ***		
		(0.00)		(0.00)		
CEO pay slice			**3.57** **	**5.10** ***		
			(0.03)	(0.00)		
R&D$_{t-1}$					**20.04** ***	
					(0.00)	
GIM-Index						**0.04**
						(0.13)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R-squared	0.101	0.098	0.101	0.110	0.107	0.106
N	705	705	590	590	415	582

*** Significant at 1% level; ** significant at 5% level; * significant at 10% level.

expected given the very low levels of total savings for the sample. For example, increasing Tobin's Q by one standard deviation (1.06) increases savings by 0.25%.

While there may be other possible explanations, agency costs and managerial power are consistent with all observed effects. Managers are harder to monitor and likely to have more leeway if more of their company value is attributed to future cash flows (high Tobin's Q and high R&D). Moreover, the negative coefficient on cash flow shortfall (the difference between cash dividends and net cash flow from investment and net cash flow from operating activities all over assets) is consistent with Jensen's (1986) agency cost of cash flow hypothesis: the less cash from operations is used to invest or to pay dividends, the more is available for managers to divert and the higher is the likelihood of organizational slack.

Among the governance variables, CEO pay slice is highly significant, while the GIM-Index has the correct sign but is insignificant. This suggests a particular role for internal governance. The GIM-Index predominantly measures external governance, which is relevant for takeovers and may influence managers' tendency to extract rents from their investment policy or acquisition policy. CEO pay slice, on the other hand, is related to internal governance and measures the balance of power between the CEO and the board. The pay-setting process is likely to depend on this balance of power and the sign and significance of CEO pay slice lends additional support to the empirical validity of our model.

5 Robustness checks

We perform a number of robustness checks on our model specification as well as on our sample. We first solve program (5) to (8) but impose the tighter restriction $\phi \geq 0$. Table 8, which has the same structure as Table 2, shows the resulting distribution of optimal strike prices. The results are essentially unchanged. The mean strike price is now at 108% and the median is now at precisely 100%. Savings from recontracting are 0.77% compared to 0.79% before. Since base salaries are restricted, adjusting the level of fixed pay is not as effective anymore, and a larger fraction of savings are due to efficient setting of the strike price. We also repeat the analysis of Table 7 with the additional restriction on base salaries and find similar results (not tabulated).

Table 8: Optimal strike prices and savings for the model with restricted base salary. The table shows the distribution of optimal strike prices when the model is individually optimized for all CEOs in the sample. The base salary is restricted to be positive ($\phi \geq 0$). P_0 is the observed stock price. K^* is the derived optimal strike price. The table also reports total savings the firm can generate by switching from observed contract to derived optimal contract. "Savings with at the money options" is the component of total savings that could be realized by optimizing over stock, options, and fixed salaries for observed strike prices. "Savings from endogenous strike price" are incremental savings that can be realized by endogenizing the strike price. Number of observations: 704.

	Mean	Std. Dev.	10% Quantile	Median	90% Quantile
Panel A: Optimal strike prices					
K^* / P_0	108.0%	76.5%	25.0%	100.0%	200.0%
Percent with K^* not larger than P_0	70.7%	-	-	-	-
Panel B: Potential savings					
Total savings	0.77%	1.29%	0.01%	0.16%	2.49%
Savings with at the money options	0.15%	0.53%	0.00%	0.00%	0.37%
Savings from endogenous strike price	0.62%	1.16%	0.00%	0.09%	2.10%

In a second check we want to know how much our results depend on the assumed reference wage. We therefore change the parameter θ in equation (4) and investigate higher levels of the reference wage. We perform this analysis for the representative CEO first. Figure 4 shows that savings tend to increase with the reference wage and that premium options become more attractive for higher reference wages. For the representative CEO $K^*/P_0 = 1.64$ for $\theta = 0.3$, but total savings and the savings from endogenizing the strike price are still small. For higher levels of the reference wage savings from recontracting are higher overall, but become less dependent on the strike price. For $\theta = 0.7$, savings are in the range of 4%, but incremental savings from endogenizing the strike price essentially disappear and almost all savings can be generated by optimizing the structure of the contracts (salary, stock, and options) alone.

