Indexing Executive Compensation Contracts[*]

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Abstract

We introduce indexed contracts into the standard model of executive compensation. We calibrate the model to a sample of US CEOs and analyze two settings, one that assumes efficient contracting and another one where shareholders can use indexed contracts to recapture rents from CEOs. The main finding is that the benefits from indexing are typically small: Average gains are 3% of compensation costs in our baseline case and zero for the median firm in many plausible scenarios. The main reason is that for about 80% of the CEOs in our sample, indexing destroys incentives because it reduces option deltas and the likelihood of bad outcomes, and much of the incentives of observed contracts come from the desire to avoid these bad outcomes. Finally, if the benchmark is the stock market index, which is associated with a market risk premium, the benefits from indexing decline further. The incentive effect and the risk-premium effect together annihilate most of the potential benefits from improved risk-sharing through indexation. If we assume that CEOs extract rents, then indexing contracts is an inadequate instrument to recapture these rents, because the higher volatility of non-indexed securities is an efficient way to provide incentives.

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1. Introduction

In this paper we analyze the indexation of executive compensation contracts in a standard contracting model. We address the puzzling fact that economic models prescribe that compensation should be benchmarked, whereas compensation practice typically does not involve indexation for *ex ante* contracts like restricted stock or stock options. We calibrate the model to a large sample of US CEOs and identify the costs and benefits from indexing. The net benefits are generally small, even if we grant the assumptions of the rent-extraction view of executive compensation. We show that indexing compensation contracts has hidden costs because it often destroys incentives, whereas it has large benefits for a small number of CEOs.

The standard contracting view on compensation is based on the models of Holmström (1982) and Diamond and Verrecchia (1982) and supports indexing based on a simple and powerful argument: Shareholders (principal) have to compensate the CEO (agent) for any risk they impose on her. Shareholders therefore benefit from filtering any exogenous risk from the contract. Commentators on executive compensation have repeatedly suggested to index stock options and restricted stock awarded to executives and voiced concern over the apparent lack of indexed contracts in practice (Rappaport (1999), Bebchuk and Fried (2004)).

The empirical literature has investigated these issues in the context of research on relative performance evaluation, but, in contrast to the prescriptions of the theoretical literature, it has found practically no evidence for relative performance evaluation.[1] Later work often finds evidence for partial relative performance evaluation by paying more attention to the diversity of compensation practices across firms. Bertrand and Mullainathan (2001) find that the quality of corporate governance matters for the existence of "pay for luck," Garvey and Milbourn (2003) show that individual characteristics like the CEO's wealth are taken into

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[1]The first paper we are aware of is Antle and Smith (1986). Barro and Barro (1990), Janakiraman, Lambert, and Larcker (1992), Jensen and Murphy (1990), and Aggarwal and Samwick (1999b) also find no evidence for relative performance evaluation. A notable exception is Gibbons and Murphy (1990), whose findings are consistent with the prescriptions of the theoretical models.

consideration, and Albuquerque (2009) points out that the appropriate benchmarks differ across companies, even for companies within the same industry.

The entire empirical literature employs a cross-sectional regression methodology that analyzes the *ex post* payouts to executives that include changes in fixed salary and new stock and option grants. By contrast, theoretical models predict that benchmarks are built into *ex ante* contracts.[2] Indexing of *ex ante* contracts requires that stock options or restricted shares are adjusted so that they subtract an appropriate benchmark to calculate the final payoff. This adjustment could remove the risk of the benchmark from the contract, but it is apparently never used in practice.

The cross-sectional evidence for relative performance evaluation is based exclusively on adjustments of new compensation awards to industry or market-wide effects. This evidence is therefore also consistent with the alternative interpretation that boards regard CEOs' performance relative to their industry peers as information about CEOs' talent.[3] Superior performance relative to a benchmark reveals the CEO's superior talent to the managerial labor market and therefore increases her outside employment opportunities. Boards reset base salaries and other forms of pay accordingly. These dynamic considerations are largely orthogonal to the design of *ex ante* contracts to provide efficient effort incentives and to avoid "pay for luck," which are the concerns of critical commentators and the earlier contracting literature. In our discussion we therefore distinguish between relative performance evaluation, which also includes the *ex post* adjustment of base salaries and bonus payments, and indexation, by which we refer exclusively to the benchmarking of *ex ante* contracts and the attempt to remove pay for luck.

There are two different views of the apparent lack of benchmarking in CEOs' compensation contracts. The first view is the rent-seeking view advocated by Bebchuk and Fried (2004), who present the lack of indexed options as one important piece of evidence for their

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[2]The literature on the compensation of fund managers also addresses benchmarking in *ex ante* contracts, see for example Coles, Suay, and Woodbury (2000).

[3]See Dye (1992) and Oyer (2004) for theoretical elaborations of the talent argument and Rajgopal, Shevlin, and Zamora (2006) and Bizjak, Lemmon, and Naveen (2008) for empirical evidence.

claim that the pay-setting process for top executives is defective. The second view regards the lack of relative performance evaluation as a puzzle that needs to be explained and consists of a range of proposals to reconcile observed practice with the efficient contracting paradigm. We identify five arguments along these lines. Relative performance evaluation (1) induces unwanted incentives to intensify industry competition (Aggarwal and Samwick (1999a)); (2) provides incorrect incentives for entering or exiting industries (Dye (1992); Gopalan, Milbourn, and Song (2009)); (3) provides incentives to shift returns away from the benchmark (Levmore (2001)); (4) is tax inefficient, because indexed options would not qualify for the same advantageous tax treatment as conventional options; (5) can be replicated by managers through appropriate rebalancing of their own portfolio between the benchmark portfolio and the risk-free asset (Garvey and Milbourn (2003), Jin (2001), and Maug (2000)). The first four arguments are outside the scope of our paper and identify additional effects that limit the usefulness of relative performance evaluation, whereas our analysis identifies limitations for the usefulness of indexing in a standard contracting model. The tax-argument seems to be specific to the US-context and cannot explain the absence of indexed contracts in environments outside the US. The last argument plays some role in our discussion and we label it the *homemade indexing* argument.

Our analysis addresses the problem with an approach that bridges both views, the efficient contracting view as well as the rent-extraction view. We calibrate a standard model of compensation individually to each of 755 CEOs from the ExecuComp universe. The model has been widely used in the literature and allows us to point out several theoretical effects that were disregarded in the previous discussion, even though they were implicitly present.[4] Our methodological innovation to this literature is twofold. First, we analyze *ex ante* contracts rather than looking at cross-sectional regressions. Second, we perform calibrations at the individual CEO level for a sample of US CEOs and quantify the impact of indexation on

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[4]Some of the earlier contracting literature pointed out the potential usefulness of randomized contracts, i.e. of contracts that enhance incentives by increasing the uncertainty for the agent, but no paper we are aware of drew the implications of these arguments for the usefulness of indexation. See, e.g., Gjesdal (1982) and Arnott and Stiglitz (1988).

these contracts.[5]

Our main result is that the indexation of compensation contracts generates either little or no value for shareholders. We begin with the indexation of options and first consider the case where CEOs do not extract rents so that their participation constraint is binding. For brevity we will refer to this case as the efficient contracting case. Then efficiency gains from indexing for shareholders are almost zero for the median firm in our baseline case, and average savings across all CEOs in our sample are 3% of compensation costs, and these benefits are skewed towards a minority of firms. We also investigate mandatory indexation and assume that an outside regulator imposes that all stock options are fully indexed. Mandatory indexation destroys value and increases indexation costs on average and for the median firm.

The critical insight is that the indexation of options destroys incentives for about 80% of the CEOs in our sample. This happens for two reasons. First, indexed options have a lower risk-neutral option delta and therefore provide less pay-for-performance sensitivity than conventional options so that shareholders need to restore incentives by offering more deferred pay.

Second, indexation provides insurance to risk-averse CEOs. If CEOs are insured against any kind of risk, for example through indexing their options, then the probability that their pay falls to very low levels is reduced. However, much of their incentives come from the possibility of low payoffs where CEOs' utility is low and where their marginal utility and therefore their incentives are high. CEOs' vulnerability to an exogenous source of risk therefore increases their incentives and the early contracting literature discusses the potential improvements from randomized contracts.[6] If shareholders index options or shares, they remove this vulnerability to stock-market risk and have to offset the resulting reduction in incentives by granting CEOs either more stock or more stock options, which is costly to

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[5]Calibration analysis has a long tradition in the compensation literature, beginning with Lambert, Larcker, and Verrecchia (1991), Garen (1994), Haubrich (1994), and Hall and Murphy (2002), among others. Our CEO-level approach is the closer to Dittmann and Maug (2007) and Dittmann, Maug, and Spalt (2010).

[6]Gjesdal (1982) and Arnott and Stiglitz (1988) show that randomized incentive schemes may improve incentives. Gjesdal shows that in some cases this effect may be sufficiently strong so that a randomized contract becomes even optimal. In our model, randomized contracts are not optimal, but removing the benefits from randomization is still costly to shareholders.

shareholders. In line with a related literature in insurance and risk management, we call this effect the *background-risk* effect (see for example Gollier and Pratt, 1996).

The background-risk effect is sufficiently strong for the majority of CEOs in our sample, but we also find that for about 20% of the CEOs, the effect of indexation on incentives reverses and for these CEOs indexation creates incentives. Further investigation shows that these CEOs tend to have significantly higher option holdings. Then the background-risk effect described above reverses. The fact that indexation makes low payoffs less likely is irrelevant for CEOs with large option holdings because options do not pay off in the lower part of the distribution. Symmetrically, indexation reduces the likelihood of very large payoffs in favor of intermediate payoffs where marginal utility and therefore incentives are higher. For sufficiently large option holdings, this second effect dominates. As a result, indexing options is beneficial for a minority of CEOs with large option holdings.

In addition to the effect of indexation on incentives, indexation is suboptimal if the benchmark is correlated with the stock market index. The important consideration here is that stock market risk is priced so that CEOs who bear stock market risk also receive a risk-premium.[7] Then firms must compensate the CEO for the risk-premium removed by indexation, because they must match the CEO's outside option. CEOs desire a certain exposure to market risk, and removing it through indexing is therefore potentially inefficient.[8]

In the next step of our argument we drop the assumption that CEOs' outside options are binding and assume instead that CEOs extract rents in the pay-setting process. We then ask whether indexation is an appropriate strategy for shareholders to recapture these rents. Effectively, we ask which contracts would be optimal if firms want to provide a given level of incentives, but do not need to take into account CEOs' outside option because it is not binding. There is no agreed-upon modeling approach to contracting with rent extraction and

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[7]Meulbroek (2001) is the only contribution we are aware of that considers the risk premium explicitly. However, her measurement of the efficiency of compensation contracts does not use a complete contracting model.

[8]We abstract from the homemade indexing argument in this step. If we allow for homemade indexing, indexing affects contracting costs only if there are frictions that prevent the CEO from reaching her desired exposure to market risk, for example short-selling or borrowing constraints. In our sample these constraints are typically binding for the majority of CEOs.

we argue below why our modeling approach captures the spirit of the rent extraction view most closely. This investigation shows that for about three quarters of all CEOs, indexation does not help to recover rents. The intuition for this result is that indexing destroys incentives for the same reasons as in the efficient contracting case, and if shareholders recover rents, they are only interested in incentives. Moreover, the theoretical benefits from indexing come from the positive impact indexation has on the utility of risk-averse CEOs, a factor shareholders disregard in a context where the CEO's participation constraint is not binding.

We then develop a slightly different approach to the analysis of rent-seeking CEOs and allow shareholdings to change. This analysis shows that most CEOs are overexposed to the risk of their own company so that *reducing* their stockholdings would *increase* their incentives. This result is puzzling at first and arises because additional shares do not just create a stronger alignment of CEOs' wealth with the value of their firms (the direct effect), but the additional shares also make CEOs more wealthy, which reduces their marginal utility and thereby their incentives (the indirect effect). The indirect effect does not arise in a standard contracting model where CEOs do not extract rents, because CEO utility is then held constant. For the majority of CEOs in our sample, the indirect effect dominates the direct effect. We conclude that, while indexation accomplishes little, adjusting compensation contracts by reducing restricted stock can often be beneficial.

