

# 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 in which shareholders can use indexed contracts to recapture rents from CEOs. The main finding is that the benefits from indexing are typically small: On average they are about 3% of compensation costs in our baseline case. The main reason is that for about 75% of the CEOs in our sample, indexing destroys incentives because it reduces the likelihood of bad outcomes. Much of the incentives of observed contracts come from the desire to avoid these bad outcomes. This effect also applies to the scenario where CEOs extract rents, so that indexing contracts is an inadequate instrument to recapture these rents. We show why conventional arguments for indexation often do not apply and conclude that the prevalence of pay for luck does not generally prove that contracting is inefficient or that corporate governance is poor.

Keywords: Executive compensation, indexed options, relative performance evaluation

JEL Classifications: G30, M52

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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 make use of benchmarks that filter exogenous risks, whereas compensation practice typically does not involve the indexation of equity-based pay. We calibrate the standard model used in the compensation literature 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 substantial benefits for a small number of CEOs.

The standard contracting view on compensation is based on the models of Holmstrom (1979, 1982) and Diamond and Verrecchia (1982) and supports indexing based on a simple and powerful argument: Shareholders have to compensate the CEO for any risk they impose on her. Shareholders therefore benefit from filtering any exogenous risk from the contract. However, this filtering of risk almost never happens in practice. 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)). While many observers suggest that the absence of indexing constitutes evidence for deficiencies in corporate governance (e.g., Bertrand and Mullainathan (2001)), the results in our paper show that the absence of indexing can be explained on the basis of a much more parsimonious model based on the fundamental trade-off between risk and incentives in CEO pay.

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.<sup>1</sup> Later work often

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<sup>1</sup>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.

finds evidence for partial relative performance evaluation by paying more attention to the diversity of compensation practices across firms.<sup>2</sup> However, the empirical literature on relative performance evaluation addresses a somewhat different question than we do, because it employs a cross-sectional regression methodology that analyzes *ex post* payouts 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.<sup>3</sup> Indexing could remove the risk of the benchmark from the contract, but it is apparently hardly used in practice. This distinction between *ex ante* benchmarking and *ex post* adjustments of pay is important, because the cross-sectional evidence for relative performance evaluation is also consistent with the alternative interpretation that boards regard CEOs' performance relative to their industry peers as information about CEOs' talent.<sup>4</sup> According to this argument, superior performance relative to a benchmark reveals the CEO's superior talent. Boards reset base salaries and other forms of pay as they update their assessment of the CEO's talent, a dynamic consideration that is 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.

In this paper, we investigate how much money, if any, firms leave on the table by using non-indexed executive compensation contracts. 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

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<sup>2</sup>Bertrand and Mullainathan (2001) argue that well-governed firms use relative performance evaluation more than poorly governed firms, Garvey and Milbourn (2003) show that individual characteristics like the CEO's wealth have to be taken into consideration, and Albuquerque (2009) points out that researchers may not find relative performance evaluation because the appropriate benchmarks differ across companies.

<sup>3</sup>The literature on the compensation of fund managers also addresses benchmarking in *ex ante* contracts, see for example Coles, Suay, and Woodbury (2000).

<sup>4</sup>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.

disregarded in the previous discussion of indexation. Our methodological innovation to this literature is twofold. First, we analyze *ex ante* contracts rather than looking at changes in realized pay. Second, we perform calibrations at the individual CEO level instead of cross-sectional regressions across a sample of CEOs.<sup>5</sup>

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. Average gains 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 indexing and assume that an outside regulator imposes that all stock options are fully indexed. Mandatory indexing destroys value and increases compensation costs on average and for the median firm.

We ask why the gains from indexation are so surprisingly small and decompose the efficiency gains from indexing into several effects. The case for indexing stock options often relies on the informal argument that it appears more efficient to increase the strike price with the stock market index, because the CEO has no control over the market index. According to this view, indexing makes incentive provisions more efficient and “the same amount of incentives can be provided at a lower cost, or more incentives can be provided at the same cost” (Bebchuk and Fried (2004), p. 190). A central finding of our paper is that this claim does not hold for a large majority of CEOs: Indexation of strike prices to the market index destroys incentives for about 75% of the CEOs in our sample.

The primary reason for this result is that indexation provides insurance to risk-averse CEOs, so that the probability that their pay falls to very low levels declines because the strike price also falls if the market index falls. However, much of CEOs’ incentives come from the possibility of low payoffs where their utility is low and where their marginal util-

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<sup>5</sup>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).

ity and therefore their incentives are high. CEOs' vulnerability to an exogenous source of risk therefore increases their incentives, a finding that reflects discussions in the early contracting literature, which even analyzes the potential improvements from using randomized contracts to exploit this precautionary motive.<sup>6</sup> If shareholders index options or shares, they remove CEOs' 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 shareholders. In the literature on insurance and risk management, this phenomenon is well-established and referred to as *background-risk* (see for example Gollier and Pratt, 1996). We show that the background-risk effect is sufficiently strong to outweigh the potential benefits from indexation for most CEOs and on average for our sample.

For the remaining 25% of the CEOs the background-risk effect reverses and indexing options simultaneously improves incentives and reduces compensation costs. Indexation replaces a small chance of very high payouts with a larger chance of intermediate payouts, which increases incentives because marginal utility is declining and the incentive impact of very large prospective payouts is negligible. This effect always exists, but it dominates only for CEOs of volatile firms, with lower wealth (hence: higher absolute risk aversion), and larger option holdings. With higher absolute risk-aversion, the incentive creation effect becomes larger. With larger option holdings, the background-risk effect becomes less important. The reason is that the observed contract with non-indexed options already features a limited downside, so that the additional insurance and therefore the incentive destruction from indexing becomes less important.

The more formal argument for indexation relies on Holmstrom's (1979) informativeness principle, which in our case states that shareholders have to pay the CEO an unnecessarily high risk premium for exposing her to risk that could be filtered through benchmarking her performance. We first show that the application of this argument to the indexation of CEOs' compensation contracts overlooks that stock market risk is priced. Hence, the CEO also

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<sup>6</sup>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.

receives a risk premium from her exposure to this risk.<sup>7</sup> Any benchmark that is correlated with the stock market index also takes away some or all of this risk premium. Shareholders have to compensate the CEO for this loss 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.<sup>8</sup> Without this market risk premium effect, the benefits from indexation increase, but remain moderate for two reasons. First, the destruction of incentives through the background-risk effect still applies. Second, the informativeness principle applies only to contracts with optimal functional forms, not to piecewise linear contracts that can be constructed from shares and options.

In the second part of our paper we adopt the perspective of the rent-extraction view and drop the assumption that CEOs' outside options are binding. This step of the analysis is important because proponents of the rent-extraction view may not agree with the presumption that shareholders have to compensate CEOs for their loss of the market risk premium. 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' utility and their outside option. There is no agreed-upon modeling approach to contracting with rent extraction and we argue below why our modeling approach captures the spirit of the rent extraction view most closely. We then ask whether indexation is an appropriate strategy for shareholders to recapture rents. This investigation shows that for about three quarters of all CEOs, indexation does not help with recovering rents. The intuition for this result is that indexing destroys incentives for the same reasons as in the efficient contracting case. Moreover, with rent extraction, it is only the effect of indexation on incentives that is important and not the effect on CEOs' utility.

Several contributions in the literature address the glaring gap between the prescriptions

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<sup>7</sup>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.