In Table 9 Panel A, we repeat this analysis for the whole sample of CEOs. We calculate optimal contracts for a strike price equal to the current stock price (P_0), for a strike price equal to the expected stock price $E(P_T)$ for each CEO, and, as a basis for comparison, for the observed strike price. We report mean values for total savings, salary, stock, and options. The results show that total savings increase with the reference point, and that the level of

Table 9: Comparative static results for preference parameters. This table shows means for base salaries, stock, and stock options of the optimal contract when preference parameters are varied. Results are presented for three different strike prices for the whole 2005 sample. The expected value of the stock price is calculated for each individual firm as $E[P_T] = P_0 e^{r_f T}$. Number of observations: 705.

	Total savings			Salary			Stock			Options		
	$K = K^d$	$K = P_0$	$K = E[P_T]$	$K = K^d$	$K = P_0$	$K = E[P_T]$	$K = K^d$	$K = P_0$	$K = E[P_T]$	$K = K^d$	$K = P_0$	$K = E[P_T]$
Panel A: $\alpha = \beta = 0.88$; $\lambda = 2.25$												
$\theta = 0.1$	0.43%	0.69%	0.72%	$2,202	$2,253	$1,763	1.70%	1.87%	1.94%	1.45%	1.51%	1.57%
$\theta = 0.3$	1.44%	1.88%	2.03%	-$171	$3,609	$4,183	1.89%	1.63%	1.64%	1.19%	1.82%	2.04%
$\theta = 0.5$	2.25%	2.47%	2.66%	-$4,131	-$990	$478	2.42%	2.19%	2.04%	0.50%	0.95%	1.37%
$\theta = 0.7$	2.78%	2.85%	2.97%	-$6,243	-$5,422	-$4,437	2.55%	2.53%	2.50%	0.26%	0.36%	0.54%
Panel B: $\alpha = \beta = 0.88$; $\theta = 0.1$												
$\lambda = 1.75$	0.39%	0.54%	0.56%	$1,695	$1,515	$844	1.83%	2.01%	2.11%	1.28%	1.31%	1.32%
$\lambda = 2.25$	0.43%	0.69%	0.72%	$2,202	$2,253	$1,763	1.70%	1.87%	1.94%	1.45%	1.51%	1.57%
$\lambda = 3.00$	0.52%	0.88%	0.93%	$2,353	$2,500	$2,031	1.66%	1.81%	1.88%	1.49%	1.61%	1.67%
Panel C: $\theta = 0.1$; $\lambda = 2.25$												
$\alpha = \beta = 0.80$	1.17%	1.23%	1.23%	-$1,229	-$1,882	-$2,518	2.22%	2.41%	2.46%	0.72%	0.71%	0.73%
$\alpha = \beta = 0.88$	0.43%	0.69%	0.72%	$2,202	$2,253	$1,763	1.70%	1.87%	1.94%	1.45%	1.51%	1.57%
$\alpha = \beta = 0.95$	0.22%	0.64%	0.73%	$4,124	$3,985	$3,683	1.34%	1.61%	1.68%	1.86%	1.84%	1.90%