In the final step of our analysis, we consider the indexation of restricted stock the CEO holds as part of her compensation package. We consider again the efficient contracting view and show that many qualitative effects are similar to the case of indexed options, but the benefits to shareholders are significantly smaller. Interestingly, however, indexing restricted shares does not destroy incentives, in contrast to indexing options. The reason is that indexation reduces the volatility of indexed stock. The sensitivity of the share price to firm value does not depend on the volatility of share, whereas option deltas of out-of-the money options decline with volatility.

The remaining part of the paper is organized as follows. The following Section 2. intro-

duces the model and our calibration approach. Section 3. describes the data set. Section 4. contains the main part of the analysis of the indexation of options for the efficient-contracting as well as for the rent-extraction case. Section 6. repeats the analysis for the indexation of restricted stock. Section 7. concludes with additional discussions and a perspective on future research. Some of the more technical material is gathered in the appendix.

2. The model and methodology

We consider a standard principal-agent model in the spirit of Holmström (1979). The CEO (agent) provides costly and unobservable effort on behalf of shareholders (principal). At the beginning of the period (time 0) shareholders propose a contract to the CEO. When the CEO accepts the contract, she exerts effort e during the contracting period, and this effort positively affects the end-of-period stock price P_T, where T denotes the length of the contracting period. As effort is not observable, the contract depends on the stock price P_T and, for the purpose of indexation, on the stock market index M_T only and generates a payoff π_T to the agent at the end of the period.

The CEO's utility The CEO's wealth that is not invested in her own firm is denoted by W_0. For brevity we refer to W_0 as non-firm wealth. A fraction $\omega \in [0, 1]$ of this wealth is invested in the market portfolio and yields return per dollar invested of $\frac{M_T}{M_0}$ at the end of the period, while the remaining wealth is invested at the risk-free rate r_f. The CEO's end-of-period wealth therefore is

$$W_T = W_0 \left((1 - \omega)e^{r_f T} + \omega \frac{M_T}{M_0} \right) + \pi_T. \tag{1}$$

The CEO's utility is additively separable in end-of-period wealth and effort, i.e., $U(W_T, e) = V(W_T) - C(e)$, where $C(e)$ is increasing and convex. The CEO is risk-averse in wealth with

constant relative risk aversion (CRRA):

$$V(W_T) = \frac{1}{1 - \gamma} W_T^{1-\gamma}, \tag{2}$$

where γ is the coefficient of relative risk aversion (if $\gamma = 1$, we define $V(W_T) = ln(W_T)$). We use constant relative risk aversion because this assumption has become the benchmark model in the compensation literature.[9] The CEO's outside option when she declines the contract is $\underline{U}$.

Contracts and shareholders' optimization We consider piecewise linear contracts that consist of fixed salary ϕ, the number of shares n_S, and the number of options n_O, where we express n_S and n_O as a proportion of all outstanding shares. Moreover, a proportion $\psi \in [0, 1]$ of the options is indexed, so that the CEO's wage is

$$\pi_T = \phi e^{r_f T} + n_S P_T + n_O \left(\psi O_T^{indx} + (1 - \psi) max \left\{ P_T - K, 0 \right\} \right).$$

Here, K is the strike price of the option and O_T^{indx} is the payoff of an indexed option. The base salary is paid at the beginning of the contracting period and invested at the risk-free rate r_f.

Shareholders' problem is to minimize the expected costs $E[\pi_T]$ subject to the two constraints that the CEO accepts the contract and that she will exert the desired effort level e^*:[10]

$$\min E[\pi_T] \tag{3}$$

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[9]CRRA preferences and lognormal prices have been used, among others, by Lambert, Larcker, and Verrecchia (1991), Hall and Murphy (2000, 2002), Himmelberg and Hubbard (2000), Hall and Knox (2004), and Oyer and Schaefer (2006).

[10]For the incentive compatibility constraint, we assume that the first-order approach is satisfied. A sufficient condition is that the optimization problem is globally concave, and this is the case if the cost function $C(e)$ is sufficiently convex and the production function $P_0(e)$ is sufficiently concave. Dittmann and Maug (2007) numerically check whether the optimal contract induces the CEO to choose less effort than the observed contract. We do not follow their approach here, because our main result is that the improvement of the optimal contract over the observed contract is only marginal, so that we do not suggest that firms should switch to the optimal contract.

subject to:

$$E\left[U\left(W_T, e^*\right)\right] \geq \underline{U} \tag{4}$$

$$\frac{d}{de} E\left[U\left(W_T, e^*\right)\right] = 0. \tag{5}$$

Stock price and market index We assume that the end-of-period stock price P_T is lognormally distributed,

$$P_T = P_0\left(e\right) \exp\left\{\left(\mu_P - \frac{\sigma_P^2}{2}\right) T + u_P \sigma_P \sqrt{T}\right\}, \tag{6}$$

where $P_0\left(e\right)$ is an increasing and concave function in effort e, μ_P is the expected annual total return (dividends plus capital gains), σ_P is the annual standard deviation of stock returns, u_P is a standard normal random variable, and T denotes the length of the contracting period.

Similarly, the end-of-period value of the stock market index M_T is lognormally distributed:

$$M_T = M_0 \exp\left\{\left(\mu_M - \frac{\sigma_M^2}{2}\right) T + u_M \sigma_M \sqrt{T}\right\}. \tag{7}$$

The definitions of μ_M, and σ_M are analogous to those for P_T. The actions of the CEO do not affect the market return or the value of the index. Furthermore, u_P and u_M are correlated with a coefficient of correlation ρ. The CAPM holds, so $\beta = \rho \frac{\sigma_P}{\sigma_M}$ and[11]

$$\mu_P = r_f + \beta\left(\mu_M - r_f\right). \tag{8}$$

Payoffs and valuation of indexed stock and indexed options. Johnson and Tian (2000) show that the expected value of P_T given the value of the index M_T is:

$$E\left[P_T|M_T\right] = H_T \equiv P_0\left(\frac{M_T}{M_0}\right)^\beta e^{\eta T}, \tag{9}$$

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[11]Compared to the setup of Johnson and Tian (2000), we ignore the possibility of deviations from the security market line here. In their notation, we set $\alpha = 0$.

where

$$\eta \equiv (1 - \beta) \left(r_f + \frac{1}{2}\rho\sigma_M\sigma_P \right), \tag{10}$$

so that for $\beta = 1$ we have $\eta = 0$ and $H_T = \frac{P_0 M_T}{M_0}$. If $\beta = 0$, then $\rho = 0$ and $H_T = P_0 e^{r_f T}$.

H_T represents the systematic component of stock returns. We define

$$O_T^{indx} = max\left\{P_T - H_T, 0\right\}. \tag{11}$$

We use the Black-Scholes formula and the formula of Johnson and Tian (2000) to value, respectively, conventional options and indexed options at time $t = 0$ (JT=Johnson-Tian value):

$$JT = e^{-dT}\left[P_0 N(d_1^{indx}) - P_0 N(d_2^{indx}) \right], \tag{12}$$

$$\text{where: } d_1^{indx} = \frac{ln(P_0/H_0)}{\sigma_I\sqrt{T}} + \frac{\sigma_I\sqrt{T}}{2} = \frac{\sigma_I\sqrt{T}}{2}, \ d_2^{indx} = -\frac{\sigma_I\sqrt{T}}{2}. \tag{13}$$

Here $\sigma_I = \sigma_P\sqrt{1 - \varrho^2}$. The transformation of the expression for d_1 makes use of the fact that $H_0 = P_0$ from (9).

Calibration We use the calibration method introduced by Dittmann and Maug (2007). We denote the observed contract by $(\phi^d, n_S^d, n_O^d, \psi = 0)$ ("d" stands for "data") and assume that the observed contract, implements the desired effort level e^* and does not leave the CEO with a rent. We define the utility-adjusted pay-for-performance sensitivity $UPPS$ as:[12]

$$UPPS(\phi, n_S, n_O, \psi) \equiv \frac{d}{dP_0}E\left[V(W_T(\phi, n_S, n_O, \psi))\right]. \tag{14}$$

We distinguish between unrestricted shares n_{SU} and restricted shares n_{SR} such that $n_S = n_{SU} + n_{SR}$. The CEO and shareholders bargain over fixed salary ϕ, the number of restricted

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[12]Note that for the case of risk neutrality where $V(W_T) = W_T$, $UPPS$ reduces to the more familiar pay-for-performance sensitivity, which in our case is equal to $n_S + n_O(1 - \psi)N(d_1) + n_O\psi N(d_1^{indx})$; $N(d_1)$ and $N(d_1^{indx})$ denote the delta of, respectively, conventional and indexed options.

shares n_{SR} and the proportion ψ of options that are indexed. We fix the number of options n_O and unrestricted shares n_{SU} at their observed levels, i.e., $n_O = n_O^d$ and $n_{SU} = n_{SU}^d$. Then the optimization problem can be rearranged as follows:

$$\min_{\{\phi, n_{SR}, \psi\}} E\left[\pi_T(\phi, n_{SR}, \psi)\right] \tag{15}$$

subject to:

$$E\left[V\left(W_T\left(\phi, n_{SR}, \psi\right)\right)\right] \geq E\left[V\left(W_T\left(\phi^d, n_{SR}^d, 0\right)\right)\right] \tag{16}$$

$$UPPS(\phi, n_{SR}, \psi) \geq UPPS(\phi^d, n_{SR}^d, 0). \tag{17}$$

$$\psi \in [0, 1] \tag{18}$$

Hence, we search for the cheapest contract that provides the CEO with at least the same utility as the observed contract and that induces at least the same level of effort as the observed contract. If indexing is important, a contract with $\psi > 0$ should be optimal and significantly cheaper than the observed contract.

We assume that the firm can negotiate neither over unrestricted stock n_{SU} nor over the number of options n_O^d. We cannot endogenize the number of options, because the contracting model we use would then predict zero option holdings, which would render the whole question about the indexation of options meaningless (Dittmann and Maug (2007)). We therefore pose only the more limited question about the optimal degree of indexation without endogenizing the structure of the contract itself. As the number of options is exogenous, the number of shares has to be determined endogenously in order to satisfy the incentive compatibility constraint (5).

We do not include the possibility that the CEO optimizes over her portfolio composition ω and instead report results for a grid of exogenous values for ω. The literature on the home-made indexation argument, which we reference in the Introduction, emphasizes that CEOs choose ω optimally and thereby fully or partially undo the indexation in their compensation

contracts.[13] The use of a grid of exogenous values for ω avoids tedious case distinctions that occur because ω must lie between zero and one, and our results imply that these boundaries are frequently assumed.By abstracting from the homemade indexing argument we are therefore better able to show the other effects at work here. Our analysis overstates the benefits from indexation since we sometimes attribute benefits to indexation which the CEO could also generate through adjusting ω.

Program (15) to (18) assumes efficient contracting and is analyzed in Section 4.. In Section 5., we analyze a rent-extraction scenario where we drop the participation constraint (16) and fix the salary ϕ at its observed level ϕ^d. The firm then minimizes costs (15)over (n_{SR}, ψ) subject to the incentive compatibility constraint (17) only. This problem captures the idea that CEOs earn rents that can be recouped through an adjustment in the structure of pay. We will discuss this case in more detail in Section 5..

We can completely parameterize the expressions in (16) and (17) by determining appropriate values for the contract parameters ϕ^d, n_S^d, and n_O^d, the parameters of the stock price processes (6) to (8), and the CEO's risk aversion parameter γ. When we calculate the value of the contract $E[\pi_T]$, we use the Black-Scholes formula for standard options and equation (12) for indexed options.

3.   Data

We use the ExecuComp database to construct approximate CEO contracts at the beginning of the 2006 fiscal year. We first identify all persons in the database who were CEO during the full year 2006 and executive of the same company in 2005. We calculate the base salary ϕ as the sum of salary, bonus, and "other compensation" from 2006 ExecuComp data and

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[13]We do not incorporate this optimal choice into our model, because there is no closed-form solution of the CEO's portfolio problem and we would therefore have to work with a nested optimization problem where the firm first chooses the optimal contract and the CEO then adjusts her private portfolio accordingly. Also, the firm would have to anticipate the CEO's actions, so that the inner optimization problem would have to be solved at every point where the outer optimization problem is evaluated. It is unlikely that such a model can be solved in a reasonable amount of time with today's computing power.

take information on stock and option holdings from the end of the 2005 fiscal year. We regard the data for 2006 as more representative for our purposes as subsequent years were affected by the financial crisis.