<sup>8</sup>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.

of standard economic models and observed compensation practice within the efficient contracting paradigm. First, relative performance evaluation might induce unwanted incentives to intensify industry competition (Aggarwal and Samwick (1999a)) and provide incorrect incentives for entering or exiting industries (Dye (1992); Gopalan, Milbourn, and Song (2009)). Our paper differs from these papers by focusing on indexation with respect to the general market. Since the market as a whole is clearly outside the decision span of CEOs, the strategic considerations that might explain the absence of industry benchmarking seem unlikely to have much bite in our setting. Second, indexed options might be tax inefficient, because they would not qualify for the same advantageous tax treatment as conventional options. However, the tax-argument is specific to the US-context and cannot explain the absence of indexed contracts in other countries. We propose a deeper economic reason for the absence of indexing that is unrelated to the tax code. Lastly, indexed options could be replicated by managers through appropriate rebalancing of their own portfolio between the benchmark portfolio and the risk-free asset if such rebalancing were costless (Garvey and Milbourn (2003), Jin (2001), and Maug (2000)). Formally incorporating this *homemade indexing* argument into our model would reduce the benefits from indexation even further.

The remaining part of the paper is organized as follows. The following Section 2 introduces the model and our calibration approach. Section 3 describes the data set. Section 4 contains our analysis of the indexation of options for the efficient-contracting case. The rent-extraction case is the topic of Section 5, and 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 Holmstrom (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 only on the stock price  $P_T$  and on the stock market index  $M_T$ , and generates a payoff  $\pi_T$  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 a 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 also owns  $n_{SU}$  unrestricted shares and we assume that these are not part of the contract negotiations, but contribute to her incentives and her wealth. The CEO's end-of-period wealth therefore is

$$W_T = W_0 \left( (1 - \omega)e^{r_f T} + \omega \frac{M_T}{M_0} \right) + n_{SU} P_T + \tilde{\pi}_T, \quad (1)$$

where  $\tilde{\pi}_T$  is the CEO's income from the employment with the firm. 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):

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

where  $\gamma$  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.<sup>9</sup> The CEO's outside option when she declines the contract is  $\underline{U}$ .

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<sup>9</sup>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).

**Contracts and shareholders' optimization** We consider piecewise linear contracts that consist of a fixed salary  $\phi$ , the number of restricted shares  $n_{SR}$ , and the number of options  $n_O$ , where we express  $n_{SR}$  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

$$\tilde{\pi}_T = \phi e^{r_f T} + n_{SR} P_T + n_O (\psi O_T^{indx} + (1 - \psi) \max \{P_T - K, 0\}).$$

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  $E[\tilde{\pi}_T]$  subject to the two constraints that the CEO accepts the contract and that she will exert the desired effort level  $e^*$ :<sup>10</sup>

$$\min E[\tilde{\pi}_T] \tag{3}$$

subject to:

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

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

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

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

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<sup>10</sup>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.

where  $P_0(e)$  is an increasing and concave function in effort  $e$ ,  $\mu_P$  is the expected annual total return (dividends plus capital gains),  $\sigma_P$  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:

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

The definitions of  $\mu_M$ , and  $\sigma_M$  are analogous to those for  $P_T$ . The actions of the CEO do not affect the value of the index. Furthermore,  $u_P$  and  $u_M$  are correlated with a coefficient of correlation  $\rho$ . The CAPM holds, so  $\beta = \rho \frac{\sigma_P}{\sigma_M}$  and:<sup>11</sup>

$$\mu_P = r_f + \beta (\mu_M - r_f). \quad (8)$$

**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:

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

where

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

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

$$O_T^{indx} = \max \{ P_T - H_T, 0 \}. \quad (11)$$

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<sup>11</sup>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  $\alpha = 0$ .

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

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

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

Here  $\sigma_I = \sigma_P \sqrt{1 - \rho^2}$ . 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:<sup>12</sup>

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

We distinguish between unrestricted shares  $n_{SU}$  and restricted shares  $n_{SR}$ . The CEO and shareholders bargain over fixed salary  $\phi$ , the number of restricted shares  $n_{SR}$ , and the proportion  $\psi$  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  $n_{SU} = n_{SU}^d$ .<sup>13</sup> Then the optimization problem can be rearranged as follows:

$$\min_{\{\phi, n_{SR}, \psi\}} E [\tilde{\pi}_T(\phi, n_{SR}, \psi)] \quad (15)$$

<sup>12</sup>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 conventional options and indexed options, respectively.

<sup>13</sup>Alternatively, we could fix the number of shares and endogenize the number of options. We do not report results for this case, because for some CEOs in our sample indexing options would lead to a violation of the upper bound  $n_O \leq 1$ . For these CEOs, the options in the observed contract already have an incentive effect that is close to zero. Indexing then dramatically reduces incentives in relative terms, so that an endogenous  $n_O$  explodes. By adjusting  $n_S$  instead of  $n_O$ , we move the contract shape unambiguously closer to the linear shape that has been proved optimal in Dittmann and Maug (2007). Therefore, this choice would overestimate efficiency gains.

subject to:

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

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

$$\psi \in [0, 1]. \quad (18)$$

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  $\omega$  and instead report results for a grid of exogenous values for  $\omega$ . The literature on the home-made indexing argument, which we reference in the Introduction, emphasizes that CEOs choose  $\omega$  optimally and thereby fully or partially undo the indexation in their compensation contracts.<sup>14</sup> The use of a grid of exogenous values for  $\omega$  avoids tedious case distinctions that occur because  $\omega$  must lie between zero and one, and our results imply that the constraints on

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<sup>14</sup>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.

$\omega$  are often binding. 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 that the CEO could also generate through adjusting  $\omega$ .

Program (15) to (18) assumes efficient contracting and is the subject of Section 4. In Section 5, we analyze a rent-extraction scenario where we drop the participation constraint (16) and fix the salary  $\phi$  at its observed level  $\phi^d$ . The firm then minimizes costs (15) over  $(n_{SR}, \psi)$  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  $\phi^d, n_S^d$ , and  $n_O^d$ , the parameters of the stock price processes (6) to (8), and the CEO's risk aversion parameter  $\gamma$ . When we calculate the value of the contract  $E[\tilde{\pi}_T]$ , 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  $\phi$  as the sum of salary, bonus, and "other compensation" from 2006 ExecuComp data and 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.<sup>15</sup> 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 yield  $d$  from 2005. We estimate the firm's stock return volatility  $\sigma$  and CAPM beta  $\beta$  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.<sup>16</sup> To arrive at meaningful wealth estimates, we discard all CEOs who 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 0.23% is unrestricted. Median

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<sup>15</sup>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.

<sup>16</sup>These wealth estimates can be downloaded for all years and all executives in ExecuComp from <http://people.few.eur.nl/dittmann/data.htm>.

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  $\gamma$ . We use  $\gamma = 2$  as a baseline case for most of our analysis and also report results for  $\gamma = 1$ ,  $\gamma = 3$ , and  $\gamma = 6$ .<sup>17</sup>

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. This assumption implies that we overstate the potential efficiency gains from indexing.

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.

## 4 Indexation of options when contracting is efficient

In this section we present the core of our analysis and investigate the costs and benefits on indexing CEOs' stock options. We analyze the optimization problem (15) to (18).

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<sup>17</sup>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 0.2 and 1.

