Restricting CEO Pay*

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We analyze several proposals to restrict CEO compensation and calibrate two models of executive compensation that describe how firms would react to different types of restrictions. We find that many restrictions would have unintended consequences. Restrictions on total realized (ex-post) payouts lead to higher average compensation, higher rewards for mediocre performance, lower risk-taking incentives, and the fact that some CEOs would be better off with a restriction than without it. Restrictions on total ex-ante pay lead to a reduction in the firm's demand for CEO talent and effort. Restrictions on particular pay components, and especially on cash payouts, can be easily circumvented. While restrictions on option pay lead to lower risk-taking incentives, restrictions on incentive pay (stock and options) result in higher risk-taking incentives.

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1 Introduction

In this paper, we analyze proposals to restrict CEO compensation. Demands for regulating executive pay are regularly put forward at times of economic crisis when voters express stronger concerns about inequality and fairness. The financial crisis after 2007 is no exception to this rule, and several governments recently considered or even passed laws to rein in compensation packages deemed to be excessive. We provide an overview of restrictions currently proposed or enacted in several developed countries and identify three types of restrictions on executive pay: restrictions on the total level of realized pay, restrictions on components of pay, such as fixed salary, option pay, or incentive pay, and restrictions on the ex-ante value of pay.

The objective of our analysis is to investigate the consequences of restrictions on executive compensation, particularly unintended consequences, and to quantify them. As such, we conduct a counterfactual analysis of how compensation contracts would look if restrictions on CEO pay had already been in place. We fit a contracting model to observed pay, and predict from the model how contracting would change if restrictions on pay were introduced. Our analysis uncovers a number of indirect consequences of restrictions on pay that may not be intended by the proponents of these restrictions. Depending on the type of restriction, risk-taking incentives can substantially decrease or increase, CEOs can be rewarded more for mediocre performance, and the value of the firm can drop when the restriction forces firms to reduce managerial talent or effort. We also identify those types of restrictions that firms can easily circumvent and that are therefore ineffective.

There is a heated and ongoing debate in the literature on whether executive compensation is efficient or not. While some studies produce evidence that observed pay is by and large efficient, other papers argue that contracting is inefficient and point out pay arrangements that are difficult to reconcile within the efficient contracting paradigm.[1] Our model combines these two aguments. We analyze the effect of restrictions on CEO

[1] In a highly influential book, Bebchuk and Fried (2004) argue that executive compensation in the United States is dysfunctional as managers capture the pay-setting process and use ever more complex compensation arrangements to camouflage the excessive size of their pay packages. See also Bebchuk and Fried (2003), Bebchuk, Cremers, and Peyer (2007), and Bebchuk, Grinstein, and Peyer (2009). Kuhnen and Zwiebel (2007) provide an explicit economic model of the pay process that also incorporates the Bebchuk-Fried notion of "camouflage" and "hidden pay," and Kuhnen and Niessen (2009) document that public opinion affects executive compensation. On the other hand, Core, Guay, and Thomas (2005) and Edmans and Gabaix (2009) provide a critical review of Bebchuk and Fried's reading of the literature. They argue that many controversial contracting practices as well as general pay levels can be reconciled with the efficient contracting paradigm.

pay for those firms where the pay setting process is efficient in the sense of Pareto efficiency. Hence, we allow for the possibility that CEOs are powerful, capture the pay-setting process, and extract rents, but we assume that they extract rents efficiently so that CEOs and boards maximize the joint value of the firm to shareholders and to the CEO. Put differently, in our model the structure of the contract provides the correct level of incentives and implements efficient risk-sharing, but the level of pay may reflect some transfer of value from the firm to the CEO.

We recognize that our argument does not fully capture the perspective of the rent-extraction view and the potential rationales of the proponents of pay regulation. In particular, our presumption of efficient rent extraction rules out interventions intended to address market failures. For example, Acharya and Volpin (2010) model an economy in which firms can provide incentives either through compensation contracts or through improved governance, but firms do not internalize the fact that opting for weaker governance and more incentive pay increases CEOs' outside options and therefore the economy-wide level of compensation. Outside interventions may address such governance externalities and general equilibrium effects, but they are outside the scope of our analysis, which considers each firm in isolation.[2] Market failures may also result from turnover costs or from the limited disclosure of executive pay.[3] None of these arguments, however, gives rise to a calibratable model of executive compensation. We therefore cannot quantify the potential efficiency gains from mitigating market failures through pay restrictions. We partially address this limitation by excluding poorly governed firms from our analysis. In these firms, contracting may not just transfer value to the CEO but may also be inefficient. Bertrand and Mullainathan (2000a, 2000b, 2001) and Kim and Lu (2009) produce evidence that contracting is efficient for firms with good corporate governance and we therefore restrict our analysis to firms where contracting is likely to be efficient. More specifically, we follow Bebchuk, Grinstein, and Peyer (2009) and require that all members of the compensation committee are independent directors.

The analysis of the paper has two parts, each of which discusses a model that is

[2]See also Dicks (2010) for a similar model of governance externalities and general equilibrium effects in the managerial labor market.

[3]Limited disclosure is the basis of Bebchuk and Fried's (2004) argument that CEOs extract rents through "hidden compensation," i.e., benefits that are not visible to outside observers and that result in efficiency losses. We know of no satisfying model of hidden compensation and the efficiency losses it entails. Similarly, turnover costs may lead to managerial rents when firms find it difficult to replace their current CEOs. Taylor (2010) estimates these turnover costs and shows that they are large.

tailored to a particular purpose. In the first part of the paper, we analyze restrictions on ex post payouts and on the structure of compensation contracts. We calibrate a principal-agent model with a loss-averse CEO to each of the 796 CEOs in our data set, so that the model predicts observed compensation contracts if no restrictions on pay are imposed. Dittmann, Maug, and Spalt (2010) show that this model can generate meaningful option holdings, and we extend this result by showing that the model can be calibrated for most CEOs such that it *exactly* reproduces stylized observed contracts. When we analyze restrictions with this model, we assume that firms want to provide the same effort incentives as before and that externally imposed restrictions on compensation do not change the balance of power between the board and the CEO. Consequently, we assume that restrictions on CEO pay do not affect the effort choice of the CEO or the rents the CEO might obtain. These assumptions are plausible for restrictions on pay that are externally imposed, for example through legislation. If restrictions are imposed by large shareholders, then the bargaining power between the board and the CEO may also change.

We first address restrictions of the total level of realized CEO pay. This rule is based on the notion that the total payout to the CEO when she leaves the firm and sells all her shares and options should not exceed a certain dollar amount in order to avoid public outrage. Restrictions of this type are in line with public demands, now enshrined in legislation in some countries, that boards should "stress test" compensation plans to avoid ex post high realizations of pay. Since compensation that involves restricted stock or standard stock options is potentially unlimited, such a cap can be implemented only with stock appreciation rights or phantom stock that includes a limited upside, but is otherwise identical to standard securities used to pay executives. Our results indicate that such a restriction has three, probably unintended consequences. First, on average, pay increases. If firms wish to prevent extremely large payouts for extreme performance, then incentive provision requires more high-powered compensation contracts for mediocre performance and therefore a higher risk-premium. For example, if firms limit ex-post pay to three times its expected ex-ante value, average compensation costs increase by 3.1%, and pay for mediocre performance increases by 14.9%.

Second, in some cases CEOs may be better off and extract higher rents if pay is restricted compared to the case where no restrictions are in place. The reason is that pay restrictions result in more high-powered contracts below the cap. As the downside of CEO pay is limited due to limited liability, contracts can often be high-powered only if the CEO earns a rent and is better off than without a cap. In the above example, 8.5% of all CEOs are better off and on average extract an additional rent worth 13.2% of their observed pay.

Third, risk-taking incentives decline as restrictions become more severe. Intuitively, restricted contracts are more concave because of their limited upside. For the observed contracts in our sample we estimate that CEOs would accept projects that increase the firm's annual standard deviation of stock returns by one percentage point as long as firm value increases by at least 0.2%. For restricted contracts this threshold would increase more than fourfold to 0.9% and we argue that many realistic projects that have a positive net present value but increase firm volatility would not be realized if restrictions on realized compensation were in place. We suspect that this consequence is also unintended for firms outside the financial industry. For these firms, concerns about insufficient entrepreneurial risk-taking incentives seem to be just as legitimate as concerns about excessive risk-taking.

We then analyze proposals to levy penalty taxes on particular components of pay and show that even in our highly stylized model, firms and CEOs have sufficient flexibility to contract around such taxes. Taxes on cash payments (salary and bonus) can be circumvented entirely at little cost by using more stock and less options, because stock is more valuable per unit of incentives than options. A tax on option pay can likewise be circumvented to a large extent by replacing options by more stock while cutting cash payments. Only a penalty tax on all forms of incentive compensation (stock and options) cannot be avoided easily. If stock and options are both taxed, firms will provide incentives through options only, because their value per unit of incentives is lower than for stock. As a consequence, risk-taking incentives increase to the point where most CEOs in our sample would be willing to take on risky projects even if these projects destroy some firm value.

In the second part of the paper, we shift our attention to restrictions on the total value of compensation, which cannot be addressed with a model that holds effort and talent constant. Faced with a restriction on the value of compensation, firms must decide on the optimal way to divide the value of compensation between variable compensation and fixed compensation. Variable compensation creates performance incentives, but is risky and therefore reduces the value of the contract to the CEO and will in all likelihood attract less talented CEOs. By contrast, a larger proportion of fixed compensation will make the contract more valuable and therefore potentially attract more talented CEOs, but will then induce less performance incentives. We therefore develop a model that is based on a simple production function where CEO talent and effort are the factors of production. We calibrate the model separately for each firm in our sample, and analyze the impact of a restriction on total CEO pay on firm value. Our model produces higher output elasticities of effort for firms where incentive provision is more important, in particular for firms with higher R&D expenditure. We show in a model with frictionless managerial labor markets that a realistic cap on the value of compensation has only a small impact on firm value: cutting CEO pay by 20% implies that firm value declines by 0.07%. In absolute terms, firm value declines by $0.12 for each dollar of the 20% cut in compensation.

Several other papers propose models for the executive labor market. Our model is closest in spirit to Murphy and Zabojnik (2004) and Gabaix and Landier (2008) who treat talent as a factor in the firm's production function. We extend their reasoning and also include incentive pay as a factor in the production function. To the best of our knowledge, we are the first to estimate the talent-effort trade-off empirically.[4] Our model is much simpler than the models in Edmans, Gabaix, and Landier (2009) and Sung and Swan (2009), because we do not model the moral hazard problem that gives rise to incentive pay. The simplicity of our model allows us to calibrate it for an individual firm and to generate predictions about the impact of pay restrictions on firm value.

There is an emerging literature on pay restrictions. The paper closest to ours is Llense (2010), who uses an assignment model and also finds that caps have only a moderate impact on shareholder value. Her model ignores effort choice and does not address restrictions that also affect the structure of compensation contracts. Garner and Kim (2010) provide evidence on a regulation in South Korea, where shareholders have to vote on the maximum amount of compensation that managers can receive. This regulation is more akin to say-on-pay rules and different from restrictions imposed by regulators or through legislation. Several papers address compensation in the financial services industry in the wake of the financial crisis. Bolton, Mehran, and Shapiro (2010) argue that linking executive pay to debt prices (credit default swaps) would improve (i.e., reduce) risk-taking incentives, but that such contracts may not be optimal from the perspective of shareholders. Thanassoulis (2010) develops a theoretical argument for caps on bankers' bonuses. Cadman, Carter, and Lynch (2010) show that TARP restrictions on pay deterred firms from participating in the government-sponsored bailout program in the US. None of these papers develops a model that incorporates effort choice and

[4] In contemporaneous research, Edmans and Gabaix (2010) also formulate a model that includes effort incentives as well as talent and they calibrate their model to firms in the S&P 500.

none of them addresses the impact of restrictions on realized compensation payments.