We estimate each CEO's option portfolio with the method proposed by Core and Guay (2002) and then aggregate this portfolio into one representative option. Indexed options are at-the-money and $H_0 = P_0$ from (9). We therefore set $K = P_0$ and calculate the number of representative options n_O^d and the maturity T of the representative option so that they have the same Black-Scholes value and the same option delta as the estimated option portfolio.[14] In this step, we lose five CEOs for whom we cannot numerically solve this system of two equations in two unknowns.

We take the firm's market capitalization P_0 from the end of 2005. While our formulae above abstract from dividend payments for the sake of simplicity, we take dividends into account in our empirical work and use the dividend rate d from 2005. We estimate the firm's stock return volatility σ and CAPM beta β from monthly CRSP stock returns over the five fiscal years 2001 to 2005 and drop all firms with fewer than 45 monthly stock returns. The risk-free rate is set to the U.S. government bond yield with five-year maturity from January 2006.

We estimate the non-firm wealth W_0 of each CEO from the ExecuComp database by assuming that all historic cash inflows from salary and the sale of shares minus the costs of exercising options have been accumulated and invested year after year at the one-year risk-free rate. We assume that the CEO had zero wealth when she entered the database, which biases our estimate downward, and that she did not consume since then, which biases our estimate upward.[15] To arrive at meaningful wealth estimates, we discard all CEOs who

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[14] We take into account the fact that most CEOs exercise their stock options before maturity by multiplying the maturities of the individual option grants by 0.7 before calculating the representative option (see Huddart and Lang (1996) and Carpenter (1998)). In these calculations, we use the stock return volatility from ExecuComp and, for the risk-free rate, the U.S. government bond yield with 5-year maturity from January 2006. Data on risk-free rates were obtained from the Federal Reserve Board's website. For CEOs who do not have any options, we set $T = 7$ (10-year maturity multiplied by 0.7) as this is the typical maturity for newly granted options.

[15] These wealth estimates can be downloaded for all years and all executives in ExecuComp from http://people.few.eur.nl/dittmann/data.htm.

do not have a history of at least five years for 2001 to 2005 on ExecuComp. During this period, they need not be CEO. This procedure results in a data set with 755 CEOs.

[Insert Table 1 here]

Table 1 provides an overview of our data set. The median CEO in the sample owns 0.25% of the stock of his company, of which 0.02% is restricted and 0.023% is unrestricted. Median option holdings are on 1.02% of the company's stock. Median base salary is \$1,04m, and the median non-firm wealth is \$13.49m.

The only parameter in our model that we cannot estimate from the data is the manager's coefficient of relative risk aversion γ. We use $\gamma = 2$ as a baseline case for most of our analysis and also report results for $\gamma = 1$, $\gamma = 3$, and $\gamma = 6$.[16]

Murphy (1999) reports that in a sample of 627 firms that granted stock options to their executives in 1992, only a single firm used indexed options. Since ExecuComp does not report indexing, we therefore assume that all stock and options in the observed contract are not indexed. Indexing should not be confused with performance vesting. In recent years, more and more option grants do not vest automatically after a certain time period but only when some performance criterion (e.g., a minimum return on assets) has been achieved (see, e.g., Bettis et al. (2008)). Note also that some bonus schemes like phantom stocks or bonuses that depend on the performance of a peer group constitute relative performance pay (see Murphy, 1999). By treating bonuses as fixed salary, we do not include these features in our stylized observed contract.

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[16]Different strands of the literature use different values of relative risk aversion and there is no consensus on this subject. Ait-Sahalia and Lo (2000) survey the research on this topic, which supports values between 0 and 55. The macroeconomic literature typically uses higher values (see Campbell, Lo, and McKinlay (1997), chapter 8, for a survey and discussion). The compensation literature often uses lower values. For example, Murphy (1999) uses 1, 2, and 3 and Hall and Murphy (2002) use 2 and 3. Dittmann, Maug, and Spalt (2010) calibrate a loss-aversion model and show that it fits compensation data well. The degree of relative risk-aversion implied by their analysis varies between 0.5 and 1.

4. Indexation of options when contracting is efficient

In this section, we analyze the optimization problem (15) to (18).

4.1 The net benefits from indexation

Table 2 shows the results for three values of the coefficient of relative risk aversion γ (1, 2, and 3) that have been considered in the literature (e.g., Hall and Murphy (2002)). For illustrative purposes we also report $\gamma = 6$, although this value is outside the range typically considered in the compensation literature. For each value of γ, the table provides the results for five levels of the proportion ω of CEO non-firm wealth that is invested in the stock market. The table reports the means of the base salary ϕ and of restricted stock holdings n_{SR} in the optimal contract. The number of options is held constant at the observed number of options, so $n_O = n_O^d$ by construction and is therefore not reported. The same applies to the number of unrestricted shares n_{SU}. We also report the mean and median of the optimal degree of indexation ψ and the proportion of all CEOs for whom the lower bound on ψ is binding ($\psi = 0$) as well as the proportion of all CEOs for whom the upper bound on ψ is binding ($\psi = 1$). Finally, we report the efficiency gains from recontracting. Efficiency gains are defined as the difference between the cost of the observed contract π^d and the cost of the optimal contract predicted by the model, π^*, expressed as a percentage of π^d, so $S = (\pi^d - \pi^*)/\pi^d$. Our numerical routines do not converge for all observations and all parameterizations. The number of observations therefore varies slightly in Table 2.

[Insert Table 2 here]

Our first important result is that the level of indexation and the efficiency gains firms can realize by indexation are small across many specifications considered in Table 2. As a baseline case we use $\gamma = 2$ and $\omega = 0.5$ throughout, and for these parameters firms index on average 34.57% of their options (median: 10.35%) . For 13.99% of all firms, full indexation ($\psi = 1$) is optimal, while 46.71% of all firms would not index their CEO's options at all,

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i.e. for them, $\psi = 0$. The efficiency gains firms can realize by indexing options are 3.08% of total compensation costs on average, and almost zero for the median firm. Indexation becomes more valuable if the CEO is more risk-averse and if the CEO's investment in the stock market is high. We observe large efficiency gains in Table 2 only if we simultaneously assume large stock market investments ω and high levels of risk-aversion γ. However, such a combination of high γ and high ω is implausible because CEOs choose their investment in the stock market, and the optimal exposure to the stock market is inverse to their risk aversion. The parameters ω and γ can therefore not both be high.

Low efficiency gains from indexation contradict the general enthusiasm for indexed options and seem to violate the intuition based on standard contracting models. Note that our analysis in Table 2 does not feature the homemade indexation effect because CEOs' private investment in the stock market is exogenous in our analysis. Including this effect would reduce efficiency gains even further. Also, our analysis contains none of the economic reasons against indexation that we have reviewed in the introduction.

For our further analysis, it is instructive to consider the case of full or mandatory indexation (i.e., $\psi = 1$). For some firms, indexation destroys value and leads to efficiency losses, so that the optimal degree of indexation is zero. As a consequence, the efficiency gains in Table 2 are biased towards those CEOs where gains can be achieved. Mandatory indexation is also an interesting case for regulators who might see indexation as way to avoid 'pay for luck'. We therefore solve the program (15) to (17) with $\psi = 1$.

[Insert Table 3 here]

Table 3 reports the contract parameters ϕ and n_{SR}, mean and median efficiency gains as a percentage of the observed contract, and the proportion of firms who benefit from indexation. For our baseline parameters ($\gamma = 2$, $\omega = 0.5$), savings are negative on average and for almost two thirds of all firms, although the magnitude of wealth destruction is small. The number of firms that would benefit from mandatory indexation increases with CEOs' assumed investment in the stock market ω and with their assumed risk aversion γ. This

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finding is intuitive: efficiency gains are positive if CEOs' optimal exposure to stock market risk is lower than their assumed exposure.[17]

4.2 Why are efficiency gains so low?

To further analyze the efficiency gains from Table 3 we decompose them into two components. The first part, S_{RS}, are the efficiency gains from changes in risk-sharing: we set $\psi = 1$ and $n_{SR} = n_{SR}^d$ and minimize objective (15) subject to the participation constraint (16). We drop, for the time being, the incentive compatibility constraint, so incentives may be higher or lower than in the observed contract. S_{RS} therefore reflects the gains from mandatory indexation net of the additional salary that must be paid to the CEO to make her sign the contract. The second part, S_I is simply the remaining efficiency gain from Table 3, i.e., $S_I = S - S_{RS}$. This part is the efficiency gain from adjusting incentives to their initial level. Here, restricted stock n_{SR} and fixed salary ϕ are both adjusted.

[Insert Table 4 here]

Table 4 shows the averages of S, S_{RS}, and S_I, where the average efficiency gain S is repeated from Table 3. Benefits from changes in risk-sharing are small for $\gamma = 1$ but become sizeable for $\gamma = 2$ or $\gamma = 3$ where they range from 7.5% to 15.1%. These benefits are offset partly by large efficiency losses S_I when incentives are restored. These losses range from 4.7% to 10.4% and are not monotonic across γ. Our first conclusion from Table 4 therefore is that - if incentives are not taken into account - indexation generates large efficiency gains. This presumably is the reason why many experts call for indexation. However, Table 4 also shows that indexation destroys incentives on average. There are large efficiency losses in the second step when incentives are restored that (at least partially) offset the efficiency gains

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[17]We encounter severe numerical problems for $\omega = 1$ in the cases $\gamma = 1$ and $\gamma = 2$. The reason is that CEO utility approaches infinity as the CEO's end-of-period wealth approaches zero. For $\omega = 1$, CEOs have invested their entire private wealth into the stock market, so that their fixed salary must be positive in order to ensure a positive end-of-period wealth. Our implicit assumption for $\omega = 1$ therefore is $\phi \geq 0$. Problems occur as ϕ approaches zero, so that those solutions where $\phi^* = 0$ are likely to drop out due to numerical problems whereas solutions with $\phi^* > 0$ are more likely to converge. As a consequence, our results for $\omega = 1$ are biased towards low savings and should be interpreted with caution.

from the first step. That indexation destroys incentives can also be seen in Tables 2 and 3 where average restricted stock holdings n_{SR} exceed their observed average 0.125% (see Table 1) by 16% to 380%. In the following two sub-sections, we further analyze the efficiency gains S_{RS} and S_I, respectively.

4.3   Efficiency gains from changes in risk-sharing

We distinguish between three effects that affect efficiency gains from changes in risk-sharing, S_{RS}. As a first step, we observe that indexation of options combines a reduction in the volatility of the underlying asset and an increase in the strike price of the option. To see this, note that we can we can reinterpret the value of indexed options according to the Johnson-Tian (2000) formula (12) also as a Black-Scholes value of a conventional option on a share with volatility σ_I and strike price $P_0 exp((r_f - d)T)$. Substituting these parameters into the Black-Scholes formula yields:

$$BS = e^{-dT} P_0 N(d_1) - e^{-r_f T}(P_0 e^{(r_f-d)T})N(d_2)$$
$$= e^{-dT} \left[P_0 N(d_1) - P_0 N(d_2) \right], \tag{19}$$

where the d_1-value is also the same as that for the Johnson-Tian formula from (13). Indexed options are therefore different in value from otherwise identical conventional options for two reasons: (1) indexed options are written on an asset with a lower volatility $\sigma_I < \sigma_P$; (2) indexed options are equivalent to premium options with a strike price that exceeds the current stock price by a factor of $exp\{(r_f - d)T\}$.