## 4.1 The net benefits from indexation

Table 2 shows the results for three values of the coefficient of relative risk aversion  $\gamma$  (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  $\gamma$ , the table provides the results for five levels of the proportion  $\omega$  of CEO non-firm wealth that is invested in the stock market. The table reports the means of the base salary  $\phi$  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  $\psi$  and the proportion of all CEOs for whom the lower bound on  $\psi$  is binding ( $\psi = 0$ ) as well as the proportion of all CEOs for whom the upper bound on  $\psi$  is binding ( $\psi = 1$ ). Finally, we report the efficiency gains  $S$  from recontracting. Efficiency gains are defined as the difference between the cost of the observed contract  $\pi^d = E[\tilde{\pi}_T^d]$  and the cost of the optimal contract predicted by the model,  $\pi^* = E[\tilde{\pi}_T^*]$ , scaled by  $\pi^d$ , so  $S = (\pi^d - \pi^*)/\pi^d$  (“S” for “savings”). 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 with indexed options 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, 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 equal to 0.03% of compensation costs

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  $\omega$  and high levels of risk-aversion  $\gamma$ . However, such a combination of high  $\gamma$  and high  $\omega$  is implausible because CEOs choose their investment in the stock market, and the optimal exposure to the stock market is inversely related to their risk aversion. The parameters  $\omega$  and  $\gamma$  can therefore not both be high.

Low efficiency gains from indexation contradict the general enthusiasm for indexed options and the intuition based on standard contracting models. Note that our analysis in Table 2 does not feature the homemade indexing 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. The approach in Table 2 does therefore not lend itself to an analysis of the countervailing effects that reduce or even eliminate the benefits from indexation. Mandatory indexation is also an interesting case for regulators who might see indexation as a 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  $\phi$  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. The number of firms that would benefit from mandatory indexation increases with CEOs' assumed investment in the stock market  $\omega$  and with their assumed risk

aversion  $\gamma$ . This finding is intuitive: Efficiency gains are positive if CEOs' optimal exposure to stock market risk is lower than their assumed exposure.<sup>18</sup> Overall, the results in this section suggest that making indexing mandatory might destroy more value than it creates.

## 4.2 Why are efficiency gains so low?

We further analyze the efficiency gains from Table 3 to understand why these gains are so low and often negative. For this purpose we separate the impact indexation has on incentives from the impact indexation has on the utility of CEOs if incentive issues can be ignored. Hence, we decompose efficiency gains into two components and proceed as follows. In a first step, we set  $\psi = 1$  for all CEOs (mandatory indexing) and fix restricted stock holdings at their observed level ( $n_{SR} = n_{SR}^d$ ). We minimize objective (15) only subject to the participation constraint (16) and drop the incentive compatibility constraint (17) from the program. This step allows us to isolate the benefits from indexing without considering the impact of indexation on incentives. We refer to these gains as 'gross efficiency gains', because they reflect the benefits of mandatory indexation before netting out the incentive effect. The resulting contract has costs  $\pi_G$  and generates efficiency gains  $S_G \equiv (\pi^d - \pi_G) / \pi^d$ . In a second step we then compute the efficiency gains from adjusting incentives,  $S_I$ , which are simply the remaining gains from Table 3, i.e.,  $S_I = S - S_G$ . These additional gains result from restoring incentives to their initial level. The second step therefore involves adjusting restricted stock  $n_{SR}$  and the fixed salary  $\phi$  so that the contract simultaneously satisfies the participation constraint (16) and the incentive constraint (17).

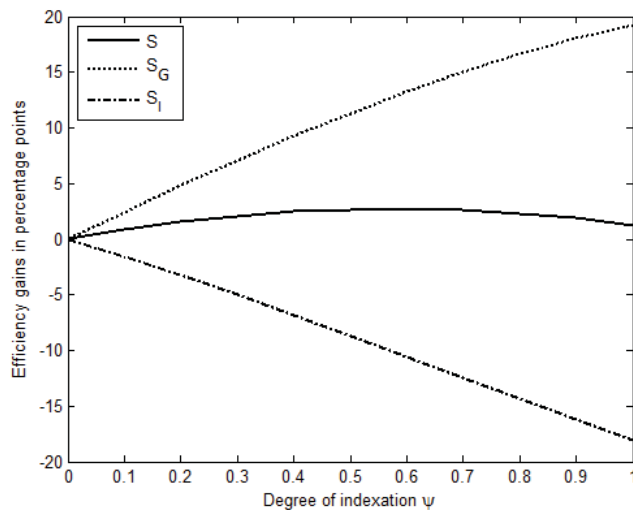
[Insert Table 4 here]

Table 4 repeats the average efficiency gain  $S$  from Table 3 and in addition shows the averages of  $S_G$  and  $S_I$ . The table also shows a further breakdown of  $S_G$ , on which we com-

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<sup>18</sup>For  $\gamma = 1, 2$ , the last line in Table 3 reports our results for  $\omega = 90\%$ . We do not show results for  $\omega = 100\%$ , because we encounter severe numerical problems in these cases. 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 numerical problems occur when base salaries are low.

ment below. Gross efficiency gains from indexing are small for  $\gamma = 1$  but become sizeable for  $\gamma = 2$  or  $\gamma = 3$  where they range from 7.5% to 14.4%. These benefits are partly offset by almost equally large efficiency losses  $S_I$  from restoring incentives, which range from 4.5% to 10.3%. Our first conclusion from Table 4 is therefore that indexation can generate large gross efficiency gains. However, efficiency losses from restoring incentives are also large and sometimes even overcompensate gross efficiency gains, which runs counter to the intuition that indexing compensation instruments would “provide the same incentives at lower cost” (Bebchuck and Fried (2004)). The magnitude of the necessary adjustment to restore incentives can be seen from comparing average restricted stock holdings in the observed contract (0.125% from Table 1) with the corresponding number for optimally indexed contracts (0.174%, see Table 2 for  $\omega = 0.5$ ,  $\gamma = 2$ ) and for fully indexed contracts (0.328%, Table 3).



**Figure 1: Decomposing Savings.** The figure shows efficiency gains  $S = (\pi^d - \pi^*) / \pi^d$  and their components  $S_G$  and  $S_I$  for one individual CEO as functions of the degree of indexation  $\psi$ . The solid line represents net efficiency gains  $S$ , the dotted line gross efficiency gains  $S_G$ , and the dashed line gains from restoring incentives  $S_I$ . The parameters are  $\gamma = 2$ ,  $\omega = 0.5$ ,  $W_0 = \$19.8m$ ,  $\phi = \$1.4m$ ,  $n_S = 0.14\%$ ,  $n_O = 0.52\%$ ,  $P_0 = \$12.1bn$ ,  $\sigma = 15.4\%$ ,  $\beta = 1.08$ ,  $d = 0$ ,  $r_f = 4.35\%$ , and  $T = 7.0$ .

Figure 1 shows the net efficiency gains  $S$  and their two components  $S_G$  and  $S_I$  as a function of the degree of indexation  $\psi$ . The plot is typical for the majority of the CEOs in our sample if  $\gamma > 1$ . 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%.

### 4.3 Indexation and incentives

Table 4 demonstrates that indexing destroys incentives on average and for the median firm. However, the average hides considerable variation across CEOs. We therefore split our sample into a subsample with CEOs whose incentives decline with the degree of indexation and another subsample with those CEOs whose incentives increase with indexation. We numerically calculate the marginal increase in  $UPPS$  from a change in the degree of indexation  $\psi$  for  $\gamma = 2$ ,  $\omega = 0.5$ , and  $\psi = 0$ . Table 5 displays the means and medians of several key variables in our data set when we split the sample according to the sign of  $\frac{\partial UPPS}{\partial \psi}$ . According to this measure, incentives increase for 24.6% of the CEOs in our sample (176 out of 716). The table reports the means and medians for several characteristics of firms and their CEOs as well as the p-values for two tests for the statistical significance of the differences between the two subsamples.