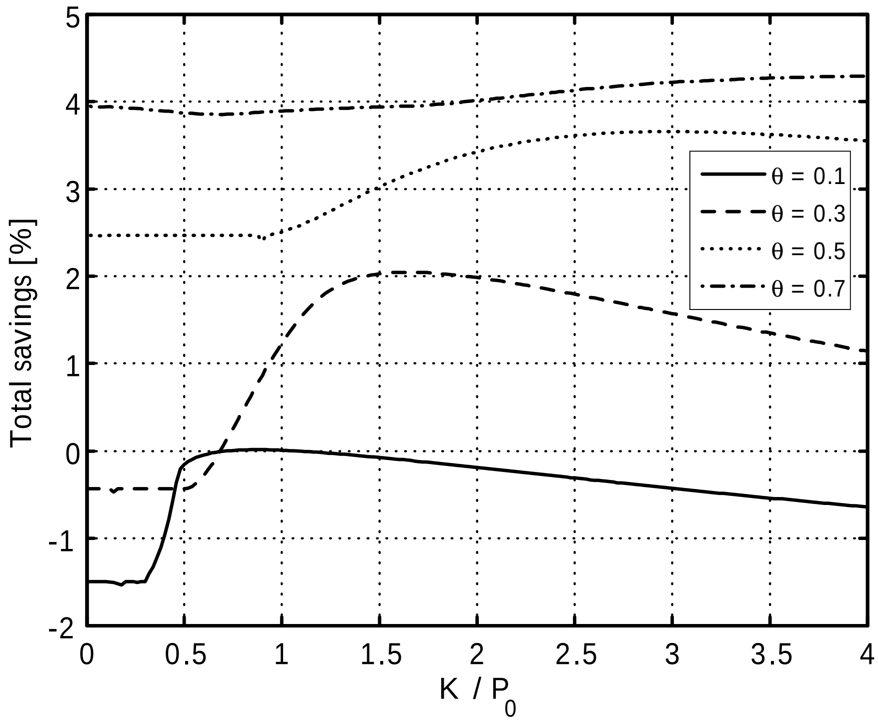

Figure 4: This figure shows the savings the firms could generate for a given strike price by switching from the observed to the optimal contract for the representative CEO. Four different reference point parameterizations (θ) are considered.

savings is even smaller for the whole sample than for the representative CEO. Incremental savings from endogenizing the strike price are largest for $\theta = 0.3$ and decrease with higher reference points. The optimal levels of salary, stock, and options change with the reference point specification. For high reference points, predicted contracts do not resemble observed contracts anymore and the model predicts low base salaries, more stock, and less options.[25]

Table 9 also shows robustness checks with respect to the other preference parameters. In Panel B, we vary the loss-aversion parameter λ. For higher degrees of loss aversion, savings increase slightly and exchanging stock for higher base salary and more stock options becomes attractive. This is the core of our model: loss-averse CEOs value downside protection. Panel C shows that increasing the degree of diminishing sensitivity, by increasing the curvature parameters α and β in the value function, diminishes the attractiveness of stock options. The payoff distribution from options is skewed to the right and a higher curvature of the

[25]See Dittmann, Maug, and Spalt (2007) for a more detailed analysis and discussion of the relationship between the reference point and the fit of the model.

Table 10: Descriptive statistics for the 1997 sample. The table shows descriptive statistics for our dataset of 887 managers who were CEO in 1997. Stock and options are the total number of shares and options the CEO holds at the beginning of the year, normalized by firm value. Moneyness and maturity report the strike price and maturity of a hypothetical option grant with the same value and option delta as the actual option portfolio held by the CEO. Stock volatility and dividend yield are taken directly from ExecuComp. Tobin's Q is defined as market value of equity plus book assets minus book equity all over assets. Cash flow shortfall is common plus preferred dividends plus cash flow from investing activities less cash flow from operating activities all over assets. All dollar amounts are given in thousands.