The remainder of the paper is organized as follows. The next section discusses the institutional context and some of the proposals on regulating top executive pay. Section 3 presents our model of optimal compensation. Section 4 describes our data set and how we calibrate the model to the data. Section 5 analyzes the impact of caps and taxes on total realized payouts. Section 6 discusses restrictions on individual components of pay. Section 7 analyzes the impact of restrictions of the value of total compensation on the value of the firm, and Section 8 concludes.

2 Proposals on regulating executive pay

The public debate on executive pay. Demands to regulate and restrict top executive compensation recur, especially in times of economic crisis. Public commentators demanded curbs on executive pay in the Great Depression, complaining about "corporations in the red paying excessive salaries" (Sen. Burton Wheeler, 1934).[5] At the end, the US eschewed more radical proposals to legislate against excessive compensation and relied on market mechanisms instead. In particular, companies had to publicly disclose compensation, a requirement that was successively tightened in subsequent reforms. Between 1971 and 1973, executive compensation fell under general wage controls imposed by the Nixon administration to curb inflation.[6] After 1992, the Clinton administration taxed fixed compensation in excess of $1 million that is not performance related. Finally, the recent financial crisis produced a flurry of proposals to reform executive pay as well as concrete legislative proposals. We group proposals to restrict executive compensation into three groups, which we discuss in turn: (1) restrictions on ex post realized compensation, (2) restrictions on the ex ante value of compensation, and (3) restrictions on specific components of pay.

Proposals to restrict realized compensation. Realized compensation payments can be high if a significant part of compensation is paid in the form of stock or options.

[5]One source for the historical debate on executive pay in the U.S. is an unpublished and untitled note by David Yermack. We are grateful to David Yermack for letting us have this note, from which we take this citation. He attributes the citation to Sen. Burton Wheeler, quoted by the New York Times March 5, 1934. See also Dew-Becker (2008) and Wells (2010), who review the history of executive compensation regulation.

[6]Crystal (1991) reports that the first version of pay controls imposed a 5% cap on all pay increases, even if executives changed firms, which reduced turnover. The second version allowed pay increases only if executives changed firms, which then increased managerial turnover.

After unusual events, for example a CEO's departure, a takeover, or extreme changes in the company's stock price, shareholders and journalists typically scrutinize the realized value of the CEO's compensation. Large realized pay then often receives a lot of negative news coverage, with claims that these payments are unjustified. Boards of directors might therefore want to restrict such high terminal payouts. Politicians may also attempt to restrict realized pay, but due to legal and constitutional obstacles they can typically only appeal to the board of directors to implement restrictions. Some recent examples include:

- The "2009 Executive Compensation Principles" by the Canadian Coalition for Good Governance stipulate: "Boards should formally 'stress test' a number of possible scenarios to see how their compensation plan will react to future external and internal events to ensure that there are no windfalls for unsustainable performance."

- In the summer of 2009, the German parliament passed a law on the "Adequacy of management board compensation," which includes the requirement that the supervisory board should provide for the possibility of limiting pay in case of "exceptional developments." The law is ambiguous and does not specify what would qualify as "exceptional". It imposes a general norm that should be followed rather than concrete binding restrictions.

- The Dutch Corporate Governance Code, which follows the comply-or-explain principles, states: "The supervisory board shall determine the level and structure of the remuneration of the management board members by reference to the scenario analyses carried out and with due regard for the pay differentials within the enterprise." The requirement for scenario analysis indicates that boards should stress test compensation plans to ensure that "pay differentials" stay in line with acceptable norms.

Hence, regulation in Canada, Germany, and The Netherlands all require boards to pay explicit attention to the design of compensation plans with respect to scenarios that may lead to large payouts to executives. Boards should "stress-test" compensation plans and ensure that they avoid "windfalls" and "exceptional developments."

Legally binding standards may be difficult to implement. In *Rogers vs. Hill,* the U.S. Supreme Court ruled that total *ex post* pay was too high in American Tobacco in 1933. A shareholder complained against a company by-law that gave 10% of profits above a historical benchmark value to the six top executives of the firm and argued that the resulting amounts were too high. The court did not rule against the by-law but still in favor of the plaintiff when it argued: "But the rule prescribed by it [the by-law; the authors] cannot, against the protest of a shareholder, be used to justify payments of sums as salaries so large as in substance and effect to amount to spoliation or waste of corporate property." This decision was generally seen as an error and did not become a precedent for subsequent cases.[7]

Proposals to restrict the value of compensation. There is also a more general concern with the overall level of executive compensation, and several proposals address the total value of compensation:

- There are recurring proposals that compensation of top management should not exceed some multiple of the lowest-paid worker in the firm. Chrystal (1991) traces this argument back to Plato, who recommended that this multiple should not exceed five. In modern times, J. P. Morgan ordered that CEOs of Morgan firms should not be paid more than twenty times the wage of the lowest-paid worker (see Crystal, 1991, p. 24). Morgan's policy was endorsed more generally by Peter Drucker in an essay in 1984.[8]

- The American Recovery and Reinvestment Act, signed into law on Feb. 17, 2009, limits tax-deductible executive pay to $500,000 for all recipients of any Troubled Asset Relief Program (TARP) financial assistance, including both past and future recipients under the Capital Purchase Program. The limitation applies to any compensation that is earned in the current year, even if payment is deferred to a later tax year.[9]

- The German Financial Markets Stabilization Act (Finanzmarktstabilisierungsgesetz) that became effective on 18 October 2008 empowers the government to

[7]Lower courts argued in new cases that they are not comparable to this one and the supreme court did not accept any new cases. See Wells (2010) for more details and http://caselaw.lp.findlaw.com/scripts/getcase.pl?court=US&invol=582&vol=289 for the full ruling.

[8]Drucker had agreed to a multiple of twenty-five in an earlier essay in 1977. See Byrne, John A.; Gerdes, Lindsey, Business Week, November 28, 2005, "The Man Who Invented Management." (http://www.businessweek.com/magazine/content/05_48/b3961001.htm). Year after year this proposal is introduced in the U.S. Senate by a democratic senator. Every year it is delegated to a committee and is voted down within the committee. It is never voted on in the Senate.

[9]Source: http://www.crowehorwath.com/crowe/Publications/detail.cfm?id=2041. Kim (2010) finds that TARP recipients experienced negative abnormal stock returns on the days when the restrictions were announced.

formulate and enforce restrictions on executive compensation for all firms that receive government aid from the stabilization fund. Subsequent government regulation from 20 October 2008 restricts total annual executive compensation to 500,000 Euro for these firms. The strict rules on executive compensation are probably the reason why many financial institutions (including Deutsche Bank) never accepted any money from the stabilization fund.

- BMW announced in October 2009 that they would increase CEO pay at the same rate as regular workers' pay in the future. This announcement is probably intended to reduce public pressure on the company and to win a particular group of customers.

The "multiple per lowest-paid worker" standard is legally difficult to implement because it can be avoided easily through outsourcing activities with low-paid workers. The TARP standard and the German Financial Markets Stabilization Act apply only to a small, though significant, subset of firms.

Proposals to restrict components of pay. Restrictions on pay components are popular, because they are often feasible. Over time, particular pay components have gained or lost popularity with politicians and the general public. Clinton's one-million-dollar rule demonstrates that in the 1990s the majority was concerned with high pay that is not linked to performance; this rule discriminates against fixed salary and restricted stock and made bonus payments and stock options more desirable.[10] The current debate shows that the public is concerned with risk-taking incentives, so they want to limit incentive pay, in particular option-like pay and bonus payments that are contingent only on short-term performance. High base salaries that were seen as problematic in the 1990s do not raise eyebrows in 2009. Severance pay is also often seen as problematic as it seems to provide a reward for poor performance, and has also been ruled out by TARP.

3 A model of contracting on CEO pay

We use the contracting model of compensation developed in Dittmann, Maug, and Spalt (2010) (henceforth DMS), which is a standard principal-agent model with unobservable

[10] Rose and Wolfram (2002) show that Clinton's rule had no effect on the growth of executive compensation or on incentives.

effort where managers are loss averse. This model is particularly suitable for our task because it incorporates options as part of the optimal contract and it is easy to calibrate to data.[11] We sketch the salient features of the model here and provide an intuitive description. DMS contains a more detailed analysis as well as formal proofs.

In this model, shareholders or the board make a take-it-or-leave-it offer to the CEO for a wage contract that consists of a fixed salary ϕ, a number of shares n_S, and a number of options n_O with a strike price K. The contract is for a period of T years, and this time horizon also represents the maturity of the stock options of the CEO. The wage $\tilde{w}$ of the CEO therefore depends on the end of period stock price as:

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

The end of period stock price P_T depends on the CEO's effort $e \in [0, \infty)$ and on a random variable u, which is distributed standard normal:

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

where r_f is the riskfree rate of interest, σ is the annualized volatility of log stock returns, and P_0 is the current stock price. Hence, the stock price P_T is lognormally distributed and the log return $ln\left(P_T/P_0\right)$ over T years is distributed normal with mean $r_f T$ and variance $\sigma^2 T$. Our use of the lognormal distribution follows the prior literature (see Dittmann and Maug (2007) and the references they cite). We have not explored other distribution models. However, option pricing models that improve on distributional assumptions typically favor thick-tailed distributions and we conjecture that the impact of caps on CEO pay would become more pronounced with distributions that have more probability mass in the upper tail of the distribution.

The managers' preferences are separable in income and effort and the manager is loss-averse. We denote the costs of effort by $C(e)$ and assume that these costs are

[11] DMS show that the optimal contract in the loss aversion model is convex for all realistic levels of future stock prices. In contrast, in the traditional model with an effort-averse and risk-averse manager, optimal contracts are always concave (see Dittmann and Maug (2007)). As a consequence, the risk aversion model cannot explain why shareholders do not voluntarily restrict the high payouts for very good outcomes that are observed in practice. There are a few other extensions of the risk-aversion model that can explain option holdings. For instance, Oyer (2004) models options as a device to retain employees when recontracting is expensive, but neither this model nor several others have been calibrated to data.

increasing and convex in effort e. The CEO's payoff is $U(\tilde{w}) - C(e)$, with

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

This preference specification follows Tversky and Kahneman (1992). Here w^R denotes the reference wage and λ is the degree of loss aversion. If the wage $\tilde{w}$ is above the reference wage, the CEO regards the difference to the reference wage $\tilde{w} - w^R$ as a gain, whereas she recognizes a wage below the reference wage as a loss. The loss-aversion parameter $\lambda > 1$ reflects the notion that losses have a larger impact on the CEO's utility than gains of comparable size. U is concave over gains, but convex over losses. The parameter α describes the curvature of the payoff function and captures the diminishing sensitivity of the CEO to gains as gains become larger, and to losses as losses become larger.[12]

Given the payoff from the contract, the CEO will choose a certain effort level e. We assume that, in the initial setting without any restriction on CEO pay, the observed contract is optimal, i.e. it implements the optimal (second-best) effort level. Denote the observed contract by (ϕ^d, n_S^d, n_O^d), where the superscript 'd' stands for 'data.' The contract then provides the CEO with utility $E\left[U(\tilde{w}) - C(e) \,\middle|\, \phi^d, n_S^d, n_O^d, e\right]$ and with effort incentives $\frac{d}{dP_0}E\left[U(\tilde{w}) \,\middle|\, \phi^d, n_S^d, n_O^d, e\right]$. These effort incentives are the pay-for-performance sensitivity, adjusted for the preferences of the CEO. If we replaced $U(\tilde{w})$ simply with $\tilde{w}$, then we would obtain the standard, risk-neutral definition of the pay-for-performance sensitivity. This is equal to $n_S + n_O N(d_1)$ in our case, where $N(d_1)$ is the Black-Scholes option delta.