While it is intuitive that indexed options are similar in value to conventional options with lower volatility, it is rather surprising that indexed options can be reinterpreted as *premium* options, i.e. $K > P_0$. To develop an intuition for this result, we consider the effect of indexation on a conventional at-the-money option and compare this effect to an increase in the option's strike price. Conventional options are granted at the money (i.e., $K = P_0$)

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but they are in the money in expectation at maturity T. More precisely, the expectation of the stock price P_T is $E(P_T) = P_0 exp\{\mu_P T\} = P_0 exp\{(r_f + \beta(\mu_M - r_f) - d)T\}$ from equations (6) and (8). The conventional at-the-money option therefore is in the money in expectation at maturity by a factor of $exp\{(r_f + \beta(\mu_M - r_f) - d)T\}$. Under risk-neutral valuation, we can set $\mu_M = r_f$, because the factor $exp\{(\beta(\mu_M - r_f))T\}$ is the compensation for systematic risk and therefore not priced in the market. The expected moneyness at maturity under risk-neutral valuation therefore is $exp\{(r_f - d)T\}$. Intuitively, indexation removes this expected in-the-moneyness at maturity and that is exactly what a premium option with $K = P_0 exp\{(r_f - d)T\}$ does as well. Based on this insight we can split the benefits from changes in risk sharing S_{RS} into two effects.

Leverage effect. The leverage effect of indexation is related to replacing conventional options with strike price P_0 with premium options and strike price $P_0 exp((r_f - d)T)$.[18] Hall and Murphy (2002) show for $\gamma = 2$ and $\gamma = 3$ that the risk-premium drops when in-the-money options are replaced by at-the-money options (see their Figure 1), so we expect that this effect generates positive efficiency gains. While the leverage effect is well-established for conventional options, we are not aware of any paper that argues that this effect is also relevant for indexed options.

The second effect of indexation is the volatility effect where the option's volatility is reduced from σ_P to σ_I. It is instructive to split this effect into two sub-effects:

Noise-reduction effect. Part of the volatility effect is the noise-reduction effect from Holmström (1979). Equation (19) shows that the market value of indexed options is equal to the Black-Scholes value of an option written on an underlying asset with lower volatility $\sigma_I < \sigma_P$. Less risk results in a lower risk-premium for undiversified executives, and the effect therefore generates positive efficiency gains as long as $\beta > 0$.

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[18]We call this effect "leverage effect", because equity in a levered firm can be considered a call option on the value of the firm with exercise price equal to the face value of debt (see Jensen and Meckling (1976)).

Market-risk-premium effect. Another part of the volatility effect is the market-risk-premium effect that is closely related to the noise-reduction effect but goes into the opposite direction. The risk that is removed by indexing is systematic risk that earns a risk premium. Hence, some other component of CEO pay must be increased to compensate the CEO for the loss of the risk premium, and the effect generates efficiency losses if $\beta > 0$.

The market risk premium μ does not appear in the formulae (12) and (19), because these formulae assume risk-neutral pricing. In her private portfolio decision, the CEO will trade-off utility gains from the market premium with utility losses from being exposed to more systematic risk. In equilibrium she will choose portfolio weights where marginal benefits equal marginal costs, so that the market premium exactly offsets the disutility from the higher risk exposure. As a consequence, the market-risk-premium effect exactly offsets the risk sharing effect in equilibrium and the risk premium μ drops out of the equilibrium pricing formulae.

In our setting, however, the CEO will in general not be in equilibrium. We do not allow for home-made indexation, i.e. for an endogenous proportion ω of CEO investments into the stock market. Even if ω were endogenous, the CEO might not be able to reach the equilibrium with $\omega \in [0,1]$, because she is forced to hold large stakes in her own firm. The sum of the risk-sharing effect and the market-risk-premium effect (i.e., the volatility effect) will therefore not be zero in general. If the CEO is underexposed to market risk and wishes to take on more market risk, the sum of the two effects will be negative as additional indexation destroys value. On the other hand, if the CEO wishes to reduce market exposure, the sum of the two effects will be positive and indexation is valuable.

Decomposition of efficiency gains from changes in risk-sharing S_{RS}. Table 4 displays a decomposition of efficiency gains from changes in risk-sharing S_{RS} into the three components: gains from leverage S_L, gains from the market risk premium S_{MRP}, and gains from noise-reduction S_{NR}, such that $S_L + S_{MRP} + S_{NR} = S_{RS}$. The true relation between these three effects is highly nonlinear, so that any additive decomposition can only be a

rough approximation.

Recall that for the calculation of S_{RS}, we set $\psi = 1$ and $n_{SR} = n_{SR}^d$ and minimize objective (15) subject to the participation constraint (16). This optimization brings us from the observed contract C^d with n_O^d conventional options to the contract C^{RS} with n_O^d indexed options that provides the CEO with the same utility as the observed contract. Efficiency gains are then defined as the difference in costs between contract C^{RS} and contract C^d scaled by the costs of C^d. We define two intermediate contracts, C^L and C^{MRP} so that we can split total efficiency gains in three parts: gains from the transition from C^d to C^L, gains from the transition from C^L to C^{MRP}, and gains from the transition from C^{MRP} to C^{RS}. In all steps, we keep $\psi = 1$ and $n_{SR} = n_{SR}^d$ and adjust fixed salary ϕ such that the CEO stays indifferent. To reach contract C^L, we replace n_O^d conventional at-the-money options with n_O^d premium options with strike price $P_0 exp\{(r_f - d)T\}$. We then go from C^L to C^{MRP} by setting $\beta = 0$ or, equivalently, $\mu = r_f$.[19] Finally, in the last step from C^{MRP} to C^{RS}, we reduce volatility from σ_P to σ_I.

Table 4 shows that the leverage effect S_L increases both with risk aversion γ and with the CEO's investment in the market portfolio ω.[20] The risk-premium is larger if CEOs are more risk averse or if they have invested more wealth in the market portfolio, and consequently the change in the risk-premium from adjusting the strike price is larger (see Hall and Murphy, 2002, and especially their Figure 1). In absolute terms, efficiency gains are moderate, with 3% for $\gamma = 1$, but they become more sizeable for $\gamma = 2$ or $\gamma = 3$ when they are approximately 6% or 8%, respectively.

The market-risk-premium effect S_{MRP} is negative and substantial: On average it is around 14% for $\gamma = 1$, 6% for $\gamma = 2$, and 3% for $\gamma = 3$.[21] While the market premium

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[19]The options in C^{MRP} are written on an underlying asset with systematic risk but without risk-premium. This asset therefore violates the no-arbitrage assumption, because arbitrageurs could earn a risk-free profit from going long in the asset with risk premium and short in the asset without risk premium. We therefore assume that the options in C^{MRP} are a bonus contract that is based on an observable signal $P_T = P_0 exp\left\{\left(r_f - \frac{\sigma_P^2}{2}\right)T + u\sigma_P\sqrt{T}\right\}$ and that pays out $max\{P_T - P_0 exp\{(r_f - d)T\}, 0\}$.

[20]The leverage effect increases in ω only for $\omega \leq 0.75$ in Table 4. We ignore the results for $\omega = 1$ due to the numerical problems discussed above.

[21]The market-risk-premium effect is positive for 2.7% of our CEOs for whom $\beta < 0$. For these CEOs, the

is the same in all cases, its certainty equivalent depends on the CEO's risk-aversion, because the term that contains the market risk premium $exp\left\{\left(\mu_P - \frac{\sigma_P^2}{2}\right)T\right\}$ is multiplied with the term that contains the noise $exp\left\{u_P\sigma_P\sqrt{T}\right\}$. The more noisy the payout or the more risk-averse the CEO, the lower is the subjective value of the market risk premium.

The noise-reduction effect S_{NR} is positive and ranges on average between 7% and 11%. As expected, this effect increases with the CEO's investment ω in the market portfolio. Theory also predicts that the sum of the market-risk-premium effect and the noise-reduction effect increases with risk-aversion and Table 4 shows that this is indeed the case. The sum of the two effects for $\omega = 0.5$ is -3.14% for $\gamma = 1$, 3.05% for $\gamma = 2$, and 5.2% for $\gamma = 3$. Here, a negative value indicates that CEOs on average desire a higher exposure to market risk and therefore suffer a utility loss from indexation that needs to be compensated by higher fixed salary.

The noise-reduction effect S_{NR} decreases as CEOs become more risk-averse in Table 4. The reason is that our decomposition is additive and that we remove the market-risk-premium effect first. The interaction between the market-risk-premium and the noise-reduction effects is therefore contained in S_{MRP} as shown in Table 4.

4.4 Efficiency gains from restoring incentives

Table 4 demonstrates that indexation destroys incentives on average. There are two reasons for this result. First, CEOs' utility is in general not the same for the indexed contract as it is for the observed contract. Adjusting the fixed salary to ensure participation constitutes a wealth effect that affects incentives. The second reason is that indexation reduces the dispersion of CEOs' utility levels. We call this effect the background-risk effect in line with related literature in insurance and risk management (see for example Gollier and Pratt, 1996). Figure 1 illustrates both effects for a single CEO for whom they are extreme. The figure shows the distribution of the CEO's terminal wealth once for the observed contract C^d

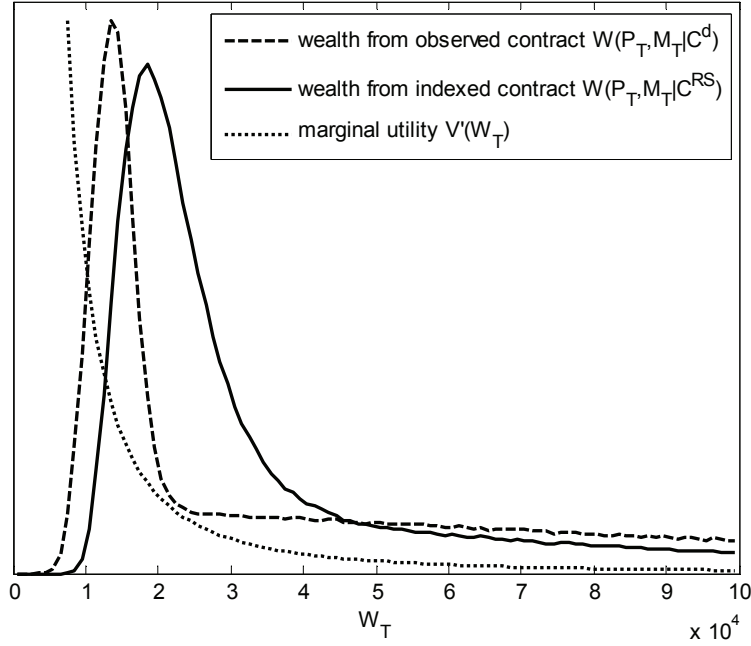---

noise-reduction effect S_{NR} is negative.

Figure 1: Background-risk effect. The figure shows two probability density functions of CEO wealth . $W(P_T, M_T|C^d)$ is the wealth under the observed contract C^d where $\psi = 0$, and $W(P_T, M_T|C^{RS})$ is the wealth under the indexed contract C^{RS} with $\psi = 1$. The contract C^{RS} holds CEO utility - but not CEO incentives - constant. Therefore, the two contracts do not implement the same effort. We have simulated both distributions by drawing 1,000,000 pairs (P_T, M_T) from a bivariate exponential distribution. The figure also shows the CEO's marginal utility $V'(W_T)$. The parameters are $\gamma = 2$, $\omega = 0.5$, $W_0 = \$6.8m$, $\phi = \$1.1m$, $n_S = 0.13\%$, $n_O = 2.05\%$, $P_0 = \$4.90bn$, $\sigma = 29.4\%$, $\beta = 1.28$, $d = 0$, $r_f = 4.35\%$, and $T = 4.6$.

and once for the indexed contract C^{RS} before restoring incentives but after restoring utility. The plot also shows marginal utility $V'(W_T)$.[22]

The indexation of options has three consequences for the distribution of payouts, where the first two consequences are linked to the background-risk effect while the third consequence is due to the wealth effect. First, very high payouts are replaced by more moderate payouts as indexation removes favorable market movements; this consequence increases expected marginal utility. Second, unfavorable market movements are also removed, so that indexed

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[22]The correct figure would be three-dimensional and would plot $E\left(\frac{dV(W_T)}{dP_0}\right)$ against P_T and M_T instead of $E\left(\frac{dV(W_T)}{dW_T}\right)$ against W_T. The figure only serves as an illustration that helps readers to develop an intuition for the background-risk effect.

options are more likely to end up in the money. This consequence shifts low payouts towards moderate payouts and therefore lowers expected marginal utility. For the worst outcomes with highest marginal utility, however, indexed options are also likely to be out of the money and therefore not to affect CEO wealth. These two consequences are caused by the background-risk effect, i.e. by the reduced dispersion of utility levels. The third consequence is due to the wealth effect: fixed salary needs to be adjusted to make CEOs indifferent between the two contracts. For the majority of CEOs, the indexed contract results in lower utility than the observed contract, so that fixed salaries must be raised and the wealth distribution under indexation shifts to the right. This shift which can be clearly seen in Figure ?? decreases incentives. For a minority of CEOs, fixed salaries may be lowered as CEOs attach higher utility to indexed contracts. They do so in particular when their assumed risk-aversion γ is high: For $\gamma = 3$ and $\omega = 0.5$, 12% of the CEOs in our sample accept a cut in their fixed salary (result not shown in the tables). The sum of these three effects is negative for the CEO shown in Figure 1, i.e. incentives are destroyed. However, it is also possible that the net effect is positive and that incentives are created.