	Mean	Std. Dev.	10% Quantile	Median	90% Quantile	N
Panel A: Observed contracts						
Stock	3.33%	6.95%	0.03%	0.43%	11.05%	887
Options	1.07%	1.34%	0.00%	0.64%	2.67%	887
Fixed Salary	$1,461	$3,619	$421	$964	$2,474	887
BS-value of options	$10,433	$26,746	$0	$3,332	$24,217	887
Value of Contract	$95,473	$847,607	$2,466	$14,253	$99,496	887
Firm Value	$4,268,301	$11,600,000	$203,112	$992,527	$8,073,254	887
K^d / P_0	76.14%	24.00%	43.35%	77.75%	100.00%	887
Maturity	5.45	1.78	4.03	5.18	7.00	887
Stock Volatility	32.03%	13.83%	17.30%	29.10%	51.60%	887
Dividend Yield	1.50%	1.81%	0.00%	0.96%	4.10%	887
Panel B: Agency and Managerial Discretion Proxies						
3-year avg. of $Assets_{t-1}$	$3,288,462	$6,923,044	$161,038	$850,169	$8,406,138	887
3-year avg. of Tobin's Q_{t-1}	1.90	1.19	1.02	1.54	3.20	887
3-year avg. of Cash flow $shortfall_{t-1}$	2.01%	8.16%	-5.80%	0.99%	10.65%	887
3-year avg. of CEO pay slice	35.96%	8.10%	26.52%	35.73%	45.28%	707
3-year avg. of $R\&D_{t-1}/Assets_{t-1}$	5.54%	8.21%	0.00%	2.60%	14.14%	470
GIM-Index 1995	9.05	2.75	5.00	9.00	13.00	591

value function makes these payoffs less attractive to the CEO. Overall, it seems save to conclude that our claim, that the absence of premium options is not a puzzle in terms of efficiency, is not affected by changing our assumptions about the preference parameters.

As a last robustness check we generate a dataset for the year 1997, which is otherwise identical to the dataset we used before. Table 10 presents descriptive statistics. Compared to 2005, base salaries and stock option holdings are lower for the 1997 sample, while stock holdings are larger. Firm value, book assets and stock price volatility are also lower in the 1997 sample compared to 2005. Among the managerial discretion proxies, cash flow shortfall is now positive: the median firm spends more on dividends and investment than its cash flow from operations (0.99% of book assets). In 2005, cash flow shortfall was negative (-2.11% of book assets).

Table 11: Optimal strike prices and savings for the 1997 sample. The table shows the distribution of optimal strike prices when the model is individually optimized for all CEOs in the 1997 sample. P_0 is the observed stock price. K^* is the derived optimal strike price. The table also reports total savings the firm can generate by switching from observed contract to derived optimal contract. "Savings with at the money options" is the component of total savings that could be realized by optimizing over stock, options, and fixed salaries for observed strike prices. "Savings from endogenous strike price" are incremental savings that can be realized by endogenizing the strike price. Number of observations: 866.

	Mean	Std. Dev.	10% Quantile	Median	90% Quantile
Panel A: Optimal strike prices					
K^* / P_0	75.8%	48.6%	0.0%	75.0%	125.0%
Percent with K^* not larger than P_0	87.4%	-	-	-	-
Panel B: Potential savings					
Total savings	0.18%	0.49%	0.00%	0.03%	0.39%
Savings with at the money options	0.09%	0.28%	0.00%	0.01%	0.21%
Savings from endogenous strike price	0.10%	0.29%	0.00%	0.00%	0.20%

Optimal strike prices for the 1997 sample are slightly lower than for the 2005 sample, as can be seen from Table 11.[26] The mean and the median firm should optimally grant stock options with a strike price at about 75% of the current 1997 stock price and premium options should be granted only for a minority of 12.6%. This reinforces our claim that premium options are not generally optimal. Savings are even smaller and the average firm could save less than 0.2% from switching to optimal contracts. Hence, the results from the 1997 sample are also consistent with optimal strike prices being a second-order issue in terms of efficiency.

In Table 12 we use median regressions to investigate whether our corporate governance results are robust. As before in Table 7, CEO pay slice and R&D are positively associated with possible savings. The GIM-Index, for which we use the value of the GIM-Index of 1995 (because the index is not available for either 1996 or 1994), has the correct sign, but is insignificant (p-value 0.12). Tobin's Q is positively related to possible savings in specification (1), indicating that inefficiencies are more pronounced for firms with more growth options, but insignificant (p-value 0.15) in specification (4). A notable difference to Table 7 is that

[26] The results presented here are based on a slightly coarser grid with 17 equally-spaced values of ψ between 0 and 4 (steps of 0.25).