We introduce restrictions on CEO pay in two different ways: First, restrictions can change the functional form of the contract (1), for instance if we cap ex post realized payouts from above. Second, restrictions can take the form of a tax and therefore make contracting more costly and work through the shareholders' objective function. We assume that shareholders want to keep the current CEO and to implement the same effort level as before. Shareholders will therefore choose a new contract (ϕ^*, n_S^*, n_O^*) that is eligible and that provides the CEO with at least as much utility and effort incentives

[12] For our numerical calibrations, we rely on the experimental literature and use $\alpha = 0.88$ and $\lambda = 2.25$. These values have become somewhat of a standard in the literature, see for example Tversky and Kahneman (1992), Benartzi and Thaler (1995), and Barberis and Huang (2008). For experimental studies on the preference parameters see Abdellaoui (2000) and Abdellaoui, Vossmann, and Weber (2005). These studies yield similar parameter values.

as the observed contract. More formally, the new contract must satisfy the incentive compatibility constraint

$$\frac{d}{dP_0}E\left[U(\tilde{w})\,|\phi, n_S, n_O\right] \geq \frac{d}{dP_0}E\left[U(\tilde{w})\,\middle|\phi^d, n_S^d, n_O^d\right], \tag{4}$$

and the participation constraint

$$E\left[U\left(\tilde{w}\right)|\phi, n_S, n_O\right] \geq E\left[U\left(\tilde{w}\right)\middle|\phi^d, n_S^d, n_O^d\right], \tag{5}$$

where the costs of effort, $C(e)$ drop out of the participation constraint as effort, and therefore the cost of effort, is held constant. Recall from our discussion in the Introduction that the last assumption does not imply that CEOs are not powerful or that they cannot extract rents. Rather, we take the value of rents to the CEO as given and assume that externally imposed restrictions on pay do not change the balance of power between the CEO and shareholders. Then, whatever level of rents the CEO obtains under the old contract will carry over to the new contract after restrictions are imposed.

The shareholders' problem is therefore to minimize expected costs of contracting $E[\tilde{w}]$ subject to the two constraints (4) and (5). In addition, we require that fixed salary ϕ, and stock holdings n_S, and total wage $\tilde{w}$ are non-negative. Intuitively, we are looking for a contract that minimizes compensation costs to shareholders, is acceptable to the CEO, and implements a level of effort not below the one induced by the observed contract. DMS show that with mild assumptions the contract that solves this optimization problem is unique, so the agent indeed chooses the same level of effort under the new contract.[13] For brevity, we shall refer to the optimal contract (ϕ^*, n_S^*, n_O^*) that is predicted by the model as the model contract.

The strength of the modeling approach developed in this section is that we do not need any information about the functional form of the production function $P(e)$ or the cost function $C(e)$, because the constraints (4) and (5) can both be evaluated independently of these functions, which we therefore do not need to parameterize. However, this modeling approach comes with a cost, because it cannot address the expected value of compensation and does not allow firms to adjust the level of effort if pay restrictions make the old effort level too costly to achieve. The second model, which we analyze in Section 7 below, can address the level of compensation.

[13]The main condition is that the cost function $C(e)$ of the CEO is sufficiently convex so that the overall objective $U(\tilde{w}) - C(e)$ is globally concave.

4 Data and Calibration of the model

4.1 Data set

We base our analysis on ExecuComp, which contains the details of the compensation contracts of the 1,500 largest listed U.S. firms. We select all executives who are CEO for the whole year 2006, who work for the same firm in years 2005 and 2006, and who are not listed as executives of another firm in 2005 or in 2006.[14] This leaves us with 1,407 CEOs. We construct the approximate option portfolio at the end of the 2005 fiscal year using the algorithm proposed by Core and Guay (2002) and aggregate this option portfolio into a representative option as described in Dittmann and Maug (2007). Effectively, we set the strike price and the maturity of the representative option such that the representative option has the same value and the same Black-Scholes delta as the observed portfolio of options. This aggregation of the option portfolio is necessary, because this portfolio typically contains options with different maturities that cannot be described in a one-period model. In this way, we obtain the number of options, n_O, the option strike price K, and the option maturity T. Likewise, we take the number of shares held by the CEO, n_S, from the end of 2005. Both variables, n_S and n_O, are expressed as the proportion of total shares outstanding.

We define fixed salary ϕ as the sum of salary, bonus, and "all other compensation" (e.g. perquisites or insurance premia) from 2006. We include bonus payments, because prior literature has shown that these payments are only weakly related to stock returns (see Hall and Liebman, 1998). ExecuComp also provides us with the firm's market capitalization P_0 at the end of 2005 and the dividend rate d during 2005. For the risk-free rate r_f, we use the yield of the 5-year U.S. government bond in January 2006. Next, we use CRSP data to calculate the firm's stock return volatility σ from daily stock returns from fiscal year 2006. We lose 26 observations because of insufficient data for the volatility calculation, and another 54 observations, because our algorithm failed to find a representative option.

Our calibration method is based on the assumption that observed contracts are efficient in the sense that risk-sharing and incentives are optimal. We cannot measure the efficiency of contracting directly and therefore use the independence of the compensa-

[14] We do not perform our analysis for a more recent year for two reasons. First, we cannot construct our sample consistently for 2007, because there was a significant change in the reporting standard in 2006; some firms reported according to the new standard while other firms still used the old standard. Second, we did not choose 2008 and 2009 to avoid using data from the financial crisis.

tion committee as a proxy for efficient contracting. We follow Bebchuk, Grinstein, and Peyer (2009) and require that all members of the compensation committee are independent. We match our data with RiskMetrics and delete the 134 CEOs from those firms where at least one member of the compensation committee was not independent in 2005. In this step, we also lose 349 CEOs because of missing data in RiskMetrics. Table 1 shows descriptive statistics for the remaining sample of 844 CEOs in Panel A. Since we lose many observations through matching with RiskMetrics we also report the same statistics before matching in Panel B.

[Insert Table 1 here.]

The table shows that the median CEO owns 0.24% of her firm's stock and has options on another 0.79% of the firm's equity. Median fixed salary is \$1.03m. Options are considerably in the money with median moneyness 73.3%, and their median maturity is 4.8 years. Our sample contains large firms with a median (average) market capitalization of \$2.636bn (\$9.707bn) and a median annualized stock return volatility of 27.4%. The table also describes the value of the contract $\pi = \phi + n_S P_0 + n_O BS$, where BS is the Black-Scholes value of the representative option. The median (average) value of the contract is \$23.6m (\$95.6m). Comparison of Panels A and B shows that matching with RiskMetrics selects in favor of larger, less volatile firms with higher median contract values. The lower average contract value for the smaller sample can be attributed to the elimination of some outliers through matching. The structure of compensation contracts is remarkably similar for the samples before and after matching.

We repeat the entire analysis of the paper for the year 1999, the first year for which membership of the compensation committee is available from RiskMetrics. The year 1999 is significantly different from 2006, with more volatile firms, more valuable compensation contracts, and a compensation structure that leans more towards stock rather than options. Still, we find that all our conclusions hold for 1999 as well (results not tabulated).

4.2 Calibration of the model

Our strategy is to introduce restrictions on compensation contracts into our model and to numerically calculate the optimal contract (the "model contract") under these restrictions. In the next step, we compare the model contract with the observed contract in order to describe how contracts would change if the considered restriction could be implemented. This approach is meaningful only if our model predicts the observed contract for the case without restrictions on pay. We therefore calibrate the CEO's reference wage w^R such that the observed contract coincides with the model contract in the absence of any restrictions on CEO pay. This subsection explains in detail how we perform this step.

Neither prospect theory nor the experimental literature provides us with much guidance regarding the reference wage of the CEO. The main idea is therefore to determine the reference wage such that the observed contract coincides with the model contract. For this step we restrict the reference wage to lie within a reasonable range. We proceed in three steps: First, we solve the model by minimizing expected compensation $E[\tilde{w}]$ subject to the incentive compatibility constraint (4) and the participation constraint (5) for a given reference wage w^R. Then we calculate the distance $\left|n_S^* - n_S^d\right|$ between this model contract (ϕ^*, n_S^*, n_O^*) and the observed contract (ϕ^d, n_S^d, n_O^d). Note that accurate approximation for one parameter implies accurate approximation for all parameters, because the model has two constraints and optimizes over three parameters. Finally, we search for the reference wage w^R that minimizes the distance $\left|n_S^* - n_S^d\right|$ and require that this distance does not exceed 10^{-6}. In this way, we identify the reference wage for which the model contract is identical to the observed contract. We shall refer to this value for w^R that rationalizes the observed contract as the *implied reference wage*.

To better compare these implied reference wages across CEOs, we follow DMS and represent the reference wage as the sum of fixed salary and a proportion $1 - \delta$ of the market value of stock and options:

$$w^R(\delta) = \phi + (1 - \delta) \cdot MV(n_S^d, n_O^d).$$

Here MV represents the market value of the CEO's stock and options and δ can be interpreted as the discount the CEO applies to her deferred compensation. If $\delta = 0$, then there is no discount and the reference wage equals the market value of the CEO's compensation in the previous period. If $\delta = 1$, then the discount is 100% and stock and options do not enter the formation of the reference wage at all so that the reference wage then equals fixed compensation. We restrict δ to lie within the unit interval, which implies that the reference wage lies between last year's fixed compensation and the market value of all compensation. Table 2 shows descriptive statistics for the implied reference wages parameterized by the discount δ.

[Insert Table 2 here.]

The table shows that for 85.0% (or 717) of the CEOs in our data set, we obtain two solutions for the reference wage.[15] The solution with the higher discount δ has an average discount of 90%, whereas the discount for the second solution averages 66%. For 79 CEOs (9.4%), we find exactly one solution with an average discount δ of 72%. For the remaining 48 CEOs (5.7%), there does not exist any reference wage for which the model can replicate the observed contract. A close inspection of these 48 CEOs shows that they manage smaller and more volatile firms, and get almost no stock (results not tabulated).[16]

In the remaining part of the paper we therefore work with the subsample of 796 CEOs for which a solution for the implied reference wage exists. If we obtain two solutions, we use the solution with the lower value for the discount δ, which seems more plausible and is also closer to the values we obtain if there is only one solution. In unreported results, we repeat our main analysis for the higher value of the discount δ and find very similar results.

5 Restricting total realized compensation

We now ask how the optimal contracts would be different if we imposed restrictions on compensation contracts. The first restriction we look at is an *ex post* restriction, such that realized compensation cannot exceed a certain threshold. This restriction would apply to a CEO who leaves her firm and immediately cashes in all her options and shares. The resulting high realized payouts might trigger public criticism or outrage, and the laws in some countries (e.g., Canada, Germany, The Netherlands) have put compensation committees on notice that they should stress-test their compensation contracts and avoid excessive payouts.

Legal standards on this question are vague and lack the precision we require for our modeling purposes. In particular, we need to relate the realized payouts that qualify as excessive to some measure of average or typical compensation. We use the expected payout under the observed contract of the CEO, $E\left[\tilde{w}^d\right]$, as a benchmark, because this

[15]To allow for multiple solutions, we first perform a grid search with 100 grid points for δ between 0 and 1. Then we identify the intervals in which $n_S^* - n_S^d$ changes signs, and finally perform a numerical minimization within these intervals.

[16]For one of these 48 CEOs, we find a solution with $\delta < 0$. For another CEO, the model contract has a corner solution at $n_S = 0$ for all $\delta \in [0,1]$, so that we cannot identify an implied δ. For the remaining 46 CEOs, we find no solution. In these cases, $\left|n_S^* - n_S^d\right|$ achieves a minimum for some $\delta \in [0,1]$, but this minimum exceeds 10^{-6}.

amount can be regarded as typical and therefore not objectionable for a particular company. Our model above takes the firm's choice of CEO and her effort as given and therefore cannot say anything about the determinants and the acceptability of average or expected pay itself. We address such questions in Section 7.

