DISCUSSION PAPER SERIES

DP15243
(v. 5)

HOW LARGE IS THE PAY PREMIUM FROM EXECUTIVE INCENTIVE COMPENSATION?

Ana Albuquerque, Rui Albuquerque, Mary Ellen Carter and Flora Dong

FINANCIAL ECONOMICS

ISSN 0265-8003

HOW LARGE IS THE PAY PREMIUM FROM EXECUTIVE INCENTIVE COMPENSATION?

Ana Albuquerque, Rui Albuquerque, Mary Ellen Carter and Flora Dong

Discussion Paper DP15243
First Published 01 September 2020
This Revision 26 April 2023

Centre for Economic Policy Research
33 Great Sutton Street, London EC1V 0DX, UK
Tel: +44 (0)20 7183 8801
www.cepr.org

This Discussion Paper is issued under the auspices of the Centre’s research programmes:

- Financial Economics

HOW LARGE IS THE PAY PREMIUM FROM EXECUTIVE INCENTIVE COMPENSATION?

Abstract

We estimate the pay premium associated with CEO incentive compensation. Using explicit detailed U.S. CEO compensation contract data and simulation analysis, we find that CEOs with riskier pay packages receive a premium for pay at risk that represents 15% of total pay. The premium is positively correlated with proxies for CEO risk aversion, but implied risk aversion values suggest that the premium is economically smaller than suggested by prior studies. We perform our tests using a variety of proxies to measure the variance of pay and find consistent evidence of economically small pay risk premiums. These results are consistent with recent findings suggesting that risk may have a more limited effect over the level of pay than previously thought.

JEL Classification: D81, G30, J33

Keywords: Ceo pay, Incentive pay, Contract theory, Incentive lab

Ana Albuquerque - albuquea@bu.edu
Boston University

Rui Albuquerque - rui.albuquerque@bc.edu
Carroll School of Management and CEPR

Mary Ellen Carter - maryellen.carter@bc.edu
Boston College

Flora Dong - qdong2@kennesaw.edu
Kennesaw State University

Acknowledgements
We thank Joshua D. Anderson, Kee-Hong Bae, Philip Bond, Brian Cadman, Pierre Chaigneau, Shane Dikolli, Eitan Goldman, Luis Marques, Kevin Murphy, Peter Oh, Yihui Pan, Jeff Pontiff, Jean-Charles Rochet, Jun Yang, and Wenyu Wang for their comments as well as seminar participants at the Atlanta Federal Reserve Bank/Emory University joint seminar, Bank of Portugal, Boston College, Boston University, Indiana University, and at the conferences, FARS, FIRS, the New Research on Executive Compensation and on Sustainability conference at Bar-Ilan University, the joint McGill-HEC Montreal, Telfer Annual Conference on Accounting and Finance, andWestern Finance Association. This paper circulated previously under the title “Are CEOs paid extra for riskier pay packages?” Ana Albuquerque: Boston University, albuquea@bu.edu. Rui Albuquerque: Boston College, ECGI, CEPR, rui.albuquerque@bc.edu. Mary Ellen Carter: Boston College, maryellen.carter@bc.edu. Flora Dong: Kennesaw State University, qdong2@kennesaw.edu. Rui Albuquerque gratefully acknowledges financial support from the European Union Seventh Framework Programme (FP7/2007- 2013) under grant agreement PCOFUND-GA-2009-246542 and from the Foundation for Science and Technology-FCT under grant PTDC/EGEOGE/ 30314/2017. We thank Michael Guo for excellent research assistance in getting detailed information about compensation contracts from Proxy Statements. The usual disclaimer applies.

How large is the pay premium from executive incentive compensation?*

Ana Albuquerque, Rui Albuquerque, Mary Ellen Carter, Qi (Flora) Dong

April 26, 2023

Abstract

We estimate the pay premium associated with CEO incentive compensation. Using explicit detailed U.S. CEO compensation contract data and simulation analysis, we find that CEOs with riskier pay packages receive a premium for pay at risk that represents 15% of total pay. The premium is positively correlated with proxies for CEO risk aversion, but implied risk aversion values suggest that the premium is economically smaller than suggested by prior studies. We perform our tests using a variety of proxies to measure the variance of pay and find consistent evidence of economically small pay risk premiums. These results are consistent with recent findings suggesting that risk may have a more limited effect over the level of pay than previously thought.