Table 12: Agency costs and contractual inefficiency for the 1997 sample. Median regression of total savings on stock volatility, dividend yield, and proxies for agency costs and managerial discretion. Tobin's Q, assets, cash flow shortfall, and research and development (R&D) are three-year averages. CEO pay slice is the fraction of pay to top 5 executives that goes to the CEO. GIM-Index is the value of the GIM-Index in the year 1995. Industry dummies are based on 30 Fama-French industries for all specifications. P-values are reported in parentheses. All coefficients are multiplied by 1,000.

	Dependent variable: Log (1 + savings)					
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)
Firm volatility$_{t-1}$	**4.79 *** **	**4.50 *** **	**4.07 *** **	**4.22 *** **	**4.21 *** **	**4.44 *** **
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Dividend yield$_{t-1}$	**3.12 * **	**2.14**	**1.52**	**2.37**	**-1.10**	**5.01**
	(0.10)	(0.30)	(0.53)	(0.35)	(0.77)	(0.18)
Log of Assets$_{t-1}$	**0.13 *** **	**0.11 *** **	**0.10 *** **	**0.13 *** **	**0.10 *** **	**0.12 *** **
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Log of Tobin's Q$_{t-1}$	**0.15 ** **			**0.12**		
	(0.01)			(0.15)		
Cash flow shortfall$_{t-1}$		**0.84 *** **		**0.97 ** **		
		(0.01)		(0.01)		
CEO pay slice			**0.92 ** **	**0.74 ** **		
			(0.01)	(0.04)		
R&D$_{t-1}$					**3.82 *** **	
					(0.00)	
GIM-Index						**0.02**
						(0.12)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R-squared	0.078	0.078	0.071	0.073	0.091	0.083
N	866	866	689	689	458	575

*** Significant at 1% level; ** significant at 5% level; * significant at 10% level.

cash flow shortfall is now positive and significant, which implies that firms with less cash flow have less efficient contracts. We have seen in Table 10 that overall cash flow shortfall was much higher in 1997 and it may be possible that this influences our results.

Overall, Table 12 supports our results from the 2005 sample, which suggest that internal governance matters. Our results regarding proxies for agency problems are either weaker or inconsistent with those for the later period.

6 Conclusion

This paper calibrates a principal-agent model with a loss-averse manager to a sample of U.S. CEOs and finds that premium options are optimal for higher assumed levels of the reference wage, but not for lower values of the reference wage. The model predicts that options granted in the past that are now deep in the money should be replaced by at the money options. Overall, the case for premium options is only weak, because the savings these options would generate for shareholders through more efficient compensation contracts are small: generally, they are less than 0.5% for our benchmark model and less than 2% for most alternative specifications we consider. Hence, the size of the inefficiency from not using premium options – if there is any – is small.

We calibrate the model to each individual CEO in our sample, which gives us the opportunity to also analyze the cross-sectional variation in compensation practice. Surprisingly, this variation should be less than observed rather than more. Firms in the lowest quintile with respect to the moneyness of their options should increase it, whereas those in the top quintile should reduce it. Similar conclusions also hold for other parameters of the compensation contract, like the use of stock or the size of base salaries. The model is therefore consistent with the conclusion that "one size fits all" and that pay practices should be even more similar across companies rather than more diverse.

We also interpret the savings from recontracting as an indication of potentially inefficient corporate governance and find mixed evidence. While potential savings from switching to another contract are consistently related to measures of CEO power, and therefore suggest that internal governance matters to some extent, they are small. With the exception of R&D

expenses, other measures of the quality of governance and agency problems were either not consistently related to these savings over time, or not significant at all.

This paper only investigates premium options, but we believe that similar results hold also for other types of options, such as indexed options. The fundamental intuition behind our results is that the costs of the contract are largely determined by the outside option of the CEO and by the need to provide incentives to the CEO. Any change in the contract that reduces the value of stock options to the CEO forces an increase in another component of pay. Similarly, any change in the design of stock options that reduces the incentives they provide has to be offset by increasing the number of either options or shares.