We define pay as excessive if it exceeds expected pay $E\left[\tilde{w}^d\right]$ by more than a prespecified multiple M. More formally, we require that the wage function for the capped contract, which we denote by $\tilde{w}_{Cap}$, satisfies $\tilde{w}_{Cap} \leq M \cdot E\left[\tilde{w}^d\right]$. Note that $E\left[\tilde{w}^d\right]$ is the market value of the entire observed compensation contract that also includes options and stock granted in previous years or held voluntarily by the CEO. So, if $M = 5$ and the market value of the CEO's contract is \$20 million, then we only consider wage functions that never pay out more than \$100 million for any realization of the stock price. The shape of the contract therefore becomes:

$$\begin{aligned} \tilde{w}_{Cap} &= Min\left\{M \cdot E[\tilde{w}^d], \phi e^{r_f T} + n_S P_T + n_O \max\left(P_T - K, 0\right)\right\} \\ &= \phi e^{r_f T} + n_S P_T + n_O \max\left(P_T - K, 0\right) \\ &\quad -(n_S + n_O) max\left(P_T - K - \frac{M \cdot E\left[\tilde{w}^d\right] - \phi e^{r_f T} - n_S K}{n_S + n_O}, 0\right). \end{aligned} \tag{6}$$

The wage function in (6) imposes a ban on all payouts in excess of $M \cdot E\left[\tilde{w}^d\right]$.[17] The capped contract has therefore the shape of a bull spread, which is long in a call option with strike price K, and short in a call with strike price $K + \frac{M \cdot E\left[\tilde{w}^d\right] - \phi e^{r_f T} - n_S K}{n_S + n_O}$ that exactly counterbalances the impact of shares and options so that pay cannot increase above the cap. This structure cannot be implemented with plain vanilla stock options, but could be implemented with stock appreciation rights and is similar to many bonus schemes, which also cap maximum payouts (see Healy, 1985, and Murphy, 1999).

It may not be possible to find an optimal contract $\tilde{w}_{Cap}$ that satisfies the two constraints (4) and (5) and the additional constraint $\tilde{w}_{Cap} \leq M \cdot E\left[\tilde{w}^d\right]$ if M is too small. The reason is that M restricts the incentives the contract can provide, so that the incentive compatibility constraint (4) might not be satisfied. We calculate the minimum M for which the model contract can still be found for each CEO. We find that the average minimum M is 2.1 and that the minimum M is smaller than three for 753 CEOs in our sample (results not tabulated). For these 753 CEOs, we calculate the model contracts

[17]We assume that the options are in the money when the cap is reached and that the strike price for the second option in (6) is higher than K, or, more formally: $\phi e^{r_f T} + n_S K < M \cdot E[\widetilde{w}^d]$. For our sample $\phi e^{r_f T} + n_S K$ exceeds $E[\widetilde{w}^d]$ for only four CEOs, and then only slightly.

for $M = 5$ and $M = 3$ and tabulate the results in Panels A and B in Table 3. Each panel shows descriptive statistics of the three parameters (fixed salary ϕ, the number of shares n_S, and the number of options n_O) of the model contract with the respective cap. The table also describes the distribution across CEOs of the change in expected costs, the change in the CEO's pay when the stock price at the end of the contracting period equals the stock price at the beginning of the period, and the probability that the CEO's pay increases. Finally, the table displays the proportion of CEOs whose certainty equivalent CE is higher under the model contract than under the observed contract and, for the subsample of CEOs where this is the case, the average and median increase in the CEO's certainty equivalent.

To provide a graphical representation of our results, Figure 1 displays the observed contract and three model contracts ($M = 5$, $M = 3$, and for the minimum M) for a representative CEO.[18] The figure displays total payouts in million dollars as a function of the stock price expressed as P_T/P_0. The slope to the left of the lower kink point, which corresponds to K, represents stock holdings, the slope to the right of this kink point represents the combined stock and option holdings, and the intercept is the fixed salary. The higher kink point corresponds to the strike price of the second call option, in which the CEO has a short position, so that the slope above this point is zero from the cap. The figure shows that optimal contracts with restrictions resemble a bull spread, which approaches a step function as M becomes small. For more severe restrictions (lower M) option holdings increase, stock holdings decrease, and fixed salaries decline. For the representative CEO, M cannot be lower than 2.3, that is, for values of M below 2.3 the optimization problem has no solution, because the incentive compatibility constraint can no longer be satisfied.

[Insert Table 3 here.]

Mediocre performance is rewarded more. One striking feature that is apparent from Figure 1 as well as from Table 3 is that a restriction on extreme payouts implies that intermediate payouts are now higher than in the observed contract: Mediocre performance is rewarded more if large payouts are prohibited. For $M = 3$, the model contract pays out more than the observed contract with 55% probability on average

[18]We choose the CEO whose parameter values are closest to the median values in our sample for the following parameters: salary ϕ^d, stock holdings n_S^d, option holdings n_O^d, firm size P_0, stock return volatility σ, time to maturity T, and moneyness K/P_0. We define "closest" as having the smallest maximum percentage deviation.

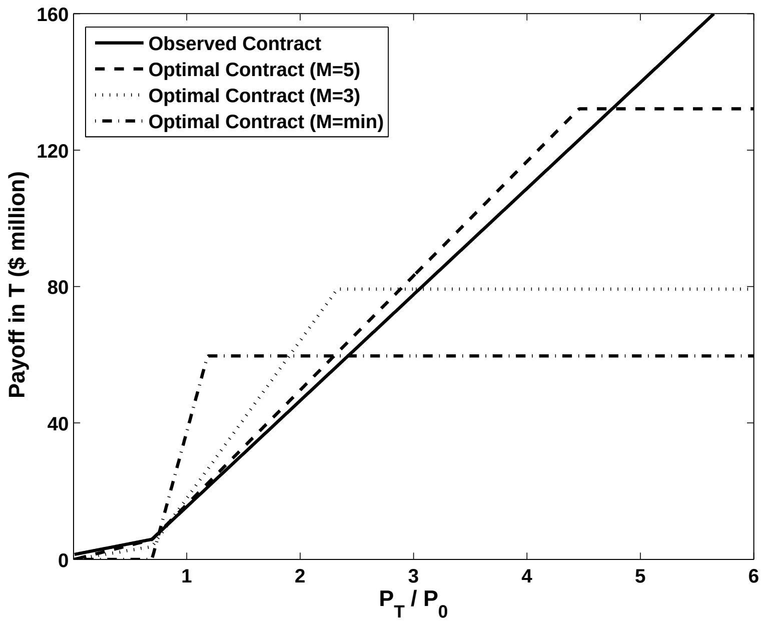

Figure 1: Cap on realized compensation. The figure displays the total payouts of four different contracts for a representative CEO. The solid line shows the payout of the observed contract while the broken lines show the payouts of three different model contracts where compensation payouts cannot exceed an upper threshold that is defined as a multiple M of expected pay. $M = min$ is the contract with the smallest multiple M for which we can find a contract that provides the agent with the same utility and the same pay-for-performance sensitivity as the observed contract. This minimum M is 2.3 for this CEO. The parameters are $\phi = \$1.1$ million, $n_S = 0.27\%$, and $n_O = 1.02\%$ for the observed contract. P_0 is \$2.42 billion, K/P_0 is 68%, $T = 5.8$ years, $\sigma = 31.2\%$, $r_f = 4.4\%$, and $d = 0$. The implied reference wage is \$5.3 million.

(see $Prob(\Delta payout > 0)$ in Table 3, Panel B), and the payout for an intermediate stock price $P_T = P_0$ increases on average by 14.9% (median: 4.6%, see $\Delta Payout$ at $P_T = P_0$). A cap reduces incentives from high payouts, so firms must resort to contracts that are more high-powered for intermediate payouts in order to provide the same effort incentives as in the observed contract. The lower the cap, the steeper the wage function has to be for intermediate stock prices. Hence, one - probably unintended - implication of caps on extreme payouts is that pay for more typical scenarios is higher.

Contracting costs increase. Restricting realized payouts *ex post* increases the costs of compensation *ex ante*. The reason is that contracting becomes less efficient if the contract has to satisfy an additional constraint. Incentives that were previously provided through payoffs above the cap must be replaced by less efficient incentives with payoffs below the cap. We find that the impact of restrictions on costs is small if $M = 5$, where costs increase by \$50,000 or 0.2% of total compensation costs for the typical CEO (see ΔExpected costs in Table 3, Panel A). However, for tighter restrictions, costs become more significant. The distribution of these costs is also skewed so that, for $M = 3$, average costs increase by \$2.25 million, but only by \$290,000 for the typical CEO. Note that our analysis provides an upper bound for the costs from adjusting contracts because our model does not allow for an adjustment of the optimal effort level. Providing firms with additional degrees of freedom, which they could use to adjust to restrictions on compensation contracts might reduce the costs from such restrictions.

Some CEOs are better off. In a few cases we find that capped contracts are not only more expensive for the firm but also more valuable to the CEOs. To provide the same incentives as the observed contract, the capped contract is much steeper below the cap. This steepness is achieved by replacing fixed salary and stock with options. Once fixed salary and the number of shares have been reduced to zero, the CEO earns a rent if steepness must be increased further to maintain incentives. For $M = 3$, this happens for 8.5% of the CEOs (see CE_higher in Panel B of Table 3) who then receive pay that increases their certainty equivalents on average by 13.2% (see ΔCE|CE_higher=1). Also, the representative CEO (see Figure 1) earns a rent of 11% if the multiple M is set to its lowest feasible value ($M = min = 2.3$). Note that our assumption that the lower bound on realized payouts is zero is rather extreme. For higher bounds the rents of CEOs and the number of CEOs who obtain rents would be higher. Hence, another - and almost surely unintended - consequence of caps on extreme payouts is that some CEOs are on average better off.

Risk-taking incentives decline. Restrictions on extreme payouts eliminate the convexity of observed contracts for high stock prices and, in this sense, make the model contract more concave. As a consequence, CEOs have a stronger inclination to avoid taking entrepreneurial risks. As a measure of risk avoidance, we use the Risk-Taking Hurdle (RTH) from Dittmann and Yu (2010):

$$RTH \equiv \left.\frac{dP_0/P_0}{d\sigma}\right|_{E[U(\tilde{w})|P_0]=const.} = -\frac{\frac{d}{d\sigma}E\left[U\left(\tilde{w}\right)|P_0\right]}{\frac{d}{dP_0}E\left[U\left(\tilde{w}\right)\right]}\frac{1}{P_0}. \tag{7}$$

RTH combines the CEO's risk aversion and the convexity of her contract. It measures how the CEO trades off an increase in firm risk against an increase in firm value. It is defined implicitly from holding the expected value $E[U(\tilde{w})|P_0]$ of the CEO's utility constant. An increase in risk by one percentage point increases the CEO's utility if and only if firm value increases by at least RTH percent.[19] We scale this ratio by P_0 in order to express the change in firm value as a percentage rather than as an absolute dollar amount.

RTH should be thought of as a hurdle rate. If a project increases firm risk by $\Delta\sigma$, then the CEO accepts this project if the relative increase in firm value from this project, $\frac{\Delta P_0}{P_0}$, is at least $RTH \times \Delta\sigma$. If RTH is positive, the CEO rejects some positive-NPV projects because they increase risk too much, and if RTH is negative the CEO accepts some negative-NPV projects that increase firm risk. Consider a project that results in a one percentage point increase in firm risk, for example, from 30% to 31%, and assume that $RTH = 0.5$. Then the CEO will not take the project unless it increases firm value at least by 0.5%, so she passes up some value-increasing projects. Similarly, if $RTH = -0.5$, the CEO will take the project as long as it does not destroy more than 0.5% of firm value, so she accepts some value-reducing projects. If $RTH = 0$, the CEO is indifferent between risk-increasing projects and risk-decreasing projects and always makes value-maximizing choices.