[Insert Table 5 here]

Table 5 reveals substantial differences between the two subsamples. Efficiency gains from mandatory indexation ( $\psi = 1$ ) as well as from optimal indexation ( $\psi = \psi^*$ ) are large only for the minority of CEOs for whom indexation creates incentives and for whom the degree of indexation is accordingly large.

Three features of the group for which incentives increase stand out. First, the CEOs in this group have larger option holdings, which are 1.81% compared to 1.49% in the group with declining incentives. Second, incentive creation is positive if volatility is higher, which holds for firm-specific volatility  $\sigma_I$  (0.386 versus 0.330) as well as for market risk as measured by the CAPM  $\beta$  (1.874 versus 0.829). Third, increasing incentives are associated with higher risk aversion. To document the last fact, we calculate the certainty equivalent wealth of each

CEO and divide it by the expected value of end of period wealth. Hence, for a risk-neutral CEO this ratio would be one, whereas for a risk-averse CEO it is smaller than one. The group of CEOs whose incentive decline values one dollar of expected terminal wealth on average at 88.7 cents, whereas the same number is 75.5 cents on the dollar for the group whose incentives increase. Hence in the second group with increasing incentives CEOs have a certainty equivalent wealth loss per dollar that is twice as large as in the first group, indicating differences in risk-aversion. We then calculate the degree of absolute risk aversion of each CEO by dividing  $\gamma$  with the certainty equivalent wealth and multiplying by  $10^8$ . As suggested by the differences in certainty equivalent wealth, absolute risk aversion is higher by about 60% for the group for which incentives increase.

To understand these differences we observe that indexation reduces the volatility of the distribution of terminal wealth  $W_T$  for each CEO. Indexation effectively hedges the CEO against stock market risk and moves probability mass from the tails to the center of the distribution. This shift of probability mass to the center affects incentives in opposite ways for both ends of the distribution: Indexation moves some probability mass of the distribution of terminal wealth  $W_T$  from the low end of the distribution to the middle, because indexation insures the CEO against declines in the stock market index. In fact, indexed options pay off even if  $P_T < K$ , i.e., if the terminal stock price is below the strike price of the conventional option, because for sufficiently low realizations of the stock market index we obtain  $H_T < K$ . This insurance reduces the probability of extremely low payoffs where marginal utility is large, so that incentives decline. Symmetrically, indexation also removes pay for luck when CEOs benefit from high returns in the stock market because the strike price increases with the stock market. Removing pay for luck moves probability mass from very high payoffs to intermediate payoffs, where marginal utility is higher so that incentives increase. The marginal utility of wealth is  $W_T^{-\gamma}$ , which is a convex function. If the reduction in volatility is therefore sufficiently symmetric for both tails of the distribution, then the first, incentive-

reducing effect dominates because of Jensen’s inequality.<sup>19</sup> As mentioned in the Introduction, we label this effect the *background-risk* effect and it explains why indexation generally reduces incentives.

However, the shift of probability mass is generally not symmetric for both tails of the distribution. Indexation creates incentives whenever the shift of probability mass from very high payoffs to intermediate payoffs dominates the shift from low to intermediate payoffs. Put differently, if the distribution of CEOs’ terminal wealth under the existing contract is sufficiently right-skewed, then the reduction in volatility can give a higher weight to the incentive-enhancing effect of shifting probability mass down from the upper tail of the distribution. This can happen for three reasons, that correspond to the three observations we make above. First, observed contracts already have a limited downside if they feature large non-indexed option holdings. The additional insurance effect from indexing these options is then small, so that large option holdings emphasize shifts of probability mass away from the upper tail of the distribution over shifts away from the lower tail of the distribution.<sup>20</sup> Second, for the lognormal distribution, skewness is positively related to volatility, so higher volatility generates a more skewed distribution and more volatile firms benefit more from indexation. Third, and finally, the background-risk effect relies on the convexity of marginal utility, which is directly proportional to the degree of absolute risk aversion.<sup>21</sup> Hence, if absolute risk aversion is lower, marginal utility is less convex and the incentive destruction from the background-risk effect becomes weaker. Therefore, the first two effects above carry more weight. The last inference is also supported by observing that the size of the incentive effect  $S_I$  is smaller for higher values of  $\gamma$  in Table 4.

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<sup>19</sup>To put it slightly more technically, the function that is relevant for this effect is the derivative of utility with respect to the stock price. This derivative is the product of marginal utility from wealth and the convexity of the relation between wealth and terminal stock price:  $dU/dP_T = (dU/dW_T) \times (dW_T/dP_T)$ . While  $(dU/dW_T) = W_T^{-\gamma}$  is unambiguously convex in  $W_T$ , it may not be convex in  $P_T$ .

<sup>20</sup>This asymmetry is in fact the qualification mentioned in the previous footnote.

<sup>21</sup>More formally, marginal utility equals  $U' = W_T^{-\gamma}$ . The convexity of this function can therefore be measured as  $con = -U'''/U'' = (1 + \gamma)/W_T$ , whereas absolute risk aversion equals  $RA = \gamma/W_T$ , so that  $con = RA \times (1 + \gamma)/\gamma$ .

To conclude, we observe that efficiency gains from indexing are much larger for those CEOs whose incentives increase with indexation for mandatory indexing (8.338 versus -3.152) and for optimal indexing (10.487 versus 0.663), and the optimal degree of indexation differs accordingly (77.9% versus 20.6%). We can therefore attribute the low average benefits from indexing to incentive destruction, which applies to a majority of CEOs, but not to relatively poor CEOs, CEOs of high volatility firms, and those with larger option portfolios.

#### 4.4 Decomposing gross efficiency gains

In this section we analyze the gross efficiency gains from indexation  $S_G$  further and identify three effects that influence the size of these gains. 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 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  $\sigma_I$  and strike price  $P_0 \exp((r_f - d)T)$ . Substituting these parameters into the Black-Scholes formula yields:

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

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  $\exp\{(r_f - d)T\}$ . Conventional options are usually deep in the money because the stock price is expected to appreciate over the lifetime of the option so that  $P_T > K$  with a large probability. Indexed options remove this aspect by increasing the average strike price. Based on this insight we identify the first two components of the

gross benefits from indexation  $S_G$ , namely, the *volatility effect* from reducing the volatility of the underlying asset, and the *strike-price effect* from increasing the strike price.

In a second step, we observe that option pricing theory relies on risk-neutral valuation, whereas we assume CEOs to be risk averse. If CEOs could adjust their exposure to market risk by choosing  $\omega$  freely and by adjusting it dynamically over time, then they would adjust their holdings until their marginal utility benefits from the risk-premium equal their marginal utility costs from being exposed to systematic risk. Accordingly, CEOs would value their marginal holdings of shares and options exactly as the market does. However, we treat  $\omega$  as fixed and invariant over time. Hence, CEOs may be underexposed or overexposed to market risk relative to their desired exposure, and indexing their options may move them either further away or closer to their desired exposure. We call this effect of indexation from changing the CEO's exposure to priced stock market risk the *market-risk-premium effect*.

Table 4 displays a decomposition of gross efficiency gains  $S_G$  into the three components: gains from increasing the strike price,  $S_{SP}$ , gains from removing the market-risk-premium,  $S_{MRP}$ , and gains from reducing volatility,  $S_V$ .