We caution the reader that we cannot conclude from this exercise that CEOs do not extract rents in the pay-setting process. We take the observed compensation as a reflection of CEOs' outside options and can therefore not address the question whether the size of total compensation is adequate, which is the subject of another literature.[27] However we do conclude that there is little indication that the structure of observed compensation contracts reflects inefficient governance.

[27] For example, Gabaix and Landier (2008).

References

[1] Aggarwal, Reena, Erel, Isil, Stulz, René, and Rohan Williamson, 2007, Do U.S. firms have the best corporate governance? A cross-country examination of the relation between corporate governance and shareholder wealth, Working Paper, Fisher College of Business.

[2] Bebchuk, Lucian, Cremers, Martijn and Urs Peyer, 2007, CEO centrality, NBER working paper 13701.

[3] Bebchuk, Lucian and Jesse Fried, 2004, *Pay without performance – The unfulfilled promise of executive compensation*, Harvard University Press.

[4] Bebchuck, Lucian and Yaniv Grinstein, 2005, The growth of executive pay, *Oxford Review of Economic Policy*, 21, 2, 283-303.

[5] Bertrand, Marianne and Sendhil Mullainathan, 2001, Are CEOs rewarded for luck? The ones without principal are, *Quarterly Journal of Economics*, 116, 3, 901-932.

[6] Brickley, James, 2003, Empirical research on CEO turnover and firm-performance: A discussion, *Journal of Accounting and Economics*, 36, 1-3, 227-233.

[7] Cai, Jie and Anand Vijh, 2005, Executive stock and option valuation in a two state-variable framework: Allowing optimal investment of outside wealth in the riskfree asset and the market portfolio, *Journal of Derivatives*, 12, 9-27.

[8] Carpenter, Jennifer, 1998, The exercise and valuation of executive stock options, *Journal of Financial Economics*, 48, 2, 127-158.

[9] Core, John and Wayne Guay, 2001, Stock option plans for non-executive employees, *Journal of Financial Economics*, 61, 2, 253-287.

[10] Core, John and Wayne Guay, 2002, Estimating the value of stock option portfolios and their sensitivities to price and volatility, *Journal of Accounting Research*, 40, 3, 613-640.

[11] Coval, Joshua and Tyler Shumway, 2005, Do behavioral biases affect prices?, *Journal of Finance*, 60, 1, 1-34.

[12] De Meza, David and David Webb, 2007, Incentive design under loss aversion, *Journal of the European Economic Association*, 5, 1, 66-92.

[13] Dittmann, Ingolf and Ernst Maug, 2007, Lower salaries and no options? On the optimal structure of executive pay, *Journal of Finance*, 62, 1, 303-343.

[14] Dittmann, Ingolf, Maug, Ernst, and Oliver Spalt, 2007, Sticks or carrotts? Optimal CEO compensation when managers are loss averse, ECGI working paper 193/2007.

[15] Dybvig, Philip and Mark Loewenstein, 2003, Employee reload options: Pricing, hedging, and optimal exercise, *Review of Financial Studies*, 16, 1, 145-171.

[16] Farrell, Kathleen and David Whidbee, 2003, Impact of firm performance expectations on CEO turnover and replacement decisions, *Journal of Accounting and Economics*, 36, 1-3, 165-196.

[17] Feltham, Gerald and Martin Wu, 2001, Incentive efficiency of stock versus options, *Review of Accounting Studies*, 6, 1, 7-28.

[18] Gabaix, Xavier and Augustin Landier, 2008, Why has CEO pay increased so much?, *Quarterly Journal of Economics*, 123, 1, 49-100.

[19] Gompers, Paul, Ishii, Joy, and Andrew Metrick, 2003, Corporate governance and equity prices, *Quarterly Journal of Economics*, 118, 1, 107-155.