Table 3, Panel C displays descriptive statistics for RTH, both for the observed contract and for the model contract with $M = 3$ and $M = 5$. In the observed contract, RTH is positive for 544 CEOs (72% of the subsample considered in the table), which means that most CEOs are averse to increasing their firms' risk and reject projects that increase risk without a sufficiently strong increase in firm value so that $\Delta P_0/P_0 < \Delta\sigma \times RTH$. The average (median) RTH is 0.20 (0.22), which means that the CEO will adopt a project that increases volatility by one percentage point only if it increases firm-value by at least 0.2%. For the median firm in our sample with market capitalization of $2,636 million, this corresponds to a value of $5.3 million. When we introduce a cap in the model contracts, RTH increases for all CEOs in our sample. RTH is positive for 653 CEOs or 87% of our sample for $M = 5$, and for 97% of all CEOs in our sample if $M = 3$. The average RTH increases substantially from 0.20 in the observed contract

[19]Our measure of risk-taking incentives is effectively the utility-adjusted vega of the compensation contract, $\frac{d}{d\sigma}E[U(\tilde{w})|P_0]$, scaled by the utility-adjusted delta, $\frac{d}{dP_0}E[U(\tilde{w})]$, where the latter is the pay-for-performance sensitivity we introduced in (4) above. We hold the CEO's expected payoff constant and, using these utility-adjusted definitions, require $delta \times dP_0 + vega \times d\sigma = 0$ from the implicit function theorem. Then (7) follows.

to 0.90 in the restricted contract with $M = 3$. Hence, if the firm switches from the observed contract to the model contract, the CEO will also pass up all projects that generate between 0.2% and 0.9% (or, for the median firm, between \$5.3m and \$23.7m) additional firm value for each percentage point of additional volatility. These projects would be accepted under the original contract. If the firm has many such marginal projects, the firm's market value can decline considerably. It is unclear whether this consequence is intended or not. It probably is intended for CEOs in the financial industry, which has been criticized for excessive risk-taking during the financial crisis. It is less clear that a reduction of risk-taking incentives is also warranted for CEOs of companies in other sectors. For these CEOs an unintended consequence of restricting pay may be that restrictions blunt entrepreneurial incentives to accept risky projects that promise unlikely but large payoffs.

Taxes on realized compensation. So far we considered a ban on total realized pay in this section. An alternative for policy makers is to make undesirable compensation contracts more costly by introducing special taxes. We therefore also analyze (in unreported results) a tax on realized payouts that exceed a threshold $M \cdot E\left[\tilde{w}^d\right]$, and allow for standard contracts $\tilde{w}$ from (1) that consist of fixed salary, stock, and options. For this case, we obtain qualitatively similar results to those reported in Table 3, although the quantitative effect is less stark because a tax is a less stringent restriction than a cap. If we hold the threshold M constant and increase the tax rate, the firm replaces option pay and fixed salary by more stock pay, and option holdings become eventually negative to approximate the flat region of the payout in the case with a cap (see Figure 1). However, this result only obtains for sufficiently high thresholds M, because the incentive compatibility constraint forces firms to provide sufficient incentives. For a lower threshold M, firms might have to use options and pay taxes even it the tax rate is very high, simply because they otherwise cannot provide the necessary incentives. The case of a cap above ignores this confounding effect, because firms that cannot provide sufficient incentives with a given cap simply drop out of the analysis.

6 Restricting components of pay

While the previous section analyzes bans and taxes on payouts above a certain limit, we turn to taxes on components of pay in this section. We continue to use the stylized representation of CEO contracts in (1) and analyze taxes on fixed pay (salary plus bonus), taxes on option pay, and taxes on all deferred compensation (options plus stock).

[Insert Table 4 here.]

Taxes on salary and bonus. For the analysis of a tax on cash payouts, we consider a 50% tax on fixed compensation that exceeds a certain threshold. A tax of 50% on compensation corresponds to a loss of tax deductability of 33%, which is close to the U.S. federal tax rate of 35% on company profits. Note that, in the US, fixed pay above $1 million is taxed, but effectively this tax is evaded by declaring fixed salary as a bonus. We therefore ignore the existing $1 million rule and analyze a stricter rule which taxes all fixed payouts, including bonus payments.

Table 4 shows the results for four different levels of the threshold above which fixed pay incurs this additional penalty tax. We report the three components of the model contract, the tax that is incurred on the model contract, and the tax that would be incurred on the observed contract if companies would not adapt their compensation structure. By adjusting the compensation structure, firms save the difference between these two tax figures, but they incur an efficiency loss, which is the additional contracting cost of the model contract compared to the observed contract when taxes are ignored. The table also shows this efficiency loss.

We find that companies respond to a tax on fixed pay by simply shifting compensation away from fixed pay towards more stock and fewer options. For a $1 million threshold, median stock compensation increases from 0.28% to 0.32% of the outstanding shares, median option compensation declines from 0.77% to 0.74%, and the median fixed salary declines from $1.03 million to $0.98 million. The logic of these adjustments is that a share of common stock is approximately equivalent to a certain number of options plus a fixed payoff. Hence, companies can replace fixed pay by a combination of additional shares and fewer options, where the exchange ratio between the additional shares and the reduction of options follows from the incentive compatibility constraint (4). The number of options to be replaced then depends on the desired reduction in fixed compensation.

The model contract does not incur any taxes. Hence, the optimal compensation contract can maintain incentives as well as the CEO's expected payoff and avoid taxes entirely for all firms. The resulting contract is more costly and therefore less efficient from shareholders' point of view, but the efficiency loss is very small and amounts to about \$3,000 for the average CEO and is zero for the median CEO for a \$1 million threshold. The adjustment of the contract leads to slightly higher risk avoidance, RTH, since options are replaced with stock, and stock makes CEOs more averse to an increase in firm risk than options.

[Insert Table 5 here.]

Taxes on option pay. We model a tax on option pay by assuming that the tax would be imposed on the Black-Scholes value of all option pay. Table 5 shows the results for five different tax rates between 10% and 100%. For a 50% tax rate, median stock compensation increases from 0.28% to 0.45% and median option compensation declines from 0.77% to 0.54%. As options become a more expensive form of compensation, shareholders maintain incentives with stock rather than with options. Because stock generates higher payoffs for the CEO, the participation constraint then requires that fixed salaries decline. Table 5 shows that the median fixed salary drops to zero for all tax rates considered in the table. For more than 50% of the CEOs in our sample we therefore have a boundary solution, where the restriction that fixed salaries have to be positive becomes binding. At this point replacing even more options with stock becomes too expensive because fixed salaries cannot be lowered any further.

Unlike in the previous case with a tax on fixed pay, companies avoid the tax on options only partially. The reason is that the substitution of options and salaries for stock stops at the point where fixed salaries become zero and the non-negativity constraint becomes binding. For a 50% tax, companies avoid on average \$1.9 (= \$11.1 - \$9.2) million of taxes, but incur an average efficiency loss of \$0.5m, so total contracting costs are reduced by only \$1.4m relative to the observed contract. For most CEOs the efficiency loss is virtually zero. The average efficiency loss increases with the tax rate as the minority of firms that faces high efficiency costs when replacing options by stock are nevertheless willing to do so if the tax rate becomes high.

Finally, the hurdle rate RTH for accepting risky projects increases for the model contracts for any tax rate compared to the observed contract. Median RTH increases from 0.22 to 0.32.

[Insert Table 6 here.]

Taxes on all deferred compensation. The third case is similar to the previous case, only that now the tax is levied on stock and options and not just on options.

We again consider five tax rates between 10% and 100% in Table 6. The adaptations of contracts are the opposite to those in the previous two cases, but they are more dramatic. For example, if the tax rate is set to 50%, median option holdings increase from 0.77% to 1.48%, stock holdings decline to zero, and fixed salaries quintuple from \$1.0 million to \$5.0 million.

As both forms of incentive pay, stock as well as options, are taxed at the same rate, taxes cannot be avoided as easily by substituting one form of deferred pay for another. However, the dollar value of options required to provide one unit of incentives (in our case, the pay-for-performance sensitivity from (4)) is less than the dollar value of stock required to provide one unit of incentives. The tax rate per dollar is the same for stock and for options, so the additional tax burden per unit of incentives is higher for stock than for options. Intuitively, stock is equivalent to options plus fixed pay, so options plus fixed pay have one component that is not taxed under this scenario. Therefore, firms replace stock by options and fixed salary up to the point where the non-negativity constraint on stock holdings becomes binding. In this way, firms can reduce their tax burden significantly. For example, if the tax rate is 50%, net benefits are on average \$15.8 million, which consists of tax savings of \$17.0 million (= \$49.3m - \$32.3m) net of an efficiency loss of \$1.2 million.

As options replace stock, risk avoidance decreases and becomes negative for most companies for all tax rates considered. Therefore, under this tax regime, most CEOs have an incentive to accept negative NPV projects that increase firm risk. For a 50% tax rate, median RTH is -0.16, so the median CEO would be willing to see the firm value drop by 0.16% in order to increase firm risk by one percentage point.

Modeling a more realistic tax system: a robustness check. This section so far analyzes penalties on components of compensation that work like taxes, even though we have not explicitly considered taxes so far. This omission may potentially bias our results, because the tax system may have built-in biases that favor some compensation instruments over others. The penalty taxes we consider may even be efficiency enhancing if they neutralize the biases of the tax system.

We therefore repeat the analysis in Tables 4 to 6 for a stylized representation of the U.S. tax system.[20] We assume that CEOs pay income tax at a constant rate of 41% (state and federal taxes combined) and that companies can deduct compensation

[20]The modeling of the tax system follows Dittmann and Maug (2007), who provide a more detailed discussion (see their section VI.A).

expenses from corporate taxes, which they pay at a rate of 35%. Our definition of base salary includes all bonus payments. We assume that all these payments accrue to the CEO at $t = 0$ and we abstract from the one-million-dollar rule that can be circumvented when fixed salary is declared as a bonus. Stock options are granted at $t = 0$ and exercised at $t = T$. The CEO pays personal taxes and the company receives a tax credit at the exercise date of the options on the difference between the stock price and the strike price, $P_T - K$. We distinguish between restricted stock and unrestricted stock. Restricted stock is taxed at the personal level at the vesting date T and firms receive a tax credit at that time.[21] The CEO also pays personal taxes on dividend income. We do not consider capital gains taxes that may never be paid when the shares are never sold.

[Insert Table 7 here.]

Table 7 repeats the analysis in Tables 4 to 6 and reports the key results. For clarity we shall refer to the additional taxes on particular compensation items as penalty taxes in order to distinguish them from standard income taxes. For this analysis we do not recalculate the reference wage for each CEO and use the reference wage for the case without taxes instead. As a consequence, the model contract for the baseline case does not correspond to the observed contract as before and we cannot report efficiency losses or gains relative to the observed contract.

The results for the case in which fixed compensation is subject to penalty taxes (Panel A of Table 7, corresponds to Table 4) are virtually unchanged relative to the case without income taxes. Base salaries and option holdings are slightly lower, which means that the substitution of base salaries and options for stock takes places even more strongly. Similar comments apply to the cases in which only options are subject to penalty taxes (Panel B of Table 7, corresponds to Table 5) and to the case in which all deferred compensation is subjected to penalty taxes (Panel C of Table 7, corresponds to Table 6).

[21] We maintain this assumption in Panels A and B of Table 7. In Panel C, we do not distinguish between restricted and unrestricted stock, so that all shares are taxed at time T. The reason is that (in contrast to Panels A and B) shareholdings decrease in Panel C and restricted stock would otherwise become negative.

7 Restricting the total value of compensation

In this section, we address a conceptually different question: we investigate the implications of *ex ante* restrictions on compensation. This is in line with proposals that limit the total value of compensation, for example as a multiple of the pay of workers in the same company. The conceptual framework of Sections 5 and 6 is not suitable to address this question, because it is based on the idea that shareholders have already minimized the total value of compensation. Hence, a further reduction of total compensation is possible only if the incentive compatibility constraint or the participation constraint can be violated.

We formulate a new model where firms choose the level of incentive pay and thereby of effort. Here, a new trade-off arises, because companies now have to decide whether they want to award a higher level of variable compensation and reduce fixed compensation. Such a change provides more incentives and elicits a higher effort level, but leads to a higher risk premium and therefore a lower subjective value of the contract for the CEO. Contracts with a high level of variable compensation are therefore less attractive to CEOs, so that firms will have to compromise on the talent of the CEOs they can attract. Our model below incorporates this trade-off between incentive provision and CEO talent.