We proceed as follows. Recall that for the calculation of  $S_G$ , we set  $\psi = 1$  and  $n_{SR} = n_{SR}^d$  and minimize objective (15) subject to the participation constraint (16) only. This optimization brings us from the observed contract  $C^d$  with  $n_O^d$  conventional options to the contract  $C^G$  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 percentage difference in costs between contracts  $C^G$  and  $C^d$ , so  $S_G = (\pi_d - \pi_G) / \pi_d$ . We now define two intermediate contracts so that we can split  $S_G$  into three parts, which correspond each to one of the three effects described above:

- Contract  $C^{SP}$  is based on the observed contract  $C^d$ , but replaces  $n_O^d$  conventional at-the-money options with  $n_O^d$  premium options with strike price  $P_0 \exp\{(r_f - d)T\}$ . Simultaneously, we adjust the base salary  $\phi$  so that the CEO is indifferent between  $C^{SP}$  and  $C^d$ . The costs of  $C^{SP}$  are  $\pi^{SP}$ , and the percentage gain  $S_{SP} \equiv (\pi^d - \pi^{SP}) / \pi^d$

is the gain from increasing the strike price.

- Contract  $C^{MRP}$  is based on contract  $C^{SP}$ , but it redefines the underlying asset of the options by setting  $\mu_P = r_f$ , i.e., by reducing the market risk premium of the underlying share to zero. We also adjust the base salary so as to keep the CEO indifferent to this change. The costs of  $C^{MRP}$  are  $\pi^{MRP}$ , and the incremental gain  $S_{MRP} \equiv (\pi^{SP} - \pi^{MRP}) / \pi^d$  is the gain from removing the market risk premium, which we scale again by the costs of the observed contract.
- Contract  $C^G$  was defined before and reduces the volatility of the underlying asset of the options from  $\sigma_P$  to  $\sigma_I$ . Again, we adjust  $\phi$  so as to keep the CEO indifferent. The incremental gain  $S_V \equiv (\pi^{MRP} - \pi^V) / \pi^d$  is the gain from reducing the volatility of the options.

Several comments are in order with respect to this decomposition. First, note that we always scale by  $\pi^d$ , so that  $S_{SP} + S_{MRP} + S_V = S_G$ . Second, we fix the order of the three steps. Hence, to the extent that the three effects interact and influence each other, the ordering of the three steps potentially influences the exact measurement of these effects. Third, the two intermediate contracts should only be seen as conceptual steps to identify the factors that influence gross efficiency gains. Specifically, contract  $C^{MRP}$  assumes an underlying asset that involves exposure to systematic risk, but does not pay a risk premium. Such an asset could not exist in arbitrage-free markets.

Table 4 shows that the strike-price effect  $S_{SP}$  increases both with risk aversion  $\gamma$  and with the CEO's investment in the market portfolio  $\omega$ .<sup>22</sup> 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). With values around 3%, efficiency gains are moderate for  $\gamma = 1$ , but they become more sizeable for  $\gamma = 2$  or  $\gamma = 3$  when they

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<sup>22</sup>The leverage effect increases in  $\omega$  only for  $\omega \leq 0.75$  in Table 4. We ignore the results for  $\omega = 1$  due to the numerical problems discussed above.

range between 6.1% and 8.5%.

The market-risk-premium effect  $S_{MRP}$  is negative and also sizeable: On average it is around 14% for  $\gamma = 1$ , around 6% for  $\gamma = 2$ , and about 3% for  $\gamma = 3$ .<sup>23</sup> The market-risk-premium effect therefore decreases with risk aversion, whereas it increases with the CEO's assumed investment  $\omega$  in the stock market. Both observations depend on whether the CEO is overexposed or underexposed to market risk at the assumed values of  $\omega$  and  $\gamma$ . For a CEO who is underexposed to market risk, indexation moves her further away from her desired exposure and she demands a larger compensation for the loss of exposure to market risk than the market risk premium. Similarly, a CEO who is overexposed to market risk is willing to give up her exposure to market risk for a price that is smaller than the market risk premium, hence indexing her options moves her closer to her optimum and therefore creates value.

According to the homemade indexing argument outlined in the Introduction, CEOs always adjust their exposure to the stock market optimally. However, for  $\gamma = 2$ , 31.95% of the CEOs in our sample would not want any indexing of their options even if they have already invested all their wealth in the stock market ( $\omega = 1$ , see Table 2). They could undo indexing by the firm only through leveraging their private portfolios so that  $\omega > 1$ .

Many proponents of indexed options argue that the firm can save the market risk 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 the argument of indexing proponents may therefore require dropping the assumption of a binding participation constraint, a subject we take up in Section 5 below.

The volatility effect  $S_V$  is positive and large, with values that average between 7% and almost 12%. This effect is the actual risk-sharing effect and increases with the CEO's invest-

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<sup>23</sup>The market-risk-premium effect is positive for 2.7% of our CEOs for whom  $\beta < 0$ . For these CEOs, the volatility effect  $S_V$  is typically negative.

ment  $\omega$  in the market portfolio, because a higher exposure to market risk increases the total exposure of the CEO to risk and therefore also her benefit from reducing this risk. Interestingly, the volatility effect declines with relative risk aversion  $\gamma$  from 10.54% ( $\gamma = 1, \omega = 0.5$ ) to 8.31% ( $\gamma = 3, \omega = 0.5$ ). At first, this observation appears surprising because we would expect a higher benefit from risk-sharing for more risk-averse CEOs. However, we measure this effect as a percentage of compensation costs and not as a percentage of CEOs' subjective valuations of their stock options. If risk-aversion is high, then CEOs attribute little value to these options, because they pay off only in those states where CEOs' marginal utility of additional payoffs is very low. Accordingly, even if CEOs' valuations of their stock options increases substantially in percentage terms from indexing, these improvements represent a smaller gain in dollar terms, which is what  $S_V$  actually measures.

**Robustness check: Varying the market risk premium.**

The market-risk-premium effect shows that indexing CEOs' compensation contracts differs from standard discussions of benchmarking based on the informativeness principle in two respects. First, if CEOs' contracts are not indexed, they receive a reward in the form of a market risk premium for accepting the additional risk. Second, they have already some exposure to this risk through the way in which they invest their non-firm wealth. In this section we investigate what happens if we change the first assumption and assume that the benchmark against which CEOs' contracts are indexed does not carry a risk premium. This would be the case for benchmarks that are not highly correlated with the market index such as exchange rates or commodity prices. We therefore consider the case where we set the market risk premium to zero so that  $\mu_P = \mu_M = r_f$ . 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 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  $\phi$ . We compute optimal contracts as before and define the incentives of observed contracts by evaluating them under the changed assumptions about the market risk premium and  $\phi$ .

[Insert Table 6 here]

Table 6 displays the results and its construction 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% (compare Tables 6 and 2). The savings from indexation increase by almost the same factor, or about 150%. 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. 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  $\omega^*$  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. 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  $\mu_M$ , 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.

## 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 indexation reduces their utility. 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 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 because 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 in firms with poor corporate governance.

We consider two variants of the rent extraction scenario. The first variant assumes that CEO entrenchment is so strong that CEOs can resist any reduction in their restricted stock grants. In this variant, the number of restricted shares  $n_{SR}$  cannot be reduced below its observed level  $n_{SR}^d$ . It is possible, however, to increase restricted shares. The second variant drops this additional assumption and allows firms to adjust restricted shares downwards as well.

[Insert Table 7 here]

Table 7 reports the results from minimizing the costs of the contract subject to the incentive compatibility constraint for  $\gamma = 2$  for the first scenario with downward rigid stockholdings. Optimization is only with respect to the degree of indexation,  $\psi$ , and with respect to the number of restricted shares,  $n_{SR}$ . Base salaries and option holdings are fixed at their observed levels,  $\phi^d$  and  $n_O^d$ , respectively. Shareholdings are flexible so that they can be increased, but they cannot be reduced. Only options are indexed, so that the analysis parallels that of Table 2. Therefore, the structure of the two tables is identical.