When does indexation increase incentives? We numerically calculate the marginal increase in $UPPS$ from a change in the degree of indexation ψ for $\gamma = 0$, $\omega = 0.5$, and $\psi = 0$. Table 8 displays mean and median of several key variables in our dataset when we split the sample according to the sign of $\frac{dUPPS}{d\psi}$. A proportion of 24.6% (176 out of 716) CEOs have such a marginal increase in $UPPS$. The table also shows mean and median efficiency gains from mandatory indexation ($\psi = 1$) as well as optimal indexation ($\psi = \psi^*$). Moreover, it shows mean and median of the optimal degree of indexation ψ^*.

[Insert Table 5 here]

The table reveals substantial differences between the two subsamples. Mean and median efficiency gains from mandatory indexation are small and negative when indexation destroys incentives but positive and much more substantial otherwise. Efficiency gains from optimal

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indexation cannot become negative by construction. They are virtually zero when indexation destroys incentives while they reach 10.5% on average and 8.9% in the median when indexation generates incentives. Consistently, the average optimal degree of indexation ψ^* is 20.6% when incentives are destroyed compared to 77.9% when incentives are generated. For the typical CEO, $\psi^* = 0$ if incentives are destroyed and $\psi^* = 89.0\%$ when incentives are generated.

Table 5 reveals that a main determinant of whether or not indexation increases incentives is the size of the CAPM β. The average β is 0.829 when indexation destroys incentives compared to 1.874 when indexation creates incentives. Moreover, firms for which indexation creates incentives have somewhat higher indiosyncratic volatility σ_I, higher option holdings n_O^d, a substantially lower certainty equivalent CE, and a shorter maturity T. The certainty equivalent CE includes the CEO's non-firm wealth W_0 so that it can be seen as subjective end-of-period wealth. For given constant relative risk aversion γ, the certainty equivalent can therefore be interpreted as a measure of absolute risk aversion. Hence, Table 5 demonstrates that indexation is more likely to create incentives if the CEO is more risk-averse.

Table 5 shows that the number of options is high when incentives are created. This result is intuitive. We saw in Figure **??** that indexation moves probability mass from the tails of the distribution to its center. If compensation is strongly convex (i.e., if option holdings are high), there is a fat right tail and a thin left tail. For the right tail, the redistribution of probability mass creates incentives whereas incentives are destroyed by the redistribution from the left tail. Hence, the more convex compensation is, the more likely it is that the net effect creates incentives.

The efficiency gains S_{RS} in the first stage of our decomposition also affect whether indexation creates incentives and generates efficiency gains S_I in the second stage. A positive efficiency gain S_{RS} implies that the CEO is better off with indexation and accepts a salary cut. This cut then translates into a shift of the wealth distribution in Figure **??** to the left towards higher values of marginal utility. The correlation between S_{RS} and S_I is significantly

negative, however (not shown in the tables). This finding demonstrates that the effects in Figure ?? are not independent of one another.

We conclude that efficiency gains from indexation are small for the majority of CEOs in our sample where indexation destroys incentives. For a minority of CEOs (a quarter for $\gamma = 2$ and $\omega = 0.5$), however, indexation creates incentives and then leads to substantial efficiency gains. Our results suggest that indexation is worthwhile for CEOs with strong risk aversion and substantial option holdings who work in firms with above-average systematic risk.

4.5 Efficiency gains at the optimal level of indexation

Figure ?? shows net efficiency gains and their components as a function of the degree of indexation ψ. The plot is typical for the majority of the CEOs in our sample. The individual components of the efficiency gains are large in absolute value for $\psi = 1$ (mandatory indexation) but the net effect is small. The optimal degree of indexation for this CEO is $\psi^* = 58\%$ and generates efficiency gains of only 2.7%. At this point, the individual components of the efficiency gains are also considerably smaller than at $\psi = 1$.

4.6 Robustness check: Varying the market risk premium

Standard options carry a risk-premium because they represent a levered investment in the stock market, whereas indexed options do not. Our decomposition of net efficiency gains above also contains a component that we attribute to the market-risk-premium effect. Due to nonlinearities, however, this component is an approximation only. In this subsection, we therefore consider a robustness check where we switch off the market-risk-premium effect by setting $MRP = 0$. This adjustment of our modeling assumptions causes a mechanical wealth effect for the CEO relative to the baseline scenario in which the company's stock earns a risk premium. Setting expected returns equal to r_f reduces CEOs' end-of-period wealth and increases their absolute risk aversion, which in turn affects optimal indexation from
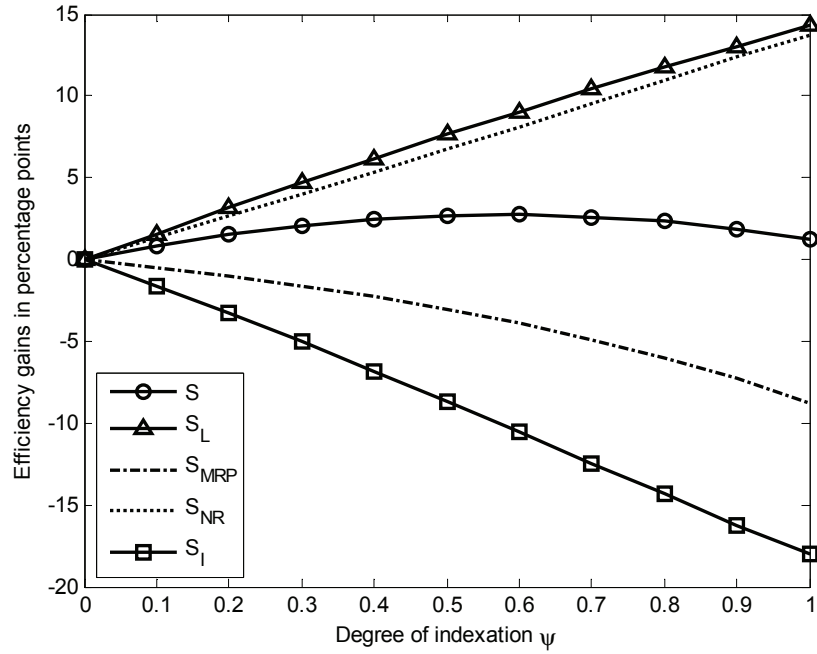
Figure 2: Decomposing Savings. The figure shows efficiency gains $\left(\pi^d - \pi^*\right)/\pi^d$ and their components for one individual CEO as functions of the degree of indexation ψ. The solid line with circles represents net efficiency gains S, the solid line with triangles the gains from the leverage effect S_L, the dashed line the gains from the market-risk-premium effect S_{MRP}, the dotted line the gains from the noise-reduction effect S_{NR}, and the solid line with squares the gains from the incentive effect S_I. The parameters are $\gamma = 2$, $\omega = 0.5$, $W_0 = \$19.8m$, $\phi = \$m$, $n_S = 0.14\%$, $n_O = 0.52\%$, $P_0 = \$12.1bn$, $\sigma = 15.4\%$, $\beta = 1.08$, $d = 0$, $r_f = 4.35\%$, and $T = 7.0$.

the results in Table 2. We therefore adjust the wealth of CEOs by assuming a higher base salary, so that their expected utility under the zero-risk-premium scenario is equal to their expected utility in the baseline scenario. More formally, we set $EU(V(W_T)|MRP = 4\%) = EU(V(W_T)|MRP = 0)$ by adjusting ϕ. We compute optimal contracts as before and define the incentives of observed contracts by evaluating them under the changed assumptions about MRP and ϕ.

[Insert Table 6 here]

Table 6 displays the results from setting MRP to zero for all CEOs while adjusting their base salaries so as to keep their expected utility constant. The construction of Table 6 is exactly the same as that of Table 2. The average degree of optimal indexation increases to 90.43% ($\gamma = 2$, $\omega = 0.5$) from 34.57% for the baseline case, but is still well below 100%. The savings from indexation increase by almost the same factor, or about 150%.A positive market risk premium reduces CEOs' benefits from indexation and results in the negative efficiency gains S_{MRP} shown in Table 4. If the market risk premium is lowered, CEO's optimal exposure ω^* to market risk also decreases, because the costs of such an exposure remain constant while the benefits decrease. With a zero market risk premium the CEO desires full indexation $\omega^* = 1$, because an investment in the market does not yield any benefits anymore. That CEOs desire full indexation if $\mu_M = 0$ can also be seen in Table 4 where the efficiency gains from the leverage effect S_L and from the noise-reduction effect S_{NR} are both positive and increase with the degree of indexation (as long as $\beta > 0$). The median degree of indexation in Table 6 is indeed 100% in all cases, but the average degree of indexation is significantly smaller than 100%. The reason is that indexation destroys incentives and that efficiency losses from restoring incentives outweigh efficiency gains from more efficient risk sharing for some CEOs.

Panel B of Table 6 reports results for four different levels of the market risk premium μ_M, which is set to zero, 2%, 4%, and 6%. The optimal degree and the benefits from indexation both decline with the assumed reward for market risk. The optimal exposure to stock market

risk depends on the assumed risk premium, so that a higher risk premium results in higher costs from indexation.

The market-risk-premium effect only applies if indexing removes risk that is priced. It does not apply to benchmarks that do not carry a risk premium, which may be the case for benchmarks related to commodity risk or exchange rate risk. Our analysis therefore shows that indexation with respect to risk that is not priced is more beneficial than indexation with respect to risk that carries a risk premium.

Many proponents of indexed options argue that the firm can save the market premium (see, e.g., Rappaport and Nodine (1999), and Bebchuk, Fried, and Walker (2002)). However, in a model with a binding participation constraint, i.e., with a binding outside option, the CEO attaches a higher value to standard options compared to indexed options and must be compensated for any loss from indexation. To address their argument, we now turn to a variant of our model where shareholders can use indexed options to recover rents.

5. Indexation of pay when shareholders can recover rents

Proponents of indexed options see the lack of relative performance evaluation and the apparent prevalence of "pay for luck" as evidence for the rent-extraction view of executive compensation. From this point of view the previous analysis is not convincing because it assumes a binding participation constraint. By contrast, the rent-extraction view suggests that CEOs do not have any outside opportunities that allow them to accept alternative employments if their utility through indexation would be reduced. We therefore interpret the rent-extraction view as saying that the participation constraint does not bind.

It is not clear how the perspective of the rent-extraction view should be modeled. The main tenet of the this view is that CEOs extract rents in the form of hidden compensation, which could be recovered through better structured contracts. From the point of view of our model, the main assumption is that CEOs' outside options do not provide binding constraints on contracts. We therefore proceed by performing the same analysis as above

under the assumption that CEOs' participation constraints do not bind. Hence, a reduction in utility from indexation will not be compensated through an increased base salary. Instead, we assume that base salaries are given and fixed at their observed levels. However, we need to adjust the number of shares in order to be able to satisfy the incentive compatibility constraint.

There are two alternative modeling strategies of the rent extraction view that we considered and ultimately dismissed. Our first alternative would model negotiations between shareholders and the CEO as a Nash bargaining game where the CEO has all the bargaining power. The results from such a game would not be much different from efficient contracting because Nash bargaining leads to efficient contracts. These contracts would be similar to the ones we obtain in the previous section, only that CEOs extract higher payoffs, mostly through higher fixed salaries. Indexation and the structure of contracts would be affected only through the associated wealth effects and the insights from such an exercise would be limited.