7.1 A model of effort and talent

We start with a simple Cobb-Douglas production function and assume that firm value is influenced by the level of effort e and the CEO's talent t:

$$V_0 = \kappa e^{\beta} t^{\gamma}, \tag{8}$$

where κ summarizes all other factors that influence firm value, and β and γ are elasticities.[22] Shareholders have to compensate the CEO for the costs of effort (denoted by $C(e)$) and for the costs of bearing idiosyncratic risk (denoted by RP for "risk premium"). Together, these two components make up the costs of incentive provision, which we express by IC (i.e., $IC = C(e) + RP$). For tractability, we assume an isoelastic supply

[22] Baker and Hall (2004), Murphy and Zabojnik (2004), and Gabaix and Landier (2008) propose production functions where talent or effort affect the output linearly.

function that relates incentive costs to the level of effort

$$IC(e) = e^{\eta}. \tag{9}$$

The firm faces a supply of talent, and we represent the costs of providing talent of quality t by the isoelastic function[23]

$$TC(t) = t^{\delta}. \tag{10}$$

Since we cannot observe effort e or talent t, the parameters β, γ, η, and δ are not identified. In our setup, we cannot distinguish between supply and demand factors. We therefore substitute (9) and (10) into (8) and rewrite:

$$V_0 = \kappa IC^{\beta/\eta} TC^{\gamma/\delta} = \kappa IC^{a_1} TC^{a_2}, \tag{11}$$

where $a_1 = \beta/\eta$ and $a_2 = \gamma/\delta$ are identifiable if we can estimate incentive costs IC and talent costs TC. Total pay equals $\pi = IC + TC$ and this amount needs to be paid to the CEO every year. If the firm expects to stick to its choice of talent and incentives in all future years, the expected cost of all future compensation is given by the perpetuity $\frac{\pi}{r}$, where r is the appropriate discount factor. If the current CEO leaves the firm, another CEO with similar talent will be employed at a similar cost. In the absence of a cap on pay, the firm therefore maximizes $V_0 - \frac{\pi}{r}$ with respect to IC and TC. The first-order conditions then imply:

$$IC = a_1 r V_0, \; TC = a_2 r V_0. \tag{12}$$

Next, we investigate the impact of a cap on CEO pay on the value of the firm. A cap on CEO pay is simply a restriction so that total expected pay π cannot exceed some upper limit $\overline{\pi}$. Hence, we require $\pi \leq \overline{\pi}$. In the appendix, we prove the following claim:

Proposition 1 (Value impact of a cap on pay): *Let π^* be the level of expected CEO compensation in the model without a cap on pay and assume that a binding cap*

[23]Existing models assume that talent in inelastic. In Murphy and Zabojnik (2004) and Sung and Swan (2009), firms can choose between two managers only. Gabaix and Landier (2008) focus on the distribution of talent among the most talented managers. We allow for elastic talent supply, because arguably talent can be developed and retirement or leisure can be deferred. For simplicity, we treat talent as a homogeneous good and abstract from the problem that a particular level of talent might not be available because there are no or too few managers with this particular level of talent.

on pay $\overline{\pi} \leq \pi^*$ is imposed. Then the log change in value of the firm with a cap on compensation, $ln(V_0(\overline{\pi})/V_0(\pi^*))$, can be written as:

$$\ln\left(\frac{V_0(\overline{\pi})}{V_0(\pi^*)}\right) = (a_1 + a_2)ln\left(\frac{\overline{\pi}}{\pi^*}\right). \tag{13}$$

If we assume that the observed level of CEO compensation is the unrestricted optimum π^* and the observed firm value is $V_0(\pi^*)$, we can use (13) in order to estimate the impact of a cap on CEO pay once we obtain estimates for the sum of the elasticities a_1 and a_2.

Proposition 1 depends on the arguably strong assumption that a cap on pay induces firms to readjust the selection of their CEOs and their compensation practice by moving along the supply curves for talent and effort. It is conceivable that a cap on pay would also result in a shift in the supply curve. In particular, if a cap on compensation would be imposed on an economy-wide basis, such a legislation would also reduce the outside options of CEOs if they consist in employments as top executives of other firms.[24] We ignore this aspect here because we have no credible way of calibrating such a shift in supply functions. Our model therefore portrays a cap that is imposed on an individual firm, for example, as a policy of external investors or as a condition for state subsidies that are available only to a small number of firms. However, even an economy-wide ban would probably result in some movement along the supply curve. For example, if a cap on compensation would affect only publicly listed companies, then talented CEOs might move to jobs in privately held companies. Alternatively, CEOs might go abroad or start their own business. It is unlikely that legislative intervention can foreclose all possible alternatives, so that the decline in value (even if it is somewhat lower than described by Proposition 1 and by (13)) would persist.

7.2 Calibration and empirical results

In this subsection, we calibrate the model individually for each firm in our sample and calculate the reduction in firm value caused by a cap on ex-ante pay from equation (13). We then estimate the elasticities a_1 and a_2 for, respectively, incentive costs and talent costs in the firm's production function (11) and validate these estimates by relating them to firm characteristics.

Our empirical results are to a large extent determined by our model assumptions, as is reflected in the fact that we can calibrate the model and generate predictions for an

[24]See Acharya and Volpin (2010) for an analysis of such general equilibrium effects.

individual firm. An alternative approach that works with weaker assumptions and estimates the model across a number of firm (e.g., from the same industry) fails, however. The reason is that by assumption, firms have optimized CEO compensation, so that any cross-sectional variation in the relation between firm value and CEO compensation can only come from firm heterogeneity (see, e.g., Himmelberg, Hubbard, and Palia, 1999). Hence, any approach that gives more power to the data fails because we do not observe out-of-equilibrium outcomes.

To estimate the reduction in firm value from (13) we need an estimate of $a_1 + a_2$. As $\pi = IC + TC$, the first-order conditions (12) imply that $a_1 + a_2 = \frac{\pi}{rV_0}$. For the costs of the contract π, we use total compensation (TDC1 from ExecuComp) from 2006.[25] As V_0 denotes the gross firm value before the deduction of wage payments to the CEO, we set V_0 equal to the sum of the firm's market capitalization at the end of 2005, the firm's total debt at the end of 2005, and the present value of all future CEO compensation which we estimate by total compensation in 2006 divided by the risk-free rate $r = 4.35\%$. We delete 74 CEOs from our sample who hold more than 5% of the shares of their firms, because these CEOs are likely to be owner-managers rather than salaried agents. We lose another 33 CEOs because we do not have enough data to construct the firm value V_0.

[Insert Table 8 here.]

Table 8, Panel A displays the results of our calibration for the full sample and separately for each of the 12 Fama-French industries. The last two columns show the loss in firm value when CEO pay is reduced by 20%. The first of these two columns displays the gross change in firm value from (13), while the second column shows the change in firm value net of CEO pay. For the purpose of this calculation, we define firm value as net firm value, which equals $V_0(\pi) - \pi/r$ and report the decline in value as a percentage change, not as a logarithmic change as in (13). The average loss across all firms in our sample is 0.64% in gross terms and 0.07% net of CEO pay. Hence, approximately $(0.64\% - 0.07\%)V_0$ comes from the 20% reduction in CEO pay. The

[25] We do not use the expected value of the observed contract $E\left(\widetilde{w}^d\right)$ from (1) because the observed contract $\widetilde{w}^d$ might contain large unrestricted stock holdings that the CEO cannot reasonably expect to receive during each contracting period of length T. Many CEOs own a considerable amount of shares in their own firm, either because they were founders of the firm or because they are required to do so by shareholders. These stock holdings are not a compensation cost to the firm as they were given to the CEO or acquired by the CEO in the past. Nevertheless, these stock holdings enter the risk premium RP. The firm need not pay for these shareholdings, but it must compensate the CEO for the disutility of holding on to them.

average gross firm value therefore declines by $\frac{0.64\% V_0}{(0.64\% - 0.07\%) V_0} = \$1.12$ for each dollar cut in compensation, which results in a net loss of \$0.12.

For the separate estimation of a_1 and a_2 we need estimates of incentive costs IC and talent costs TC. Incentive costs are the sum of the costs of effort and the risk premium ($IC = C(e) + RP$). We obtain the risk premium over the whole contracting period, $RP \cdot T$, from the model in Section 5 as the difference between the market value of the contract and the certainty equivalent of the contract for the CEO. We divide this risk premium $RP \cdot T$ by the length of the contracting period, T, over which the risk premium is measured in order to arrive at an annual value, RP. As the costs of effort are unobservable, we assume that these costs are proportional to the risk premium, so that $C(e) = \xi RP$ and consequently $IC = (1 + \xi) RP$. We repeat our analysis for different values of ξ to demonstrate that our results are robust. The talent costs are then given by $TC = \pi - IC$.

Panel A of Table 8 also shows the average estimates of the elasticities a_1 and a_2, where we assume $\xi = 0.5$, i.e. costs of effort are 50% of the risk premium. The choice of ξ affects our results in two respects. First, the relative importance of incentives and talent depends on ξ. For $\xi = 0.5$, incentives appear less important for value creation than talent, because the average a_1 is considerably smaller than the average a_2. As ξ increases, however, the difference between a_2 and a_1 shrinks and eventually changes sign. The second effect of ξ is that talent costs become negative for some CEOs, because total pay π is smaller than $(1+\xi)$ times the risk premium RP. For $\xi = 0.5$ this happens for 41 firms. We keep these firms in Table 8, because we do not want to introduce a bias in our cross-sectional results. If we assume that ξ is of similar size across industries, the differences in our estimates across industries are independent of the actual size of ξ. Table 8, Panel A then shows that effort is most important for consumer durables and business equipment and least important for utilities, and chemicals. On the other hand, talent is most important for consumer durables and chemicals, while it is least important for telephone/television, utilities, and finance.

We expect that incentive pay is more important (i.e., the elasticity a_1 is higher) in firms where the CEO has more discretion and agency problems are stronger. In Table 8, Panel B, we therefore split our sample into two groups according to the median of a_1. Here, we exclude the financial industry since their balance sheets are difficult to compare to those of industrial firms. For both groups, the group with above median values of a_1 and the group with below median values of a_1, we report the means of several firm characteristics and test whether these differences are significant. We consider tangibility, R&D expenses, and advertising expenses, all scaled by total assets. We also include the mean pay-for-performance sensitivity in each industry, once in dollar-dollar terms and once in dollar-% terms. The latter variable measures the dollar increase in CEO wealth for a percentage increase in firm value. Moreover, we estimate excess pay following the approach of Core, Holthausen, and Larcker (1999): we regress total compensation (ExecuComp item TDC1) on sales, a five-year average of the market-to-book ratio, return on assets, the standard deviation of the return on assets, the stock market return, and the standard deviation of the stock market return. Standard deviations are also calculated over five years. Excess pay is then the residual from this regression.

Table 8, Panel B shows that asset tangibility is lower by 2.3%, R&D expenditures are higher by 1.2%, and advertising expenses are higher by 0.4% for the firms where our estimate of the effort elasticity a_1 is above the median. These differences are statistically significant only for the R&D expenditures. These findings are consistent with our hypothesis that incentives play a larger role in industries where managers have more discretion and where agency problems are larger. We also find that the pay-for-performance sensitivity (if expressed in \$-\$ terms) is significantly higher for firms with high a_1 estimate. This finding is not surprising, because a_1 is by construction high when the risk-premium is high.

The right part of Table 8, Panel B displays a similar sample split with respect to the coefficient a_2 on talent. It shows that this parameter cannot be related to any of the firm characteristics shown in the table. Interestingly, our estimate for the importance of talent is also not significantly associated with excess pay. There is a debate in the literature whether excess pay is a measure of rent extraction (e.g., Core, Holthausen, and Larcker, 1999) or of managerial talent (e.g., Falato, 2007). If excess pay is a measure of talent, firms where talent is important should employ more talented CEOs and give them more excess pay, i.e., a_2 should be positively related to excess pay. We do find a positive sign, but the difference is insignificant. Altogether, our results for the coefficients a_1 and a_2 suggest that the model captures the relationship between compensation and firm value in a sensible way.

8 Discussion and conclusion

In this paper we discuss restrictions on executive pay and analyze three types of restrictions that have been advocated recently: restrictions on ex post realized pay in order to avoid large payouts to executives across a range of possible scenarios, restrictions on components of pay, and, finally, restrictions on the ex ante value of pay.