Three features stand out from Table 7 in comparison to Table 2. First, efficiency gains 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 gains 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 large.

[Insert Table 8 here]

We investigate these results further and perform the same sample split for the rent extraction case as we did for the efficient contracting case and distinguish the group of CEOs 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 with a mean of 17.93%, compared to only 10.49% for efficient contracting, but they are smaller for the group of CEOs for whom incentives are destroyed through indexing, for whom the mean is 0.18%, compared to 0.66% for efficient contracting. Since the groups of CEOs are the same as in the efficient contracting case, the same interpretation applies and we therefore refer to our detailed discussion of Table 5 above.

In the first variant of 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 of these firms, because we only calculate the reduction of compensation costs and not the increase in firm value through improved incentives.

We now turn to the second variant of the rent-extraction view where we do not assume that CEOs can protect their restricted stock grants. We 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 format as Tables 2 and 7.

[Insert Table 9 here]

**Gains for shareholders.** Several features stand out in Table 9. Efficiency gains are larger compared to the variant with downward rigid stockholdings in Table 7 by a factor of about 4. However, surprisingly, these larger gains 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*

$$E[(W_T - \gamma n_S P_T) h(P_T)] < 0, \quad (20)$$

where  $h(P_T) = \frac{dP_T}{dP_0} W_T^{-(\gamma+1)}$ . Therefore, there exists some upper bound  $\bar{n}_S$  so that UPPS decreases with  $n_S$  for all  $n_S > \bar{n}_S$ .

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 stockholdings multiplied by  $\gamma$  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 decrease 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 shares were not indexed. In this section, we consider the opposite case, in which stock is indexed but options are not.<sup>24</sup>The CEO's wage therefore is given by

$$\tilde{\pi}_T = \phi e^{r_f T} + n_{SR} (\psi P_T^{indx} + (1 - \psi) P_T) + n_O \max \{P_T - K, 0\}.$$

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  $(P_T/H_T) e^{r_f T}$ .

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

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

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

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

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

We solve program (15) to (18) as in the previous sections, with the only difference being that  $\psi$  now refers to the proportion of stock that is indexed rather than the proportion of options. We index only restricted stock and not unrestricted stock because unrestricted

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<sup>24</sup>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.

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  $\psi$  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  $\psi$  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 and often zero, even if we grant the assumptions of the rent extraction view. We identify three reasons that explain the apparent gap between the general enthusiasm for indexed contracts and our results:

1. Indexing contracts often reduces incentives. The vulnerability to stock market risk increases CEOs' incentives as long as compensation contracts that are not too convex. Then indexing compensation reduces CEOs' vulnerability to stock market risk and therefore their incentives. This effect becomes even stronger in an environment where shareholders could potentially recover rents from CEOs, because then they would ignore the benefits from improved risk sharing and focus on the incentive impact alone.

2. Whenever the benchmark is correlated with the market index, indexation involves removing the market risk premium. However, the CEO generally wants some exposure to the market index and removing it through indexation is often inefficient. With costly hedging and portfolio constraints, the CEO would not even be able to counteract indexation through adjustments of her own portfolio.
3. Holmstrom's (1979) informativeness principle guarantees that the benefits from improved risk-sharing always outweigh the countervailing incentive effects. However, even if the market risk premium were zero, the informativeness principle may not apply. Holmstrom's argument relies on a contract that is an optimized non-linear function, which is generally different from the piecewise-linear functions that can be constructed with shares and options.<sup>25</sup> There can therefore be no presumption that the informativeness principle applies to indexed options or indexed restricted stock.

Our sample is heterogeneous though. For about a quarter of CEOs, characterized by sufficiently large option exposure, high absolute risk aversion, and high volatility stock, the background-risk effect reverses and indexing options simultaneously improves incentives and reduces compensation costs. This skewness in the distribution of benefits from indexation implies that indexation may have large benefits for a small number of firms. Accordingly, our results suggest that broad, sweeping reforms that apply to all firms would be harmful and would make compensation less efficient. Similarly, the conclusion that lack of indexing and the prevalence of “pay for luck” always indicate poor corporate governance is unwarranted.

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<sup>25</sup>See Dittmann and Maug (2007) for an explicit solution and parameterization of the optimal contract in a similar model that does not distinguish between firm-specific risk and market risk. They derive the functional form is different from that of observed contracts.

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## Appendix

### Derivation of equation (22):

We rewrite  $P_T/H_T$  in (21) as

$$\begin{aligned} \frac{P_T}{H_T} = \frac{P_T^{ex}}{H_T^{ex}} = exp \times \left\{ \left( \mu_P - \frac{\sigma_P^2}{2} \right) T + u_P \sigma_P \sqrt{T} \right\} \\ \times \left\{ - \left( \mu_M - \frac{\sigma_M^2}{2} \right) \beta T - u_M \beta \sigma_M \sqrt{T} \right\} \times exp \left\{ - (1 - \beta) \left( r_f + \frac{1}{2} \rho \sigma_M \sigma_P \right) T \right\} \end{aligned} \quad (25)$$

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

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

Using (23) and (24) in (26) and inserting the resulting expression into (21) gives (22).

### Proof of Proposition 1:

The CEO's wealth is given by:

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

For the incentives, we have

$$\begin{aligned}
UPPS &= \frac{dE(U(W_T))}{dP_0} = E\left(\frac{dU(W_T)}{dP_0}\right) = E\left(W_T^{-\gamma} \frac{dW_T}{dP_0}\right) \\
&= E\left(\frac{n_S \frac{dP_T}{dP_0}}{\left[(W_0 + \phi)((1 - \omega)e^{r_f T} + \omega \frac{M_T}{M_0})e^{r_f T} + n_O \max(P_T - K, 0) + n_S P_T\right]^\gamma}\right). \quad (28)
\end{aligned}$$

This implies

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

$$= E((W_T - n_S \gamma P_T) h(P_T)) \quad (30)$$

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

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

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

**TABLE 1**  
**Description of the Data Set**

This table contains descriptive statistics for the variables in our data set. 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,  $\phi$ , is the sum of salary, bonus, and "other compensation" from ExecuComp. The value of the CEO pay contract,  $\pi$ , 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.	25 <sup>th</sup> Perc.	75 <sup>th</sup> 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)	$\phi$	1,616	1,043	4,393	0	724	1,502	105,534	755
Contract (\$M)	$\pi$	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	$\sigma_P$	38.82%	33.78%	18.93%	12.50%	25.36%	47.99%	155.21%	755
Mkt. volatility	$\sigma_M$	15.47%	15.41%	0.51%	13.47%	15.41%	15.41%	17.00%	755
Idio. volatility	$\sigma_I$	34.12%	30.52%	16.19%	12.25%	22.38%	41.60%	153.99%	755
Beta	$\beta$	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,  $\psi$ , fixed salary  $\phi$ , 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  $\omega$ . For the degree of indexation  $\psi$ , the median is also reported as well as the proportion of CEOs for whom  $\psi = 0$  and  $\psi = 1$ , respectively. The table also shows the average and median efficiency gains from indexing expressed as a percentage of the value of the CEO's observed contract. Base salary is given in million dollars. All other variables except  $\gamma$  are percentages.