[20] Grossman, Sanford and Oliver Hart, 1983, An analysis of the principal-agent problem, *Econometrica*, 51, 1, 7-45.

[21] Hall, Brian, 1998, A better way to pay CEOs?, In: Yermack, David and Jennifer Carpenter (Eds.), *Executive Compensation and Shareholder Value: Theory and Evidence*, Kluwer Academic Publishers, 33-44.

[22] Hall, Brian and Thomas Knox, 2004, Underwater options and the dynamics of executive pay-to-performance sensitivities, *Journal of Accounting Research*, 42, 2, 365-412.

[23] Hall, Brian and Jeffrey Liebman, 1998, Are CEOs really paid like bureaucrats?, *Quarterly Journal of Economics*, 112, 3, 653-691.

[24] Hall, Brian and Kevin Murphy, 2000, Optimal exercise prices for executive stock options, *American Economic Review*, 90, 2, 209-214.

[25] Hall, Brian and Kevin Murphy, 2002, Stock options for undiversified executives, *Journal of Accounting and Economics*, 33, 2, 3-42.

[26] Hall, Brian and Kevin Murphy, 2003, The trouble with stock options, *Journal of Economic Perspectives*, 17, 3, 49-70.

[27] Haigh, Michael and John List, 2005, Do professional traders exhibit myopic loss aversion? An experimental analysis, *Journal of Finance*, 49, 1, 523-534.

[28] Haubrich, Joseph, 1994, Risk aversion, performance pay, and the principal-agent-problem, *Journal of Political Economy*, 102, 2, 258-275.

[29] Haubrich, Joseph and Ivilina Popova, 1998, Executive compensation: A calibration approach, *Economic Theory*, 12, 3, 561-581.

[30] Hemmer, Thomas, Kim, Oliver, and Robert Verrecchia, 1999, Introducing convexity into optimal compensation contracts, *Journal of Accounting and Economics*, 28, 3, 307-327.

[31] Huddard, Stephen and Mark Lang, 1996, Employee stock option exercises: An empirical analysis, *Journal of Accounting and Economics*, 21, 1, 5-43.

[32] Ingersoll, Jonathan, 2006, The subjective and objective evaluation of incentive stock options, *Journal of Business*, 79, 2, 453-488.

[33] Ittner, Christopher, Lambert Richard, and Larcker David, 2003, The structure and performance consequences of equity grants to employees of new economy firms, *Journal of Accounting and Economics*, 34, 89-127.

[34] Jensen, Michael, 1986, Agency costs of free cash flow, corporate finance, and takeovers, *American Economic Review*, 76, 2, 323-329.

[35] Jewitt, Ian, 1988, Justifying the first-order approach to principal-agent problems, *Econometrica*, 56, 5, 1177-1190.

[36] Kahneman, Daniel and Amos Tversky, 1979, Prospect Theory: An analysis of decision under risk, *Econometrica*, 47, 2, 263-292.

[37] Kahneman, Daniel and Amos Tversky, 1984, Choices, values, and frames, *American Psychologist*, 39, 4, 341-350.

[38] Kahnemann, Daniel and Amos Tversky, 2000, *Choices, values, and frames*, Cambridge University Press.

[39] Kroumova, Maya and James Sesil, 2006, Intellectual capital, monitoring, and risk: What predicts the adoption of employee stock options?, *Industrial Relations*, 45, 4, 734-752.

[40] Lambert, Richard, Larcker, David, and Robert Verrecchia, 1991, Portfolio considerations in valuing executive compensation, *Journal of Accounting Research*, 29, 1, 129-149.

[41] Lamont, Owen, Polk, Christopher, and Jesus Saa-Requejo, 2001, Financial constraints and stock returns, *Review of Financial Studies*, 14, 2, 529–554.

[42] Ljungqvist, Alexander and William Wilhelm, 2005, Does Prospect Theory explain IPO market behavior?, *Journal of Finance*, 49, 4, 1759-1790.