The impact of restrictions on realized pay is mostly small, but these restrictions have some unintended consequences: CEOs earn on average more, they are rewarded more for mediocre performance, and they become generally more averse to accepting additional risks. Restrictions on individual components of pay have almost no impact at all because companies can contract around these restrictions at no or little cost. In both cases, the impact on firm value is small because firms can still hire the same CEO and implement the same level of incentives as before, unless restrictions on realized pay become too stringent.

Regulating the ex ante value of pay in order to limit compensation when it is deemed to be excessively high is potentially more costly. In this case firms cannot simultaneously provide the same level of incentives and attract executives of the same quality as before. We therefore develop a simple model that features compensation to provide incentives as well as compensation for talent. Consistent with our intuition we find that effort provision has a bigger impact on firm value when agency problems are likely, i.e., in industries with more intangible assets and more R&D. However, the model implies only an average 0.07% loss in firm value if firms are forced to reduce total CEO pay by 20%. The reason is that the model does not incorporate frictions in the market for managerial labor and assumes a significant degree of substitution between talent and effort, which provides firms with a lot of leeway to evade restrictions. Our model has this feature in common with other models of the executive labor market (e.g., Gabaix and Landier, 2008; Edmans and Gabaix, 2010) and we conjecture that models that would include more frictions would give rise to higher estimates of the costs of restricting compensation.

Throughout the paper we maintain the working hypothesis that observed compensation practice is Pareto efficient and we therefore work with a sample of firms where all directors on the compensation committee are independent. A stronger indication of efficient contracting is that one of the directors on the compensation committee holds an equity stake of at least 1% and is not an employee of the firm. There are 59 firms in our sample that qualify as "good corporate governance" according to this indicator.

In unreported work, we repeat our analysis from Sections 5 and 6 separately for this subsample, but none of our results changes much.

Our analysis does not cover the potential efficiency gains from pay restrictions, mainly because they seem to be impossible to quantify. Theoretical research on governance externalities, turnover costs, or hidden compensation is in its infancy and existing models do not lend themselves to calibration and the quantification of effects (see our discussion in the Introduction). We can only speculate that these defects of the managerial labor market would be better addressed through improvements of the pay-setting process and the managerial labor market such as better disclosure rules and improved governance, rather than through pay restrictions. More theoretical work is needed here.

We restrict our analysis to a discussion of firm value. Restrictions on compensation may have other consequences. For example, capping CEO pay may increase the utility of voters who are inequality averse and reduced risk-taking incentives may also benefit workers. While these issues may be important for the political process and for the motivations of capping CEO pay, they are beyond the scope of this paper.

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Appendix: Proof of Proposition 1

In the presence of a cap, the firm maximizes $V_0 - \frac{\pi}{r} = \kappa IC^{a_1} TC^{a_2} - \frac{IC+TC}{r}$ subject to the constraint $\pi \leq \overline{\pi}$. We assume that the restriction is binding, that is, that $\overline{\pi} < \pi^*$. The first-order conditions then are:

$$\frac{a_1}{IC} V_0 - \frac{1}{r} + \lambda = 0 \Rightarrow IC = \frac{a_1 V_0}{\frac{1}{r} - \lambda}. \tag{14}$$

$$\frac{a_2}{TC} V_0 - \frac{1}{r} + \lambda = 0 \Rightarrow TC = \frac{a_2 V_0}{\frac{1}{r} - \lambda}, \tag{15}$$

where λ is the Lagrange multiplier associated with the constraint $\pi \leq \bar{\pi}$. Together with $\pi = IC + TC$, we obtain

$$\begin{aligned} \pi &= (a_1 + a_2) \frac{V_0}{\frac{1}{r} - \lambda} \\ \Rightarrow IC &= \frac{a_1}{a_1 + a_2} \pi, \; TC = \frac{a_2}{a_1 + a_2} \pi. \end{aligned}$$

Under a binding cap, we therefore have $IC(\bar{\pi}) = \frac{a_1}{a_1+a_2} \bar{\pi}$, and $TC(\bar{\pi}) = \frac{a_2}{a_1+a_2} \bar{\pi}$. In the case without a cap, we obtain similar expressions (this is the case where the restriction is not binding, so that $\lambda = 0$.): $IC(\pi^*) = \frac{a_1}{a_1+a_2} \pi^*$, and $TC(\pi^*) = \frac{a_2}{a_1+a_2} \pi^*$. We therefore obtain:

$$\begin{aligned} \ln\left(\frac{V_0(\bar{\pi})}{V_0(\pi^*)}\right) &= \ln(V_0(\bar{\pi})) - \ln(V_0(\pi^*)) \\ &= \ln \kappa + a_1 \ln IC(\bar{\pi}) + a_2 \ln TC(\bar{\pi}) \\ &\quad - (\ln \kappa + a_1 \ln IC(\pi^*) + a_2 \ln TC(\pi^*)) \\ &= a_1 \ln\left(\frac{a_1}{(a_1 + a_2)} \bar{\pi}\right) + a_2 \ln\left(\frac{a_2}{(a_1 + a_2)} \bar{\pi}\right) \\ &\quad - a_1 \ln\left(\frac{a_1}{(a_1 + a_2)} \pi^*\right) - a_2 \ln\left(\frac{a_2}{(a_1 + a_2)} \pi^*\right) \\ &= a_1 \ln(\bar{\pi}) + a_2 \ln(\bar{\pi}) - a_1 \ln(\pi^*) - a_2 \ln(\pi^*) \\ &= (a_1 + a_2) \ln\left(\frac{\bar{\pi}}{\pi^*}\right). \end{aligned}$$

The last line shows (13).

Table 1: Description of the data set

This table displays the mean, standard deviation, and 10%, 50%, and 90% quantiles of the variables in our data set. Panel A shows these statistics of our sample of 844 CEOs from 2006 who worked in a firm where all members of the compensation committee were independent directors. *Value of contract* is the market value of the compensation package $\pi = \phi + n_S P_0 + n_O BS$, where BS is the Black-Scholes option value. All dollar amounts are in millions. Stock and options are expressed as a percentage of all outstanding shares. Panel B displays statistics for the full sample of 1,327 CEOs ExecuComp CEOs before matching them with RiskMetrics.

Panel A: Sample of 844 CEOs from 2006 (after matching with Risk-metrics)

Variable		Mean	Std. dev.	10% Quantile	Median	90% Quantile
Stock	n_S	1.88%	5.79%	0.03%	0.24%	3.60%
Options	n_O	1.25%	1.63%	0.10%	0.79%	2.87%
Fixed salary	ϕ	1.58	4.17	0.50	1.03	2.32
Value of contract	π	95.6	439.5	4.5	23.6	156.6
Firm value	P_0	9,707	27,934	559	2,636	17,930
Strike price	K	7,383	23,967	353	1,680	12,904
Moneyness	K/P_0	71.7%	22.0%	43.3%	73.3%	100.0%
Maturity	T	5.3	2.3	3.4	4.8	7.0
Stock volatility	σ	28.9%	10.5%	16.5%	27.4%	44.1%
Dividend rate	d	1.29%	2.09%	0.00%	0.72%	3.45%

Panel B: All 1,327 ExecuComp CEOs in 2006 (before matching with Risk-metrics)

Variable		Mean	Std. dev.	10% Quantile	Median	90% Quantile
Stock	n_S	1.95%	5.74%	0.03%	0.29%	4.45%
Options	n_O	1.28%	1.58%	0.10%	0.82%	2.93%
Fixed salary	ϕ	1.54	3.62	0.49	1.00	2.41
Value of contract	π	129.8	1,304.5	3.5	21.4	154.8
Firm value	P_0	8,567	24,835	365	1,999	17,311
Strike price	K	6,521	21,272	234	1,330	12,306
Moneyness	K/P_0	72.8%	26.0%	41.5%	74.0%	100.0%
Maturity	T	5.3	2.2	3.4	4.8	7.0
Stock volatility	σ	31.0%	13.5%	16.9%	29.1%	46.8%
Dividend rate	d	1.28%	3.27%	0.00%	0.51%	3.40%

Table 2: Implied reference wage

This table describes the reference wage w^R for which our model exactly predicts the observed contract. The reference wage is parameterised by the discount δ as $w^R(\delta) = \phi + (1-\delta) MV(n_S^d, n_O^d)$, where MV represents the market value of the CEO's stock and options. The table displays the mean, standard deviation, and 10%, 50%, and 90% quantiles of the discount δ for our sample of 844 U.S. CEOs.

	Two solutions		One solution	No solution
	Higher discount	Lower discount		
Observations	717	717	79	48
Mean	0.90	0.66	0.72	N/A
Std. dev.	0.08	0.20	0.20	N/A
10% Quantile	0.80	0.37	0.44	N/A
Median	0.93	0.69	0.78	N/A
90% Quantile	0.98	0.90	0.91	N/A

Table 3: Contracts with a cap on realized compensation

This table describes optimal contracts that are capped at *M* times the expected value of the observed contract, for two values of *M* (*M* = 3 in Panel A, and *M* = 5 in Panel B). The table shows the results for the subsample of 753 executives where the contracting problem can be solved for *M* = 3. *ΔExpected cost* is the difference in the expected costs between model contract and observed contract, once expressed in million dollars and once expressed as a percentage of total pay π. *ΔPayout at* $P_t = P_0$ is the difference in the payout for the stock price $P_t = P_0$ between model contract and observed contract, once expressed in million dollars and once expressed as a percentage. Prob(*Δpayout* > 0) is the probability that the model contract pays out more than the observed contract. *CE_higher* is a dummy variable that indicates whether the certainty equivalent from the model contract is higher than that from the observed contract. *ΔCE* (%) | *CE_higher*=1 is the difference in certainty equivalents between model contract and observed contract given that this difference is positive. Panel C shows the risk-taking hurdle (*RTH* from equation (7)) for the observed contract and the two model contracts, and the changes in *RTH* for the two model contracts relative to the observed contract. *RTH* is a measure of the CEO's inclination to avoid taking on additional risk.

Panel A: Model contract with a cap = w_{obs} **(*M* = 5)**

Variable	Mean	St.Dev	10% Quantile	Median	90% Quantile
Salary ($m)	0.40	1.35	0.00	0.00	1.09
Stock (%)	2.0%	5.4%	0.1%	0.4%	3.8%
Option (%)	1.4%	2.0%	0.1%	0.8%	3.1%
ΔExpected costs ($m)	0.41	3.00	0.00	0.05	0.56
ΔExpected costs (%)	0.5%	0.7%	0.0%	0.2%	1.6%
ΔPayout at $P_T = P_0$ ($m)	0.13	15.89	0.01	0.29	1.59
ΔPayout at $P_T = P_0$ (%)	3.9%	7.5%	0.0%	1.3%	11.0%
Prob(Δpayout>0)	55%	33%	9%	59%	99%
CE_higher	0.0%	0.0%	0.0%	0.0%	0.0%
ΔCE (%) | CE_higher=1	N/A	N/A	N/A	N/A	N/A

Panel B: Model contract with a cap = w_{obs} **(*M* = 3)**

Variable	Mean	St.Dev	10% Quantile	Median	90% Quantile
Salary ($m)	0.10	0.69	0.00	0.00	0.00
Stock (%)	1.8%	5.1%	0.0%	0.3%	3.5%
Option (%)	3.5%	12.1%	0.1%	1.1%	6.1%
ΔExpected costs ($m)	2.25	12.70	0.01	0.29	4.02
ΔExpected costs (%)	3.1%	5.2%	0.1%	1.3%	7.4%
ΔPayout at Pt=P0 ($m)	2.89	53.75	0.03	0.76	9.92
ΔPayout at Pt=P0 (%)	14.9%	39.2%	0.1%	4.6%	38.7%
Prob(Δpayout>0)	55%	22%	20%	58%	84%
CE_higher	8.5%	27.9%	0.0%	0.0%	0.0%
ΔCE (%) | CE_higher=1	13.2%	9.6%	2.4%	11.1%	25.2%

Panel C: Risk-taking hurdle (*RTH*)

Variable	Mean	St.Dev	10% Quantile	Median	90% Quantile	Prop. > 0
Observed contract	0.20	0.36	-0.30	0.22	0.61	72%
Model contract (*M*=5)	0.47	0.46	-0.07	0.44	1.03	87%
Model contract (*M*=3)	0.90	0.62	0.22	0.80	1.70	97%
Model – observed (*M*=5)	0.27	0.32	0.01	0.16	0.67	99%
Model – observed (*M*=3)	0.70	0.56	0.11	0.59	1.45	100%

Table 4: Taxation of fixed pay

This table shows the results for a 50% tax on fixed compensation for four different levels of the threshold above which fixed pay incurs this penalty tax. The table shows the mean and median of the three contract parameters, the taxes incurred on the observed and the model contract, and the efficiency loss, which is the difference in contracting costs between model contract and observed contract in the absence of taxes. *RTH*, the risk-taking hurdle from equation (7), is a measure of the CEO's inclination to avoid taking on additional risk. This table shows the results for the 796 CEOs for whom we can find an implied reference wage (see Table 2). We drop one additional CEO due to numerical problems.