The second alternative would cap the rents we assume by some measure, for example as a percentage of observed compensation. This modeling choice would be more realistic, since rents are probably not arbitrarily large, but calibrating such a constraint correctly would require an accurate measure of how large the rents CEOs can extract actually are. Moreover, as soon as such a cap would become binding the analysis would revert to the analysis in the previous section with binding participation constraints. We therefore prefer the more extreme assumption here, which provides an upper bound on the benefits from indexation.

Our approach leads us to overstate the benefits from indexation for two reasons. First, the participation constraint is probably binding for some CEOs but not for others. Bertrand and Mullainathan (2001) argue that the use of relative performance evaluation is correlated with the quality of corporate governance. We still drop the participation constraint for all CEOs in our sample and not just for the CEOs with poor corporate governance quality.

Second, some options may in fact be indexed, whereas we assume that all options reported in ExecuComp are not indexed, as explained above.

[Insert Table 7 here]

Table 7 reports the results from minimizing the costs of the contract subject to the incentive compatibility constraint for $\gamma = 2$. Optimization is only with respect to the degree of indexation, ψ, and with respect to the number of shares, n_{SR}. Base salaries and option holdings are fixed at their observed levels, ϕ^d and n_O^d, respectively. Shareholdings are flexible so that they can be increased, but they cannot be reduced. This constraint may appear somewhat artificial, but we will relax it below and show that this provision isolates the gains from indexation from gains that shareholders can achieve through the reduction of restricted stock. Only options are indexed, so that the analysis parallels that of Table 2. The structure of Table 7 is the same as that of Table 2 for the case with binding outside options.

Three features stand out from Table 7 in comparison to Table 2. First, savings increase relative to the efficient contracting case, from 2.29% to 4.73% of compensation costs for $\omega = 0$, and from 4.57% to 5.33% of compensation costs for $\omega = 1$. Second, for all CEOs for whom $\psi = 0$, contracts do not change at all and this fraction varies between 66.71% for $\omega = 1$ and 76.89% for $\omega = 0$. Finally, optimal indexation is lower in the rent extraction case than in the efficient contracting case, in particular for higher levels of CEOs' investment in the stock market.

Taken together these observations create a surprising picture. Optimal indexation is reduced while the savings from indexation increase. The distribution of gains is very skewed because only a small fraction of CEOs, about 23% to 33%, would optimally have indexed contracts, but for this minority the average gains from indexation are very large.

[Insert Table 8 here]

We investigate these results further and perform the same sample split for the rent extraction case as we did in the efficient contracting case and distinguish the group of CEOs

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for whom incentives increase with indexation from those for whom incentives decline with indexation. The two groups are identical as the computation of $\frac{\partial UPPS^d}{\partial \psi}$ is the same, independently of whether the participation constraint is binding or not. Overall, the results are qualitatively similar, but quantitatively more extreme in the rent-extraction case than they are in the efficient-contracting case. In the rent-extraction case, the gains from indexation are larger for the minority of CEOs for whom indexation increases incentives (mean is 17.93%, only 10.49% for efficient contracting), but they are smaller for the group of CEOs for whom incentives are destroyed through indexing (0.18% compared to 0.66%). Since the groups of CEOs are the same as in the efficient contracting, the same interpretation applies and we therefore refer to our detailed discussion of Table 5 above.

In the rent-extraction case we have a group of CEOs for whom the incentive compatibility constraint is slack so that incentives for the optimal contract are strictly higher than those for the observed contract. We find that for our baseline case, 12.6% of the CEOs have a slack incentive compatibility constraint, and their average savings from indexation are 25.2%, whereas average savings of the complement set of CEOs with binding incentive compatibility constraint is only 1.3% (these results are not tabulated). Hence, for about one eighth of the CEOs in our sample, indexing options simultaneously increases incentives and reduces the costs of their contracts so that for these CEOs, rents can be recovered through indexation. Note that our analysis underestimates the benefits to shareholders, because we only calculate the reduction of compensation costs and not the increase in firm value through improved incentives.

The discussion of the rent-extraction view based on Table 7 assumes that stockholdings are downward rigid. We now relax this assumption and repeat the analysis with exactly the same assumptions as before except that restricted stock is fully flexible, i.e., we only require that $0 \leq n_{SR} \leq 1$. Table 9 shows the results for this case and adopts the same formats as Tables 2 and 7.

[Insert Table 9 here]

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Gains for shareholders. Several features stand out in Table 9. For the benchmark case where $\gamma = 2$, savings from recontracting are larger compared to the case with downward rigid stockholdings in Table 7 by a factor of about 4. However, surprisingly, these larger savings are not mirrored by a correspondingly higher degree of indexation. The optimal degree of indexation about doubles from 20% to 43%, and the number of CEOs for whom indexation is zero remains at around 44%. Finally, restricted stock holdings decline by about 75%. The gains from recontracting are therefore large, but most of these gains do not seem to originate from the indexation of options, but from the reduction of shareholdings.

The overexposure effect. The finding that average stockholdings can be reduced by 75% is remarkable given that we require that the optimal contract maintains incentives at their observed level. Moreover, the fact that indexation creates incentives for a minority of CEOs cannot account for this finding given that these benefits were already available in the previous analysis with downward rigid stockholdings.

Instead, we propose that for many CEOs in our sample, incentives decline with increasing stockholdings. To derive this result more formally, we focus on the simplified case of a CEO who has no private investment in the stock market ($\omega = 0$) and who does not receive any option grants ($n_O = 0$). This assumption simplifies the analysis and allows us to derive a straightforward analytic result. We measure incentives by the utility-adjusted pay-for-performance sensitivity $UPPS = \frac{dE(U(W_T))}{dP_0}$. Then we can analytically show the following result:

> **Proposition 1 (Overexposure effect):** *For any CEO, UPPS decreases with n_S iff*
>
> $$E\left[(W_T - \gamma n_S P_T) h(P_T)\right] < 0, \tag{20}$$
>
> *where $h(P_T) = \frac{dP_T}{dP_0} W_T^{-(\gamma+1)}$. Therefore, there exists some upper bound $\overline{n}_S$ so that UPPS decreases with n_S for all $n_S > \overline{n}_S$.*

We call CEOs whose shareholdings are so large that additional shares reduce their incentives

overexposed. From condition (20), CEOs will be overexposed if, in expectation, their stock-holdings multiplied by γ are larger than their non-firm related wealth, where expectations are defined with respect to the weighting function $h(P_T)$. Overexposure therefore increases with relative risk aversion and decreases with non-firm wealth.

The overexposure effect is unique to a setting where CEOs extract rents and where their participation constraints do not bind. In such a setting, an increase in stockholdings has two effects. The first, direct effect is to tie CEOs' wealth to their performance, which increases incentives. The second, indirect effect is a wealth effect: Additional shares for the CEO increase her wealth and therefore decreases her marginal utility and her incentives. The second effect is absent in standard contracting models with a binding participation constraint. If the participation constraint is binding, then any change in the CEO's shareholdings is matched by an opposite change in another compensation component so as to keep the CEO's expected utility constant. As a result, there can be no wealth effect with efficient contracting, but there can be significant wealth effects if shareholders can recover rents.

6. Indexation of restricted stock

So far, our analysis has considered the indexation of options when stock were not indexed. In this section, we consider the opposite case that stock is indexed but options are not. Our analytic tools cannot determine optimal levels of indexation for stock and options independently, because indexing stock and indexing options are very close substitutes. There are many combinations of the degrees of indexation for stock and options that are approximately equivalent with respect to the objective function we maximize. The CEO's wage therefore is given by

$$\pi_T = \phi e^{r_f T} + n_S \left(\psi P_T^{indx} + (1 - \psi) P_T \right) . + n_O max \left\{ P_T - K, 0 \right\}.$$

While restricted stock without indexation earns a return P_T/P_0, indexed stock filters out the systematic component, so the return on indexed stock is $(P_T/H_T)\,e^{r_f T}$.

$$P_T^{indx} = P_0 \frac{P_T}{H_T e^{-r_f T}}.$$
(21)

In the appendix we show that the terminal value of indexed stock can be written analogously to (6) as:

$$P_T^{indx} = P_0 exp\left\{ \left(r_f - \frac{\sigma_I^2}{2} \right) T + u_I \sigma_I \sqrt{T} \right\}.$$
(22)

$$\text{where: } \sigma_I = \sigma_P \sqrt{1 - \rho^2},$$
(23)

$$u_I = (u_P \sigma_P - u_M \rho \sigma_P)/\sigma_I.$$
(24)

We still solve program (15) to (18) where the only difference to previous parts it that ψ refers to the proportion of stock rather than options that is indexed. We index only restricted stock and not unrestricted stock because unrestricted stock is CEOs' property and therefore not part of their compensation package. The results are shown in Table 10.

[Insert Table 10 here]

Several salient features emerge from Table 10. With values between 14.47% and 53.85% for $\gamma = 2$, optimal indexation is mostly lower than for the indexation of options and the proportion of firms without any indexation is often significantly higher. The savings from indexation range between 0.20% and 1.57% and are therefore much smaller than the corresponding values for the indexation of options. Finally, the percentage of CEOs for whom one of the constraints on ψ is binding is large, so that only about 5%-12% of the CEOs have strictly intermediate values for the optimal degree of indexing. Accordingly, median values of ψ are always zero.

7. Discussion and conclusion

We calibrate a standard contracting model that allows for the indexation of stock options or stock. We show how optimal contracts change with indexation and derive the gains to shareholders for a large sample of US CEOs. The main result is that the benefits from indexation are small, even if we grant the assumptions of the rent extraction view.

The key insight of the analysis is that indexing contracts often reduces incentives. The vulnerability to stock market risk increases CEOs' incentives as long as we assume preferences that feature decreasing absolute risk aversion and compensation contracts that are not too convex. Then indexing compensation reduces CEOs' vulnerability to stock market risk and therefore their incentives. In addition, we note that indexed options also have lower risk-neutral deltas and therefore a lower pay-for-performance sensitivity than conventional options. The combined impact of indexation on risk-neutral pay-for-performance sensitivity and the background-risk effect is therefore often negative.

If CEOs extract rents, then shareholders can evidently gain from adjusting contracts if they could bring themselves into a situation where they can recover these rents. However, very little of these recaptured rents would come from indexation. For most of the CEOs the negative effect of indexation on incentives dominates and for these CEOs, indexing contracts does not allow shareholders to recover rents. Most if not all of the benefits from indexation come from improved risk-sharing between the CEOs and shareholders, but these considerations are not important from the perspective of the rent-seeking view. However, for a small number of CEOs with sufficiently large option exposure, the background-risk effect reverses because the convexity of the compensation contract outweighs the concavity of the utility function. For these CEOs, indexing options simultaneously improves incentives and reduces compensation costs. Similarly, indexing shares generally improves incentives because delta of shares is not affected by the volatility of the firm's assets.

Shareholders may recover much larger rents if they could reduce excessive stock holdings. If the outside option of the CEO is not binding because the CEO extracts rents, then

the wealth effect from recovering these rents makes the CEO poorer, increases her marginal utility, and therefore also her incentives. This overexposure effect offers an important perspective on the rent-extraction view. Proponents of the rent-extraction view are particularly critical of hidden components of fixed pay such as forgivable executive loans or pensions, which are not related to performance, while they generally agree with equity-based pay. Our analysis shows that this distinction may be unwarranted because the wealth-effect from additional stockholdings can be just as detrimental to incentives as the wealth-effect from fixed compensation. Overall, we conclude that the apparent lack of indexed contracts provides therefore no evidence in favor of the rent extraction view.

Our results also show that the model behaves differently if we permit shareholders to recover rents from CEOs compared to the case of efficient contracting. We therefore show as a byproduct of our research that conclusions that can be derived from efficient contracting models do not generally hold in a world where CEOs can extract rents. Efficient contracting models can therefore also not offer normative conclusions for how shareholders can best recover rents from CEOs. Our modeling strategy for the rent-extraction case is arguably *ad hoc* and we briefly discuss alternative modeling strategies above. More research is needed here to fill this gap and to derive predictions on which contracting results we should expect if contracting is not efficient.[23]

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[23]The only attempt in this direction we are aware of is Kuhnen and Zwiebel (2007).