Keywords: CEO pay, volatility of pay premium, incentive pay, contract theory, Incentive Lab
JEL classifications: D81, G30, J33

---

[*] We thank Joshua D. Anderson, Kee-Hong Bae, Philip Bond, Brian Cadman, Pierre Chaigneau, Shane Dikolli, Eitan Goldman, Luis Marques, Kevin Murphy, Peter Oh, Yihui Pan, Jeff Pontiff, Jean-Charles Rochet, Jun Yang, and Wenyu Wang for their comments as well as seminar participants at the Atlanta Federal Reserve Bank/Emory University joint seminar, Bank of Portugal, Boston College, Boston University, Indiana University, and at the conferences, FARS, FIRS, the New Research on Executive Compensation and on Sustainability conference at Bar-Ilan University, the joint McGill-HEC Montreal, Telfer Annual Conference on Accounting and Finance, and Western Finance Association. This paper circulated previously under the title “Are CEOs paid extra for riskier pay packages?” Ana Albuquerque: Boston University, albuquea@bu.edu. Rui Albuquerque: Boston College, ECGI, CEPR, rui.albuquerque@bc.edu. Mary Ellen Carter: Boston College, maryellen.carter@bc.edu. Flora Dong: Kennesaw State University, qdong2@kennesaw.edu. Rui Albuquerque gratefully acknowledges financial support from the European Union Seventh Framework Programme (FP7/2007- 2013) under grant agreement PCOFUND-GA-2009-246542 and from the Foundation for Science and Technology-FCT under grant PTDC/EGE-OGE/30314/2017. We thank Michael Guo for excellent research assistance in getting detailed information about compensation contracts from Proxy Statements. The usual disclaimer applies.

1 Introduction

Many prominent models of optimal compensation predict that the variance of pay should be positively related to the level of pay. This paper quantifies the premium paid to Chief Executive Officers (CEOs) for the uncertainty associated with incentive pay, or pay at risk, in their compensation packages. Our approach deviates from prior research by using explicit contract information available from actual CEO compensation contract provisions on the relation between performance metrics and performance-based compensation (i.e., cash bonus, stock grants, and option grants) collected by Incentive Lab from proxy statements. These rich data combined with a simulation exercise allow us to obtain, for each CEO-year, an estimate of the variance of end-of-year pay using actual information from CEO compensation contracts signed at the beginning of the year. We are not aware of any other empirical study that directly estimates the reward for the expected variance of CEOs' total pay packages.

In the widely used principal-agent moral hazard model of Holmstrom (1979), Mirrlees (1976), and Shavell (1979), Grossman and Hart (1983) and others, incentive pay helps risk-neutral shareholders reduce principal-agent conflicts at the cost of having to pay more to the risk-averse CEO for the disutility associated with variance in total pay. This prediction of the moral hazard model relies on the participation constraint, which only requires information about the agent's expected utility. Other model predictions, including the much-studied sensitivity of incentive pay to stock return volatility, rely not only on the participation constraint but also on assumptions about the production function, the number of performance metrics used to incentivize the agent, or the principal's objective function. We estimate the main structural restriction that arises from the participation constraint that pay is positively related to the variance of pay.

While there is no dispute that CEO pay should reflect a premium for the risk in pay, how large that premium is remains unanswered. As prior studies lacked detailed compensation contract information, they were limited to estimating the risk premium based on the *implicit* assumption that all firms relied on stock returns as a performance metric, and perhaps also on another metric such as return on equity, often accompanied with assumptions on how the weights placed on the different performance metrics varied across firms. Yet, pay volatility arises not only from stock return volatility but also from the many other performance metrics used in the contracts (e.g., one CEO-year in our sample is exposed to seven performance metrics, with the average firm in our sample using 4.5 performance metrics per pay package). And, the weights on these performance metrics are not only different across firms, they can be non-linearly related between each other for the same firm. We use *explicit* and detailed CEO compensation contract information to estimate the pay premium associated with total pay volatility. We perform a series of cross sectional analyses using proxies for CEO risk aversion to provide insights regarding the sources of the pay premium, we test the robustness of results using different model specifications and assumptions, and we provide some early evidence regarding the consequences of paying "too little" of a risk premium in the context of voluntary CEO turnover.

Evaluating the CEO pay premium is nontrivial because pay contracts are generally quite complex (Albuquerque et al. 2022). For example, consider the simplest contract that includes only salary and a cash bonus grant. The bonus may have a threshold payout of 100% of base salary, a target payout of 200% of base salary, and a maximum payout of 400% of base salary. The contract defines a metric, for example net sales, and corresponding performance levels that determine the threshold, target, and maximum payouts. For such a contract, we simulate the year-end value of net sales under the assumption that it is normally distributed. We use the prior year value of net sales as the expected value and the prior volatility of net sales as the conditional volatility. For each simulated end-of-year value of net sales, we determine the corresponding bonus grant payout. The volatility of these simulated values provides the simulated variance of bonus pay, which in this case equals the simulated variance of total pay since salary is fixed.