Threshold ($m)	Fixed salary ($m)		Stock (%)		Option (%)		Efficiency loss ($'000)		RTH		Taxes ($'000) Obs. contract		Taxes ($'000) Model contract	
	Mean	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**
5.0	1.26	1.03	2.00%	0.29%	1.23%	0.77%	0.7	0.0	0.20	0.22	92.3	0.0	0.0	0.0
2.5	1.14	1.02	2.01%	0.29%	1.22%	0.76%	1.3	0.0	0.20	0.22	151.4	0.0	0.0	0.0
1.0	0.81	0.98	2.04%	0.32%	1.18%	0.74%	3.0	0.0	0.24	0.25	311.4	17.2	0.0	0.0
0.5	0.46	0.50	2.10%	0.37%	1.10%	0.67%	5.1	0.4	0.29	0.28	495.2	267.2	0.0	0.0
Observed	1.48	1.03	1.99%	0.28%	1.25%	0.77%	N/A	N/A	0.20	0.22	N/A	N/A	N/A	N/A

Table 5: Taxation of option pay

This table shows the results for a tax penalty on option pay (the Black-Scholes value of all option) for five different tax rates. The table shows the mean and median of the three contract parameters, the taxes incurred on the observed and the model contract, and the efficiency loss, which is the difference in contracting costs between model contract and observed contract in the absence of taxes. *RTH*, the risk-taking hurdle from equation (7), is a measure of the CEO's inclination to avoid taking on additional risk. This table shows the results for the 796 CEOs for whom we can find an implied reference wage (see Table 2).

Tax rate	Fixed salary ($m)		Stock (%)		Option (%)		Efficiency loss ($m)		RTH		Taxes ($m) Obs. contract		Taxes ($m) Model contract	
	Mean	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**
10%	0.12	0.00	2.15%	0.45%	1.02%	0.57%	0.007	0.002	0.32	0.32	1.8	0.7	1.6	0.6
25%	0.12	0.00	2.16%	0.45%	1.02%	0.57%	0.009	0.002	0.32	0.32	5.6	2.2	5.0	1.7
50%	0.12	0.00	2.22%	0.45%	0.96%	0.54%	0.459	0.002	0.32	0.32	11.1	4.4	9.2	3.1
75%	0.12	0.00	2.28%	0.47%	0.89%	0.47%	1.117	0.003	0.33	0.32	16.7	6.6	12.7	3.9
100%	0.12	0.00	2.43%	0.48%	0.73%	0.46%	3.710	0.003	0.37	0.32	22.2	8.8	16.7	5.0
Observed	1.48	1.03	1.99%	0.28%	1.24%	0.77%	N/A	N/A	0.20	0.22	N/A	N/A	N/A	N/A

Table 6: Taxation of all deferred compensation

This table shows the results for a tax penalty on total deferred compensation (the market value of stock and option pay) for five different tax rates. The table shows the mean and median of the three contract parameters, the taxes incurred on the observed and the model contract, and the efficiency loss, which is the difference in contracting costs between model contract and observed contract in the absence of taxes. *RTH*, the risk-taking hurdle from equation (7), is a measure of the CEO's inclination to avoid taking on additional risk. This table shows the results for the 796 CEOs for whom we can find an implied reference wage (see Table 2).

Tax rate	Fixed salary ($m)		Stock (%)		Option (%)		Efficiency loss ($m)		RTH		Taxes ($m)			
											Obs. contract		Model contract	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
10%	32.16	4.66	0.45%	0.00%	3.38%	1.44%	0.184	0.023	-0.12	-0.07	7.5	1.9	5.2	1.5
25%	35.36	5.02	0.17%	0.00%	3.93%	1.48%	0.891	0.034	-0.18	-0.13	24.7	6.1	16.4	4.6
50%	36.71	5.03	0.03%	0.00%	4.15%	1.48%	1.170	0.039	-0.20	-0.16	49.3	12.1	32.3	9.2
75%	36.74	5.03	0.02%	0.00%	4.17%	1.48%	1.178	0.039	-0.20	-0.16	74.0	18.2	48.5	13.9
100%	36.74	5.03	0.01%	0.00%	4.17%	1.48%	1.181	0.039	-0.20	-0.16	98.7	24.2	64.6	18.5
Observed	1.48	1.03	1.99%	0.28%	1.24%	0.77%	N/A	N/A	0.20	0.22	N/A	N/A	N/A	N/A

Table 7: Robustness check with taxes

This table shows robustness checks of Tables 4 to 6 when we introduce realistic taxes both at the company level and at the personal level. We use the implied reference wage from the non-tax world (higher discount from Table 2) and calculate the optimal contract with realistic taxes. The resulting contract is shown in the first line of each table. Panel A shows optimal contracts for 709 CEOs when - in addition to the baseline taxes - fixed salary is not any longer tax deductible above the threshold displayed in the first column. Panel B shows optimal contracts for 699 CEOs when - in addition to the baseline taxes - option pay is taxed with the tax rate displayed in the first column. Finally, Panel C shows optimal contracts for 748 CEOs when - in addition to the baseline taxes - option and stock pay is taxed with the tax rate displayed in the first column. For the baseline tax case in Panels A and B, we assume that unrestricted stock is not an expense to the firm and, accordingly, not tax deductible. For consistency reasons (see Footnote XXX), we assume in Panel C that all equity pay is tax deductible.

Panel A: Taxation of fixed pay

Threshold ($m)	Fixed salary ($m)		Stock (%)		Option (%)		RTH	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Infinity	2.05	0.57	2.00%	0.32%	1.21%	0.81%	0.36	0.39
5.0	1.23	0.57	2.01%	0.33%	1.19%	0.75%	0.38	0.40
2.5	0.89	0.55	2.02%	0.35%	1.17%	0.74%	0.39	0.41
1.0	0.52	0.50	2.04%	0.38%	1.14%	0.72%	0.42	0.42
0.5	0.30	0.45	2.07%	0.40%	1.11%	0.68%	0.44	0.43

Panel B: Taxation of option pay

Tax rate	Fixed salary ($m)		Stock (%)		Option (%)		RTH	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
None	4.16	0.68	1.81%	0.31%	1.28%	0.80%	0.34	0.37
10%	0.59	0.00	1.93%	0.40%	1.09%	0.64%	0.40	0.42
25%	0.08	0.00	1.99%	0.41%	1.01%	0.59%	0.43	0.43
50%	0.08	0.00	2.06%	0.44%	0.95%	0.52%	0.43	0.43
75%	0.08	0.00	2.19%	0.51%	0.83%	0.37%	0.44	0.43
100%	0.08	0.00	2.37%	0.57%	0.67%	0.24%	0.44	0.42

Panel C: Taxation of all deferred compensation

Tax rate	Fixed salary ($m)		Stock (%)		Option (%)		RTH	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
None	21.45	0.09	1.38%	0.07%	2.20%	0.97%	0.27	0.32
10%	31.75	4.52	0.39%	0.00%	3.55%	1.39%	0.08	0.12
25%	35.51	4.93	0.07%	0.00%	4.01%	1.47%	0.02	0.05
50%	35.57	4.93	0.04%	0.00%	4.05%	1.47%	0.01	0.05
75%	35.67	4.93	0.00%	0.00%	4.10%	1.47%	0.01	0.05
100%	35.67	4.93	0.00%	0.00%	4.10%	1.47%	0.01	0.05

Table 8: The effect of talent and effort on firm value

Panel A shows average estimates of the coefficients a_1 and a_2 of the production function (11) for the complete sample of 689 CEOs and separately for the twelve Fama-French industries in our sample. We lose 107 observations, because of data requirements and because we drop those CEOs who are owner-managers, i.e., their shareholdings n_S exceed 5%. The rightmost two columns in Panel A show the average estimated change in firm value ΔV when total CEO pay is reduced by 20%. The second-to-last column shows the gross change in firm value from Proposition 1. The last column shows the change in firm value net of CEO pay, where firm value equals $V_0(\pi) - \pi / r$ and the decline in value is reported as a percentage change rather than a logarithmic change as in Proposition 1. The estimates for a_1 and a_2 – but not those for ΔV – depend on the assumption that $\xi = 0.5$. Panel B shows the average of six firm characteristics for subsamples formed according to the size of our estimates for a_1 and, respectively, a_2. Here, the subgroup 'High' ('Low') refers to the firms with above median (below median) value for the considered coefficient. We exclude financial firms from our analysis in Panel B. The table also shows the p-value of the two-sample t-test. *Tangibility* refers to tangible assets and is expressed as a percentage of total assets, just like *R&D expense* and *Advertising expense*. *PPS $-$* is the pay-for-performance sensitivity that measures by how many dollars CEO wealth increases if firm value increases by $1. *PPS $-%* measures by how many dollars CEO wealth increases if firm increases by 1%. Excess pay is the residual from a regression of total CEO pay on previous year's sales, investment opportunities, ROA, stock return, and the standard deviations of ROA and stock returns over the past five years (see Core, Holthausen & Larcker (1999)).

Panel A: Estimation of the importance of effort, talent, and size for firm value

Industry	Obs.	a_1	a_2	ΔV gross	ΔV net
Full sample	689	0.007	0.022	-0.64%	-0.07%
Consumer NonDurables	37	0.008	0.025	-0.75%	-0.08%
Consumer Durables	17	0.013	0.031	-0.98%	-0.10%
Manufacturing	100	0.006	0.025	-0.69%	-0.07%
Oil, Gas, and Coal Extraction and Products	37	0.007	0.021	-0.62%	-0.06%
Chemicals and Allied Products	26	0.004	0.030	-0.75%	-0.08%
Business Equipment	115	0.011	0.022	-0.73%	-0.08%
Telephone and Television Transmission	6	0.005	0.001	-0.15%	-0.02%
Utilities	52	0.001	0.012	-0.28%	-0.03%
Wholesale, Retail, and Some Services	77	0.008	0.023	-0.71%	-0.07%
Healthcare, Medical Equipment, and Drugs	61	0.010	0.022	-0.71%	-0.07%
Finance	83	0.005	0.012	-0.37%	-0.04%
Others	78	0.006	0.029	-0.78%	-0.08%

Panel B: Do our estimates reflect firm characteristics?

	Groups formed according to a_1				Groups formed according to a_2			
	Mean in subgroup High	Mean in subgroup Low	Diff.	p-value	Mean in subgroup High	Mean in subgroup Low	Diff.	p-value
Tangibility	78.5%	80.9%	-2.3%	0.14	0.79	0.80	-0.02	0.34
R&D Expense	3.6%	2.3%	1.2%	0.00	2.8%	3.0%	-0.2%	0.63
Advertising Expense	1.2%	0.8%	0.4%	0.11	1.1%	0.9%	0.2%	0.40
PPS $-$	0.011	0.002	0.009	0.00	0.007	0.006	0.001	0.31
PPS $-%	0.32	0.48	-0.16	0.63	0.11	0.68	-0.57	0.09
Excess pay	-0.65	0.28	-0.93	0.07	0.21	-0.58	0.79	0.13
Observations	303	303			303	303		