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Appendix

Derivation of equation (??):

We rewrite P_T/H_T in (??) as

$$\frac{P_T}{H_T} = \frac{P_T^{ex}}{H_T^{ex}} = exp \times \left\{ \left(\mu_P - \frac{\sigma_P^2}{2} \right) T + u_P \sigma_P \sqrt{T} \right\} \tag{25}$$

$$\times \left\{ - \left(\mu_M - \frac{\sigma_M^2}{2} \right) \beta T - u_M \beta \sigma_M \sqrt{T} \right\} \times exp \left\{ -(1-\beta) \left(r_f + \frac{1}{2} \rho \sigma_M \sigma_P \right) T \right\}$$

We collect terms and observe that $\mu_P - \beta \mu_M = r_f(1-\beta)$ from the CAPM equation (8). Then the terms in μ_P and μ_M cancel against $(1-\beta)r_f$. Also, we can use $\beta \sigma_M = \rho \sigma_P$ from the definition of β to obtain:

$$-\frac{\sigma_P^2}{2} + \frac{\sigma_M^2 \beta}{2} - \frac{(1-\beta)\rho \sigma_M \sigma_P}{2} = -\frac{\sigma_P^2 - \sigma_P^2 \rho^2}{2}.$$

Then:

$$\frac{P_T}{H_T} = exp \left\{ -\frac{\sigma_P^2(1-\rho^2)}{2} T + (u_P \sigma_P - u_M \rho \sigma_P) \sqrt{T} \right\}. \tag{26}$$

Using (??) and (??) in (26) and inserting the resulting expression into (??) gives (??).

Proof of Proposition 1:

The CEO's wealth is given by:

$$W_T = (W_0 + \phi)((1-\omega)e^{r_f T} + \omega \frac{M_T}{M_0})e^{r_f T} + n_O max(P_T - K, 0) + n_S P_T. \tag{27}$$

For the incentives, we have

$$
UPPS = \frac{dE(U(W_T))}{dP_0} = E\left(\frac{dU(W_T)}{dP_0}\right) = E\left(W_T^{-\gamma}\frac{dW_T}{dP_0}\right)
$$

$$
= E\left(\frac{n_S\frac{dP_T}{dP_0}}{\left[(W_0+\phi)((1-\omega)e^{r_f T} + \omega\frac{M_T}{M_0})e^{r_f T} + n_O max(P_T - K,0) + n_S P_T\right]^{\gamma}}\right). \quad (28)
$$

This implies

$$
\begin{aligned}
\frac{dUPPS}{dn_S} &= E\left(\frac{d}{dn_S}\left[\frac{n_S\frac{dP_T}{dP_0}}{W_T^{\gamma}}\right]\right) \\
&= E\left(\frac{\frac{dP_T}{dP_0}W_T^{\gamma} - \gamma P_T W_T^{\gamma-1}n_S\frac{dP_T}{dP_0}}{W_T^{2\gamma}}\right) \\
&= E\left(\frac{dP_T}{dP_0}\frac{W_T - n_S\gamma P_T}{W_T^{\gamma+1}}\right) \quad (29) \\
&= E\left((W_T - n_S\gamma P_T)\,h(P_T)\right) \quad (30)
\end{aligned}
$$

where $h(P_T) = W_T^{\gamma+1}\frac{dP_T}{dP_0}$, which derives condition (20). From (29) we obtain ($\frac{dW_T}{dn_S} = P_T$):

$$
\frac{d^2UPPS}{dn_S^2} = E\left(\frac{dP_T}{dP_0}\frac{(P_T - \gamma P_T)W_T^{\gamma+1} - P_T(1+\gamma)W_T^{\gamma}}{W_T^{2(\gamma+1)}}\right)
$$

$$
= E\left(\frac{dP_T}{dP_0}\frac{P_T(1-\gamma)W_T - P_T(1+\gamma)}{W_T^{\gamma+2}}\right).
$$

The last condition is negative for all $\gamma > 1$, hence some cutoff $\overline{n}_S$ must exist.

TABLE 1

Description of the Dataset

This table contains descriptive statistics for the variables in our dataset. Share holdings and option holdings are based on end of year 2005 values from ExecuComp. Option holdings, n_O, are computed following the method of Core and Guay (2002). The number of restricted shares, n_{SR}, unrestricted shares, n_{SU}, and options are scaled by the total number of shares outstanding and presented as percentages. Base salary, ϕ, is the sum of salary, bonus, and "other compensation" from ExecuComp. The value of the CEO pay contract, π, is the sum of base salary, restricted and unrestricted shares and options. CEO outside wealth, W_0, is estimated based on past income over at least 5 years reported in ExecuComp. The market capitalization is measured at the end of 2005. Volatilities and beta for each firm are estimated based on five years of monthly CRSP returns.

Variable	Symb.	Mean	Median	S.D.	Min.	25th Perc.	75th Perc.	Max.	N
Shares (res.)	n_S	0.13%	0.02%	0.35%	0.00%	0.00%	0.12%	4.38%	755
Shares (unres.)	n_{SU}	1.74%	0.23%	5.04%	0.00%	0.07%	0.81%	50.58%	755
Options	n_O	1.49%	1.02%	1.79%	0.00%	0.45%	1.87%	23.53%	755
Base salary ($K)	ϕ	1,616	1,043	4,393	0	724	1,502	105,534	755
Contract ($M)	π	30.76	13.12	55.18	0.00	5.25	32.16	632.47	755
Wealth ($M)	W_0	63.83	13.49	654.87	0.05	6.13	33.36	17,700.00	755
Firm value ($M)	P_0	9,163	2,318	22,400	13	960	7,569	266,000	755
Maturity	T	8.14	6.17	6.47	0.11	4.51	9.11	58.07	755
Div. yield	d	1.24%	0.61%	2.24%	0.00%	0.00%	1.81%	41.23%	755
Tot. volatility	σ_P	38.82%	33.78%	18.93%	12.50%	25.36%	47.99%	155.21%	755
Mkt. volatility	σ_M	15.47%	15.41%	0.51%	13.47%	15.41%	15.41%	17.00%	755
Idio. volatility	σ_I	34.12%	30.52%	16.19%	12.25%	22.38%	41.60%	153.99%	755
Beta	β	1.08	0.89	0.82	-0.39	0.50	1.46	4.86	755

TABLE 2

Indexing Options: The Efficient Contracting Case

This table shows our results for the case in which the firm chooses the degree of indexation of options, ψ, fixed salary ϕ, and number of restricted shares n_{SR}. The firm's objective is to minimize contracting costs subject to the two constraints that the new contract provides the CEO (1) with at least the same utility as the observed contract, and (2) with at least the same effort incentives as the observed contract. Panel A shows our results for $\gamma = 1$, Panel B for $\gamma = 2$, Panel C for $\gamma = 3$, and Panel D for $\gamma = 6$. Each panel shows the mean of the parameters across CEOs for five different values of the CEO's investment in the market portfolio ω. The table also shows the average savings the new contract generates as a percentage of the observed value of the CEO's contract. Base salary is given in thousand dollars. All other variables except γ and ω are percentages.

TABLE 2 (Continued)

Indexing Options: The Efficient Contracting Case

Panel A: Results for $\gamma = 1$

						Mean		Median		
γ	ω	ϕ	n_{SR}	$\psi = 0$	$\psi = 1$	ψ	S	ψ	S	N
1	0.00	1,603	0.186	87.85	1.40	6.01	0.32	0.00	0.00	716
1	0.25	1,610	0.173	87.41	1.40	6.46	0.35	0.00	0.00	715
1	0.50	1,621	0.162	86.64	1.41	6.99	0.38	0.00	0.00	711
1	0.75	1,633	0.152	85.49	1.55	7.59	0.43	0.00	0.00	710
1	1.00	1,643	0.145	84.66	1.59	8.11	0.47	0.00	0.00	691

Panel B: Results for $\gamma = 2$

						Mean		Median		
γ	ω	ϕ	n_{SR}	$\psi = 0$	$\psi = 1$	ψ	S	ψ	S	N
2	0.00	1,295	0.168	58.18	9.93	26.40	2.29	0.00	0.00	715
2	0.25	1,283	0.169	53.63	11.59	29.62	2.63	0.00	0.00	716
2	0.50	1,269	0.174	46.71	13.99	34.57	3.08	10.35	0.03	715
2	0.75	1,280	0.181	40.87	18.96	41.64	3.70	32.58	0.37	712
2	1.00	1,266	0.186	31.95	26.25	50.94	4.57	60.69	1.01	701

Panel C: Results for $\gamma = 3$

						Mean		Median		
γ	ω	ϕ	n_{SR}	$\psi = 0$	$\psi = 1$	ψ	S	ψ	S	N
3	0.00	967	0.192	30.63	27.55	51.82	5.25	59.10	1.50	715
3	0.25	961	0.196	25.59	33.43	59.28	6.10	73.79	2.46	715
3	0.50	984	0.200	17.79	43.70	70.29	7.30	91.83	4.25	714
3	0.75	1,002	0.200	9.83	64.47	82.51	8.87	100.00	6.46	712
3	1.00	1,223	0.187	5.17	84.20	91.36	10.96	100.00	8.77	696

Panel D: Results for $\gamma = 6$

						Mean		Median		
γ	ω	ϕ	n_{SR}	$\psi = 0$	$\psi = 1$	ψ	S	ψ	S	N
6	0.00	1,112	0.163	7.64	65.85	84.50	11.88	100.00	10.56	694
6	0.25	1,280	0.153	3.78	83.11	93.12	13.94	100.00	12.96	687
6	0.50	1,471	0.137	1.75	95.05	96.85	15.94	100.00	15.21	687
6	0.75	1,518	0.121	1.30	96.39	97.64	17.70	100.00	16.88	693
6	1.00	1,617	0.115	1.15	97.84	98.33	19.21	100.00	18.54	693

TABLE 3
Mandatory Indexing

This table shows our results for the case in which the the degree of indexation of options is constraint to $\psi = 1$. Firms can choose fixed salary ϕ, and number of restricted shares n_{SR}. The firm's objective is to minimize contracting costs subject to the two constraints that the new contract provides the CEO (1) with at least the same utility as the observed contract, and (2) with at least the same effort incentives as the observed contract. Panel A shows our results for $\gamma = 1$, Panel B for $\gamma = 2$, and Panel C for $\gamma = 3$. Each panel shows the mean of the parameters across CEOs for five different values of the CEO's investment in the market portfolio ω. The table also shows the average savings the new contract generates as a percentage of the observed value of the CEO's contract. Base salary is given in thousand dollars. All other variables except γ and ω are percentages.

Panel A: Results for $\gamma = 1$

γ	ω	ϕ	n_{SR}	Mean ψ	Mean S	Median ψ	Median S	$S > 0$	N
1	0.00	-5,634	0.475	100.00	-8.19	100.00	-7.62	6.53	704
1	0.25	-4,129	0.453	100.00	-7.70	100.00	-7.01	7.18	696
1	0.50	-2,759	0.431	100.00	-7.20	100.00	-6.48	7.61	696
1	0.75	-1,314	0.411	100.00	-6.66	100.00	-5.92	8.22	681
1	1.00	1,480	0.332	100.00	-5.03	100.00	-4.61	12.02	441

Panel B: Results for $\gamma = 2$

γ	ω	ϕ	n_{SR}	Mean ψ	Mean S	Median ψ	Median S	$S > 0$	N
2	0.00	-987	0.368	100.00	-2.88	100.00	-2.89	26.85	715
2	0.25	-647	0.345	100.00	-1.64	100.00	-2.26	29.65	715
2	0.50	-345	0.328	100.00	-0.33	100.00	-1.42	34.88	711
2	0.75	-35	0.308	100.00	1.11	100.00	-0.58	43.63	706
2	1.00	1,654	0.232	100.00	4.85	100.00	2.06	62.05	448

Panel C: Results for $\gamma = 3$

γ	ω	ϕ	n_{SR}	Mean ψ	Mean S	Median ψ	Median S	$S > 0$	N
3	0.00	-230	0.297	100.00	2.33	100.00	0.55	53.91	716
3	0.25	125	0.273	100.00	4.13	100.00	1.78	61.73	716
3	0.50	430	0.249	100.00	6.04	100.00	3.91	74.72	716
3	0.75	727	0.225	100.00	8.06	100.00	6.42	84.45	714
3	1.00	1,153	0.197	100.00	10.43	100.00	8.80	92.50	693

TABLE 4
Decomposition of Savings: The Efficient Contracting Case

This table shows a decomposition of savings from indexing options when indexing is mandatory. The savings in Table 3 are decomposed into two effects: (1) the savings S_{RS} from risk-sharing and (2) the savings S_I from restoring incentives. S_{RS} is further decomposed into three subeffects: (1) the savings S_L from replacing conventional options with premium options (2) the savings S_{MRP} from eliminating the risk-premium implicit in conventional options and (3) the savings S_{NR} from reducing volatility from σ_P to σ_I. The table shows the dollar savings as a percentage of total observed pay π^d. To avoid numerical problems, the last row in Panels A and B show values for the constraint problem with $\phi > 0$ only.