Consider the implications of this contract for the association between mean and variance of pay. The fact that bonus is zero if performance is too low introduces a left truncation in pay that implies that mean and variance of pay have a positive association.[1] In contrast, the right truncation resulting from the bonus ceiling when performance is too high decreases the association between mean and variance of pay.

Strictly speaking, we are not interested in the question of how firms implement the association between total pay and variance of pay, but rather how large the trade-off, or the pay premium, is. CEO contracts may

---

[1] The left truncation in pay contracts is never optimal in linear-exponential models such as in Holmstrom and Milgrom (1987). In those models (e.g., Holmstrom and Milgrom 1987), the positive association between mean pay and volatility of pay is achieved by balancing fixed pay (i.e., salary) and incentive pay. The robust property of the agency models is not the linearity of the contracts, which may depend on specific distributional assumptions or assumptions regarding the agent's utility function, but rather that mean and variance of pay should be positively related.

include bonus, stock, and option grants in any given year, and multiple grants of each kind are possible, where multiple performance metrics may be specified across grants, and even within the same grant, with different threshold types. Some of these contract terms may include contract convexity to induce more risk taking (Bettis et al. 2018). The performance metrics may (or may not) all have to be met to yield a payout, introducing non-linearities in pay. And, finally, these characteristics may change over time for the same firm-CEO pair. Using these detailed compensation data, we use simulations to estimate the variance of total CEO pay for each CEO-year in our sample.

To obtain an estimate of the pay premium, we regress total CEO pay on the simulated variance of pay. We find a positive and statistically significant sensitivity (i.e., elasticity) of pay to the variance of pay. Measuring the risk pay premium as the extra compensation required when uncertainty in pay increases by one standard deviation, we find the pay premium associated with risk in incentive pay in our sample is 15% of total pay.[2] Our approach allows us to decompose the premium into each of the main sources of pay uncertainty: cash bonus, stock grants, and option grants. We show that stock grants carry the highest pay premium. Volatility in the value of stock grants has the highest, and the only statistically significant, coefficient estimate. The sizes of the economic premiums are 21% for stock grants, 7.6% for bonus pay, and 2.6% for option grants.

Bizjak et al. (2022) state that compensation consultants often use simulations when presenting the valuation of the awards to the board of directors. So, it is conceivable that at the beginning of the year, compensation committees rely on simulations to evaluate whether enough pay is being offered on average to the CEO given the risk in her compensation package. Our approach can provide compensation consultants and boards with a way to combine all of the effects from pay at risk in one metric – the total variance of pay – and a benchmark to evaluate how much more pay is needed when a higher level of incentives is offered to the CEO – the pay premium.

Our estimation is done under the null hypothesis of the standard agency model where the pay premium is linked to the agent's risk aversion coefficient. However, there are moral-hazard models with risk-neutral agents

---

[2] There is a literature that estimates the pay premium caused by the risk in specific events. Gipper (2021) uses the SEC's implementation of the Compensation Discussion and Analysis requirement as a shock to the risk from compensation disclosures and finds that compensation levels increase by 11% after the mandatory disclosure. Carter et al. (2019) find that executives changing employers are paid an additional 14% to compensate for the risk of fit with the new firm. Our approach does not rely on specific events and thus represents an average premium. The magnitude of our estimate of the risk premium is not directly comparable to that in Conyon et al. (2011) (see their Table 5) because theirs is calculated as a fraction of total CEO wealth in the firm.

and limited liability that demonstrate the optimality of pay packages composed of call option contracts (see Poblete and Spulber 2012 and Tirole 2006). In these models, the positive relation between pay and variance of pay arises purely due to the convexity in the (option-based) pay package. We modify our estimation by allowing the sensitivity of pay to variance of pay to depend on proxies for risk aversion. Using several proxies for risk aversion available in the literature, we find that the pay premium is significantly higher for high risk averse CEOs across all risk aversion proxies, and for one proxy there is no statistically significant premium for low risk averse CEOs. In addition, it is possible that CEO utility is characterized by decreasing absolute risk aversion of wealth. We therefore test whether CEOs with higher wealth (i.e., with presumed lower risk aversion) have lower sensitivity of pay to variance of pay. Using the inside wealth variable in Coles et al. (2006), we find a large, negative estimated coefficient on the interaction dummy for high CEO inside wealth with the variance of pay, consistent with decreasing absolute risk aversion.