**TABLE 2 (Continued)**

**Indexing Options: The Efficient Contracting Case**

Panel A: Results for $\gamma = 1$										
$\gamma$	$\omega$	$\phi$	$n_{SR}$	$\psi = 0$	$\psi = 1$	Mean		Median		N
						$\psi$	$S$	$\psi$	$S$	
1	0	1.603	0.186	87.85	1.40	6.01	0.32	0.00	0.00	716
1	25	1.610	0.173	87.41	1.40	6.46	0.35	0.00	0.00	715
1	50	1.621	0.162	86.64	1.41	6.99	0.38	0.00	0.00	711
1	75	1.633	0.152	85.49	1.55	7.59	0.43	0.00	0.00	710
1	100	1.643	0.145	84.66	1.59	8.11	0.47	0.00	0.00	691
Panel B: Results for $\gamma = 2$										
$\gamma$	$\omega$	$\phi$	$n_{SR}$	$\psi = 0$	$\psi = 1$	Mean		Median		N
						$\psi$	$S$	$\psi$	$S$	
2	0	1.295	0.168	58.18	9.93	26.40	2.29	0.00	0.00	715
2	25	1.283	0.169	53.63	11.59	29.62	2.63	0.00	0.00	716
2	50	1.269	0.174	46.71	13.99	34.57	3.08	10.35	0.03	715
2	75	1.280	0.181	40.87	18.96	41.64	3.70	32.58	0.37	712
2	100	1.266	0.186	31.95	26.25	50.94	4.57	60.69	1.01	701
Panel C: Results for $\gamma = 3$										
$\gamma$	$\omega$	$\phi$	$n_{SR}$	$\psi = 0$	$\psi = 1$	Mean		Median		N
						$\psi$	$S$	$\psi$	$S$	
3	0	0.967	0.192	30.63	27.55	51.82	5.25	59.10	1.50	715
3	25	0.961	0.196	25.59	33.43	59.28	6.10	73.79	2.46	715
3	50	0.984	0.200	17.79	43.70	70.29	7.30	91.83	4.25	714
3	75	1.002	0.200	9.83	64.47	82.51	8.87	100.00	6.46	712
3	100	1.223	0.187	5.17	84.20	91.36	10.96	100.00	8.77	696
Panel D: Results for $\gamma = 6$										
$\gamma$	$\omega$	$\phi$	$n_{SR}$	$\psi = 0$	$\psi = 1$	Mean		Median		N
						$\psi$	$S$	$\psi$	$S$	
6	0	1.112	0.163	7.64	65.85	84.50	11.88	100.00	10.56	694
6	25	1.280	0.153	3.78	83.11	93.12	13.94	100.00	12.96	687
6	50	1.471	0.137	1.75	95.05	96.85	15.94	100.00	15.21	687
6	75	1.518	0.121	1.30	96.39	97.64	17.70	100.00	16.88	693
6	100	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 constrained to  $\psi = 1$ . Firms can choose the fixed salary  $\phi$  (in million dollars), and the number of restricted shares  $n_{SR}$ . 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  $\omega$ . For the degree of indexation  $\psi$ , the median is also reported. The table also shows the average efficiency gains from indexing expressed as a percentage of the observed value of the CEO's contract and the proportion of CEOs for whom these gains are positive. Base salaries are given in million dollars. All other variables except  $\gamma$  are percentages.

Panel A: Results for  $\gamma = 1$

$\gamma$	$\omega$	$\phi$	$n_{SR}$	Mean		Median		$S > 0$	N
				$\psi$	$S$	$\psi$	$S$		
1	0	-5.634	0.475	100.00	-8.19	100.00	-7.62	6.53	704
1	25	-4.129	0.453	100.00	-7.70	100.00	-7.01	7.18	696
1	50	-2.759	0.431	100.00	-7.20	100.00	-6.48	7.61	696
1	75	-1.314	0.411	100.00	-6.66	100.00	-5.92	8.22	681
1	90	-0.150	0.393	100.00	-5.93	100.00	-5.32	9.03	642

Panel B: Results for  $\gamma = 2$

$\gamma$	$\omega$	$\phi$	$n_{SR}$	Mean		Median		$S > 0$	N
				$\psi$	$S$	$\psi$	$S$		
2	0	-0.987	0.368	100.00	-2.88	100.00	-2.89	26.85	715
2	25	-0.647	0.345	100.00	-1.64	100.00	-2.26	29.65	715
2	50	-0.345	0.328	100.00	-0.33	100.00	-1.42	34.88	711
2	75	-0.035	0.308	100.00	1.11	100.00	-0.58	43.63	706
2	90	0.263	0.292	100.00	2.13	100.00	-0.01	49.93	695

Panel C: Results for  $\gamma = 3$

$\gamma$	$\omega$	$\phi$	$n_{SR}$	Mean		Median		$S > 0$	N
				$\psi$	$S$	$\psi$	$S$		
3	0	-0.230	0.297	100.00	2.33	100.00	0.55	53.91	716
3	25	0.125	0.273	100.00	4.13	100.00	1.78	61.73	716
3	50	0.430	0.249	100.00	6.04	100.00	3.91	74.72	716
3	75	0.727	0.225	100.00	8.06	100.00	6.42	84.45	714
3	100	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 efficiency gains when indexing is mandatory. The gains in Table 3 are decomposed into two effects: (1) the gross efficiency gains  $S_G$  and (2) the gains  $S_I$  from restoring incentives.  $S_G$  is further decomposed into three parts: (1) the gains  $S_{SP}$  from increasing the option's strike price, (2) the gains  $S_{MRP}$  from eliminating the risk-premium implicit in conventional options, and (3) the gains  $S_V$  from reducing volatility from  $\sigma_P$  to  $\sigma_I$ . The table shows the dollar efficiency gains as a percentage of total observed pay  $\pi^d$ .

Panel A: Decomposition for $\gamma = 1$									
$\gamma$	$\omega$	$S$	Decomposing $S$		Decomposing $S_G$			N	
			$S_G$	$S_I$	$S_{SP}$	$S_{MRP}$	$S_V$		
1	0	-8.19	-1.70	-6.48	2.73	-14.11	9.67	704	
1	25	-7.70	-0.91	-6.79	2.80	-13.86	10.15	695	
1	50	-7.20	-0.15	-7.05	2.99	-13.68	10.54	696	
1	75	-6.66	0.85	-7.51	3.54	-13.55	10.86	681	
1	90	-5.93	1.72	-7.66	3.68	-12.98	11.02	642	

Panel B: Decomposition for $\gamma = 2$									
$\gamma$	$\omega$	$S$	Decomposing $S$		Decomposing $S_G$			N	
			$S_G$	$S_I$	$S_{SP}$	$S_{MRP}$	$S_V$		
2	0	-2.88	7.46	-10.34	6.13	-6.63	7.96	715	
2	25	-1.64	8.49	-10.13	6.29	-6.31	8.51	714	
2	50	-0.33	9.51	-9.83	6.46	-5.93	8.97	711	
2	75	1.11	10.38	-9.27	6.64	-5.49	9.23	706	
2	90	2.13	10.87	-8.74	6.65	-5.20	9.42	694	

Panel C: Decomposition for $\gamma = 3$									
$\gamma$	$\omega$	$S$	Decomposing $S$		Decomposing $S_G$			N	
			$S_G$	$S_I$	$S_{SP}$	$S_{MRP}$	$S_V$		
3	0	2.33	11.43	-9.10	7.86	-3.86	7.42	716	
3	25	4.13	12.56	-8.43	8.10	-3.49	7.95	716	
3	50	5.96	13.47	-7.52	8.28	-3.11	8.31	712	
3	75	7.97	14.38	-6.41	8.53	-2.70	8.55	708	
3	100	9.89	14.40	-4.52	8.04	-2.07	8.43	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 data set when we split the sample according to the sign of  $\left(\frac{\partial UPPS^d}{\partial\psi}\right)$ . Efficiency gains ( $\psi = 1$ ) are repeated from Table 3 (mandatory indexation) and efficiency gains ( $\psi = \psi^*$ ) are repeated from Table 2 (optimal indexation). The degree of indexation  $\psi^*$  comes from Table 2.  $CE(W_T)$  is the certainty equivalent of the end-of-period wealth and  $E(W_T)$  is the expected value of  $W_T$  under the observed contract. In addition, the table shows the CAPM- $\beta$ , idiosyncratic volatility  $\sigma_I$ , and the number of options  $n_O^d$ . The degree of absolute risk aversion of each CEO is calculated by dividing  $\gamma$  with the certainty equivalent wealth and multiplying by  $10^8$ . Efficiency gains, optimal degree of indexation, and the certainty equivalent of the end-of-period wealth  $CE(W_T)$  are all based on  $\gamma = 2$  and  $\omega = 0.5$ . The table also shows  $p$ -values for rejecting the null hypothesis of equal means and medians across the two subsamples. Values market with “%” are percentages.