Panel A: Decomposition for $\gamma = 1$

| γ | ω | S | Decomp. of S | | Decomp. of S_{RS} | | | S_{MRP} | N |
			S_{RS}	S_I	S_L	S_{MRP}	S_{NR}	$+S_{NR}$	
1	0.00	-8.19	-1.70	-6.48	2.73	-14.11	9.67	-4.44	704
1	0.25	-7.70	-0.91	-6.79	2.80	-13.86	10.15	-3.71	695
1	0.50	-7.20	-0.15	-7.05	2.99	-13.68	10.54	-3.14	696
1	0.75	-6.66	0.85	-7.51	3.54	-13.55	10.86	-2.69	681
1	1.00	-5.03	1.79	-6.82	2.68	-12.75	11.85	-0.89	440

Panel B: Decomposition for $\gamma = 2$

| γ | ω | S | Decomp. of S | | Decomp. of S_{RS} | | | S_{MRP} | N |
			S_{RS}	S_I	S_L	S_{MRP}	S_{NR}	$+S_{NR}$	
2	0.00	-2.88	7.46	-10.34	6.13	-6.63	7.96	1.33	715
2	0.25	-1.64	8.49	-10.13	6.29	-6.31	8.51	2.20	714
2	0.50	-0.33	9.51	-9.83	6.46	-5.93	8.97	3.05	711
2	0.75	1.11	10.38	-9.27	6.64	-5.49	9.23	3.74	706
2	1.00	4.85	11.60	-6.75	5.94	-4.74	10.41	5.67	448

Panel C: Decomposition for $\gamma = 3$

| γ | ω | S | Decomp. of S | | Decomp. of S_{RS} | | | S_{MRP} | N |
			S_{RS}	S_I	S_L	S_{MRP}	S_{NR}	$+S_{NR}$	
3	0.00	2.33	11.43	-9.10	7.86	-3.86	7.42	3.57	716
3	0.25	4.13	12.56	-8.43	8.10	-3.49	7.95	4.46	716
3	0.50	5.96	13.47	-7.52	8.28	-3.11	8.31	5.20	712
3	0.75	7.97	14.38	-6.41	8.53	-2.70	8.55	5.85	708
3	1.00	9.89	14.40	-4.52	8.04	-2.07	8.43	6.36	657

TABLE 5

Indexation and Incentives: Sample Split by $\partial UPPS/\partial \psi$

This table shows the mean and median values of key variables in the dataset when we split the sample according to the sign of $\left(\frac{\partial UPPS^d}{\partial \psi} \right)$. Efficiency gains are the savings from Tables 3 (optimal indexation) and 4 (mandatory indexation), respectively. The degree of indexation is the average optimal degree of indexation from Table 2 for the respective subsample. The certainty equivalent and savings are based on the results from assuming $\gamma = 2$ and $\omega = 0.5$. The table also shows p-values for rejecting the null hypothesis of equal means and medians across the subsamples.

Variable	$\partial UPPS/\partial \psi < 0$		$\partial UPPS/\partial \psi > 0$		$P-Value$	
	Mean	Median	Mean	Median	t-test	Wilcoxon
Efficiency Gains ($\psi = 1$)	-3.152	-2.335	8.338	8.596	0.000	0.000
Efficiency Gains ($\psi = \psi^*$)	0.663	0.000	10.487	8.939	0.000	0.000
Degree of Indexation ψ^*	20.609	0.001	77.904	88.998	0.000	0.000
CAPM β	0.829	0.749	1.874	1.771	0.000	0.000
Idio. Volatility σ_I	0.330	0.297	0.386	0.367	0.000	0.000
Option holdings n_O^d	0.015	0.010	0.018	0.013	0.041	0.019
Certainty equivalent ($m)	180.822	48.762	115.171	29.158	0.277	0.000
Maturity T	9.034	6.715	5.669	4.749	0.000	0.000
Number of observations	540		176			

TABLE 6

Indexing Options: Removing the Market Risk Premium

This table shows our results for the case in which the firm chooses the degree of indexation of options, ψ, fixed salary ϕ, and number of restricted shares n_{SR} assuming that the market risk premium is zero. The firm's objective is to minimize contracting costs subject to the two constraints that the new contract provides the CEO (1) with at least the same utility as the observed contract, and (2) with at least the same effort incentives as the observed contract. Panel A shows the mean of the parameters across CEOs for five different values of the CEO's investment in the market portfolio ω for $\gamma = 2$. Panel B shows results for $\gamma = 2$ and $\omega = 0.5$ for different assumptions about the market risk premium. The table also shows the average savings the new contract generates as a percentage of the observed value of the CEO's contract. Base salary is given in thousand dollars. All other variables except γ and ω are percentages.

Panel A: Results for $\gamma = 2$

| | | | | | | Mean | | Median | | |
γ	ω	ϕ	n_{SR}	$\psi = 0$	$\psi = 1$	ψ	S	ψ	S	N
2	0.00	10,399	0.196	8.53	77.34	86.77	6.83	100.00	4.50	715
2	0.25	14,888	0.190	7.83	84.34	89.44	7.28	100.00	5.04	715
2	0.50	18,677	0.184	6.75	87.34	90.43	7.71	100.00	5.34	711
2	0.75	21,819	0.176	6.44	88.52	91.44	8.09	100.00	5.89	714
2	1.00	24,276	0.172	6.30	90.06	92.23	8.51	100.00	6.41	714

Panel B: Results for $\gamma = 2$ and $\omega = 0.5$

| | | | | | Mean | | Median | | |
MRP	ϕ	n_{SR}	$\psi = 0$	$\psi = 1$	ψ	S	ψ	S	N
0	18,677	0.184	6.75	87.34	90.43	7.71	100.00	5.34	711
2 %	10,284	0.196	19.02	44.34	69.08	4.98	93.16	2.12	715
4 %	1,269	0.174	46.71	13.99	34.57	3.08	10.35	0.03	715
6 %	-7,055	0.161	65.69	5.38	19.61	2.20	0.00	0.00	650

TABLE 7

Indexing Options: The Rent Extraction Case with $n_{SR} \geq n_{SR}^d$

This table shows our results for the case in which the firm chooses the degree of indexation of options, ψ, and number of restricted shares n_{SR}. Restricted shares are not allowed to be below by the number of restricted shares in the observed contract n_{SR}^d. The firm's objective is to minimize contracting costs subject to the constraint that the new contract provides the CEO with at least the same effort incentives as the observed contract. Results are shown for $\gamma = 2$. The table presents the mean of the parameters across CEOs for five different values of the CEO's investment in the market portfolio ω. The table also shows the average savings the new contract generates as a percentage of the observed value of the CEO's contract. Base salary is given in thousand dollars. All other variables except γ and ω are percentages.

						Mean		Median		
γ	ω	ϕ	n_{SR}	$\psi = 0$	$\psi = 1$	ψ	S	ψ	S	N
2	0.00	1,646	0.127	76.89	13.73	18.60	4.73	0.00	0.00	714
2	0.25	1,645	0.129	75.91	14.15	18.88	4.53	0.00	0.00	714
2	0.50	1,645	0.130	72.87	15.52	20.47	4.53	0.00	0.00	715
2	0.75	1,645	0.130	69.61	17.09	23.00	4.84	0.00	0.00	714
2	1.00	1,645	0.130	66.71	18.88	26.24	5.33	0.00	0.00	715

TABLE 8

Indexation and Incentives: Sample Split by $\partial UPPS/\partial \psi$ under Rent Extraction

This table shows the mean and median values of key variables in the dataset when we split the sample according to the sign of $\left(\frac{\partial UPPS^d}{\partial \psi} \right)$ under the rent extraction scenario. Efficiency gains are the savings, and the degree of indexation is the average optimal degree of indexation from Table 7 for the respective subsample. The table is based on the results from assuming $\gamma = 2$ and $\omega = 0.5$. The table also shows p-values for rejecting the null hypothesis of equal means and medians across the subsamples.

	$\partial UPPS/\partial \psi < 0$		$\partial UPPS/\partial \psi > 0$		$P - Value$	
Variable	Mean	Median	Mean	Median	t-test	Wilcoxon
Efficiency Gains ($\psi = \psi^*$)	0.184	0.000	17.934	19.258	0.000	0.000
Degree of indexation ψ^*	3.674	0.001	73.765	100.000	0.000	0.000
Number of observations	540		176			

TABLE 9

Indexing Options: The Rent Extraction Case with $n_{SR} \geq 0$

This table shows our results for the case in which the firm chooses the degree of indexation of options, ψ, and number of restricted shares n_{SR}. Restricted shares are not allowed to be negative. The firm's objective is to minimize contracting costs subject to the constraint that the new contract provides the CEO with at least the same effort incentives as the observed contract. The table presents the mean of the parameters across CEOs for five different values of the CEO's investment in the market portfolio ω for $\gamma = 2$. The table also shows the average savings the new contract generates as a percentage of the observed value of the CEO's contract. Base salary is given in thousand dollars. All other variables except γ and ω are percentages.

						Mean		Median		
γ	ω	ϕ	n_{SR}	$\psi = 0$	$\psi = 1$	ψ	S	ψ	S	N
2	0.00	1,644	0.033	44.06	33.01	43.05	20.39	16.51	7.65	715
2	0.25	1,645	0.039	44.68	31.79	42.04	19.68	12.53	7.04	714
2	0.50	1,645	0.043	44.06	33.15	43.11	19.10	18.95	5.53	715
2	0.75	1,644	0.045	42.24	35.24	44.97	19.05	24.13	5.36	715
2	1.00	1,645	0.045	39.44	37.48	47.94	19.58	38.92	7.68	715

TABLE 10

Indexing Stock with Efficient Contracting

This table shows our results for the case in which the firm chooses the degree of indexation of restricted shares, ψ, fixed salary ϕ, and number of restricted shares n_{SR}. The firm's objective is to minimize contracting costs subject to the two constraints that the new contract provides the CEO (1) with at least the same utility as the observed contract, and (2) with at least the same effort incentives as the observed contract. The table presents the mean of the parameters across CEOs for five different values of the CEO's investment in the market portfolio ω for $\gamma = 2$. The table also shows the average savings the new contract generates as a percentage of the observed value of the CEO's contract. We only show results for firs with restricted stock in the observed contract. Base salary is given in thousand dollars. All other variables except γ and ω are percentages.

						Mean		Median		
γ	ω	ϕ	n_{SR}	$\psi = 0$	$\psi = 1$	ψ	S	ψ	S	N
2	1.00	1,901	0.222	83.05	12.17	14.47	0.20	0.00	0.00	419
2	0.00	2,190	0.213	66.11	27.92	30.31	0.78	0.00	0.00	419
2	0.25	2,189	0.211	59.09	31.34	35.47	0.98	0.00	0.00	418
2	0.50	2,181	0.208	50.84	38.66	44.00	1.23	0.00	0.00	419
2	0.75	2,154	0.204	39.86	47.97	53.85	1.57	0.00	0.13	419