[43] Margiotta, Mary and Robert Miller, 2000, Managerial compensation and the cost of moral hazard, *International Economic Review*, 41, 3, 669-719.

[44] Massa, Massimo and Andrei Simonov, 2005, Behavioral biases and investment, *Review of Finance*, 9, 4, 483-507.

[45] Meulbroek, Lisa, 2001, The efficiency of equity-linked compensation: Understanding the full cost of awarding executive stock options, *Financial Management*, 30, 2, 5-30.

[46] Myagkov, Mikhail and Charles Plott, 1997, Exchange economies and loss exposure: Experiments exploring Prospect Theory and competitive equilibria in market environments, *American Economic Review*, 87, 5, 801-828.

[47] Odean, Terance, 1998, Are investors reluctant to realize their losses?, *Journal of Finance*, 53, 5, 1775-1798.

[48] Oyer, Paul, 2004, Why do firms use incentives that have no incentive effects?, *Journal of Finance*, 59, 4, 1619-1650.

[49] Oyer, Paul and Scott Schaefer, 2005, Why do some firms give stock options to all employees? An empirical examination of alternative theories, *Journal of Financial Economics*, 76, 1, 99-133.

[50] Oyer, Paul and Scott Schaefer, 2006, Costs of broad-based stock option plans, *Journal of Financial Intermediation*, 15, 4, 511-534.

[51] Plott, Charles, 1996, Rational individual behavior in markets and social choice processes: the Discovered Preference Hypothesis, In: Arrow, Kenneth, Colombatto, Enrico, Perlman, Mark, and Christian Schmidt (Eds.), *The rational foundations of economic behavior*, London: Macmillan and New York: St Martin's Press, 225-250.

[52] Plott, Charles and Kathryn Zeiler, 2005, The willingness to pay-willingness to accept gap, the "endowment effect", subject misconceptions, and experimental procedures for eliciting valuations, *American Economic Review*, 95, 3, 530-545.

[53] Polkovnichenko, Valery, 2005, Household portfolio diversification: A case for rank-dependent preferences, *Review of Financial Studies*, 18, 4, 1467-1502.

[54] Post, Thierry, van den Assem, Martijn, Baltussen, Guido, and Richard Thaler, 2007, Deal or no deal? Decision making under risk in a large-payoff game show, *American Economic Review*, 98, 1, 38-71.

[55] Prendergast, Canice, 1999, The provision of incentives in firms, *Journal of Economic Literature*, 37, 1, 7-63.

[56] Prendergast, Canice, 2002, The tenuous trade-off between risk and incentives, *Journal of Political Economy*, 110, 5, 1071-1102.

[57] Rappaport, Alfred, 1999, New thinking on how to link executive pay with performance, *Harvard Business Review*, 72, 91-101.

[58] Rogerson, William, 1985, The first-order approach to principal-agent problems, *Econometrica*, 53, 6, 1357-1367.

[59] Ross, Stephen, 1973, The economic theory of agency: the principal's problem, *American Economic Review*, 63, 2, 134-139.

[60] Segal, Uzi and Avi Spivak, 1990, First order versus second order risk aversion, *Journal of Economic Theory*, 51, 1, 111–125.

[61] Tversky, Amos and Daniel Kahneman, 1991, Loss aversion in riskless choice: A reference-dependent model, *Quarterly Journal of Economics*, 106, 4, 1039-1061.

[62] Tversky, Amos and Daniel Kahneman, 1992, Advances in Prospect Theory: Cumulative representation of uncertainty, *Journal of Risk and Uncertainty*, 5, 4, 297-323.

[63] Van de Kuilen, Gijs and Peter Wakker, 2006, Learning in the Allais paradox, *Journal of Risk and Uncertainty*, 33, 155-164.

[64] Van de Kuilen, Gijs, 2008, Subjective probability weighting & the Discovered Preference Hypothesis, *Theory and Decision*, forthcoming.