Variable	$\partial UPPS/\partial\psi < 0$		$\partial UPPS/\partial\psi > 0$		$p - Value$	
	Mean	Median	Mean	Median	$t$ -test	Wilcoxon
Option holdings $n_O^d$ (%)	1.489	1.019	1.813	1.270	0.041	0.019
Idio. Volatility $\sigma_I$	0.330	0.297	0.386	0.367	0.000	0.000
CAPM $\beta$	0.829	0.749	1.874	1.771	0.000	0.000
$CE(W_T) / E(W_T)$	0.887	0.917	0.755	0.777	0.000	0.000
Absolute risk aversion $*10^8$	7.552	4.102	12.490	6.859	0.000	0.000
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
Opt. degr. of Indexation $\psi^*$ (%)	20.609	0.001	77.904	88.998	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,  $\psi$ , fixed salary  $\phi$ , and the 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  $\omega$  for  $\gamma = 2$ . Panel B shows results for  $\gamma = 2$  and  $\omega = 50\%$  for different assumptions about the market risk premium. For the degree of indexation  $\psi$ , the median is also reported as well as the proportion of CEOs for whom  $\psi = 0$  and  $\psi = 1$ , respectively. The table also shows the average and median efficiency gains expressed as a percentage of the observed value of the CEO's contract. Base salaries are given in million dollars. All other variables are percentages.

Panel A: Results for  $\gamma = 2$

$\omega$	$\phi$	$n_{SR}$	$\psi = 0$	$\psi = 1$	Mean		Median		N
					$\psi$	$S$	$\psi$	$S$	
0	10.40	0.196	8.53	77.34	86.77	6.83	100.00	4.50	715
25	14.89	0.190	7.83	84.34	89.44	7.28	100.00	5.04	715
50	18.68	0.184	6.75	87.34	90.43	7.71	100.00	5.34	711
75	21.82	0.176	6.44	88.52	91.44	8.09	100.00	5.89	714
100	24.28	0.172	6.30	90.06	92.23	8.51	100.00	6.41	714

Panel B: Results for  $\gamma = 2$  and  $\omega = 50\%$

MRP	$\phi$	$n_{SR}$	$\psi = 0$	$\psi = 1$	Mean		Median		N
					$\psi$	$S$	$\psi$	$S$	
0	18.68	0.184	6.75	87.34	90.43	7.71	100.00	5.34	711
$0.5 \times \beta^d$	10.28	0.196	19.02	44.34	69.08	4.98	93.16	2.12	715
$\beta^d$	1.27	0.174	46.71	13.99	34.57	3.08	10.35	0.03	715
$1.5 \times \beta^d$	-7.06	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,  $\psi$ , and the number of restricted shares  $n_{SR}$ . Restricted share holdings in the optimal contract are constrained from below by the number of restricted shares in the observed contract:  $n_{SR} \geq n_{SR}^d$ . 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. The table presents the mean of the parameters across CEOs for five different values of the CEO's investment in the market portfolio  $\omega$  for  $\gamma = 2$ . For the degree of indexation  $\psi$ , the median is also reported as well as the proportion of CEOs for whom  $\psi = 0$  and  $\psi = 1$ , respectively. The table also shows the average and median efficiency gains expressed as a percentage of the observed value of the CEO's contract. Base salaries is given in million dollars. All other variables are percentages.

$\omega$	$\phi$	$n_{SR}$	$\psi = 0$	$\psi = 1$	Mean		Median		N
					$\psi$	$S$	$\psi$	$S$	
0	1.646	0.127	76.89	13.73	18.60	4.73	0.00	0.00	714
25	1.645	0.129	75.91	14.15	18.88	4.53	0.00	0.00	714
50	1.645	0.130	72.87	15.52	20.47	4.53	0.00	0.00	715
75	1.645	0.130	69.61	17.09	23.00	4.84	0.00	0.00	714
100	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 the efficiency gains and the degree of indexation under the rent-extraction scenario when we split the sample according to the sign of  $\left(\frac{\partial UPPS^d}{\partial\psi}\right)$  with  $\gamma = 2$  and  $\omega = 50\%$ . The table also shows  $p$ -values for rejecting the null hypothesis of equal means and equal medians across the two subsamples.

Variable	$\partial UPPS/\partial\psi < 0$		$\partial UPPS/\partial\psi > 0$		$p - Value$	
	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 $\psi^*$	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,  $\psi$ , and number of restricted shares  $n_{SR}$ . Restricted share holdings in the optimal contract are constrained from below by zero:  $n_{SR} \geq 0$ . 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 CEOs' investment in the market portfolio  $\omega$  for  $\gamma = 2$ . For the degree of indexation  $\psi$ , the median is also reported as well as the proportion of CEOs for whom  $\psi = 0$  and  $\psi = 1$ , respectively. The table also shows the average and median efficiency gains expressed as a percentage of the observed value of CEOs' contracts. Base salaries are given in million dollars. All other variables are percentages.

$\omega$	$\phi$	$n_{SR}$	$\psi = 0$	$\psi = 1$	Mean		Median		N
					$\psi$	$S$	$\psi$	$S$	
0	1.644	0.033	44.06	33.01	43.05	20.39	16.51	7.65	715
25	1.645	0.039	44.68	31.79	42.04	19.68	12.53	7.04	714
50	1.645	0.043	44.06	33.15	43.11	19.10	18.95	5.53	715
75	1.644	0.045	42.24	35.24	44.97	19.05	24.13	5.36	715
100	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,  $\psi$ , fixed salary  $\phi$ , and the 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 CEOs' investment in the market portfolio  $\omega$  for  $\gamma = 2$ . For the degree of indexation  $\psi$ , the median is also reported as well as the proportion of CEOs for whom  $\psi = 0$  and  $\psi = 1$ , respectively. The table also shows the average and median efficiency gains expressed as percentages of the observed value of CEOs' contracts. We only show results for CEOs with positive restricted stock holdings in the observed contract. Base salaries are given in million dollars. All other variables are percentages.

$\omega$	$\phi$	$n_{SR}$	$\psi = 0$	$\psi = 1$	Mean		Median		N
					$\psi$	$S$	$\psi$	$S$	
0	2.190	0.213	66.11	27.92	30.31	0.78	0.00	0.00	419
25	2.189	0.211	59.09	31.34	35.47	0.98	0.00	0.00	418
50	2.181	0.208	50.84	38.66	44.00	1.23	0.00	0.00	419
75	2.154	0.204	39.86	47.97	53.85	1.57	81.48	0.13	419
100	2.112	0.199	31.03	58.95	63.75	2.05	100.00	0.56	419

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