Although proxies for CEO risk aversion help explain the cross section of the pay premium, we derive an implied risk aversion coefficient that is arguably low. Using the standard agency model, and a common assumption on preferences, we derive a coefficient of relative risk aversion around 1 from the estimated sensitivity of pay to the variance of pay. By comparison, Becker (2006) and Conyon et al. (2011) calibrate CEO relative risk aversion to 2 and 3 in their exercises: a value of relative risk aversion of 3 corresponds to a counterfactual elasticity of pay to variance of pay of 1, over 16 times larger than our estimated value. This evidence suggests that the pay premium is economically small – despite being statistically significant – constituting a rejection of the risk-based, standard agency model as it pertains to explain CEO pay and pay-for-performance packages. On a similar note, the low premium is consistent with evidence from a survey of directors and investors that risk has little effect on the level of CEO pay (Edmans et al. 2021). Murphy and Jensen (Murphy and Jensen) argue that the growth in incentive pay in the last two decades seems not to be driven by the provision of economic incentives, but rather due to features of the tax code. Our evidence is complementary also to Fernandes et al. (2013), Murphy and Vance (Murphy and Vance), and Murphy and Sandino (2020), who argue that risk sharing cannot fully explain the level of incentives observed in the U.S. Cadman et al. (2020) show that firms adjust their CEO equity grants to those of their peers to match outside job market opportunities and avoid CEO turnover, also consistent with levels of incentives being driven by factors other than risk diversification.

Several papers in the CEO pay literature hypothesize that CEO preferences value positively skewed payouts (Hemmer et al. 2000, Ross 2004, and Chaigneau 2015). We offer what we believe to be the first test of this prediction using a measure of skewness in pay obtained from a simulation exercise. Our estimates suggest that CEOs are in fact willing to receive less pay when they are offered more positively skewed incentive pay, though the estimates are not always statistically significant across all specifications. In addition to skewness, the regressions control for several potential sources of bias in our estimated premium by considering a wide array of factors discussed in the literature. The results are quantitatively robust.

We provide three alternative ways to estimate the variance of pay. First, we simulate pay packages using the approach developed in Core and Packard (2022). Their approach differs from ours in several ways, notably by replacing missing values with industry peers' sample averages, thus obtaining a significantly larger sample. The estimated sensitivity of pay to variance of pay using their alternative simulation approach is quantitatively similar to our main estimate. Second, we estimate the conditional variance of total pay using realized variance of past CEO pay in the spirit of Roussanov and Savor (1989) and Andersen and Bollerslev (1998). The results of regressing total pay on realized variance of pay are quantitatively consistent with the results using Incentive Lab detailed contract data that explicitly deal with time variation in contract parameters and performance metrics. Third, we use a variant of Engle (1982)'s autoregressive conditional heteroskedasticity (ARCH) model to jointly estimate the mean of total pay and the volatility of pay.[3] The ARCH-in-mean model is a statistical framework that simultaneously estimates an equation for the level of pay and an equation for the volatility of pay, while incorporating the volatility of pay as a factor in the equation for mean pay. This approach, too, generates results that are quantitatively consistent with the main results.

As a way of validating our measures of pay risk premiums, we examine whether a low pay for risk is associated with an increased propensity of CEO turnover. Consistent with theoretical predictions that failing to me a participation constraint should influence turnover, we find some evidence that CEOs have increased

---

[3] To the best of our knowledge this is the first paper that uses ARCH modeling to study CEO compensation data. We follow a long tradition in economics of using ARCH models to explain the joint time series behavior of the mean and volatility of economic variables, from inflation, in the path breaking study of Engle (1982), to GDP growth in Ramey and Ramey (1995), and to stock returns in Bollerslev et al. (1988). The last two papers, like ours, model the conditional mean of the dependent variable as a function of its conditional variance.

probability of turnover when pay risk premiums are below expectations.

In a robustness analysis, we consider the premium in the flow of current period CEO incentive compensation versus the pay risk from previously awarded stock and option grants (e.g., Core and Guay 2002 and Armstrong et al. 2015). To assess the relevance of this concern, we include the volatility of CEO wealth linked to firm performance. We show that, while there may be limitations to our analysis due to statistical power, the inclusion of the CEO's the volatility of CEO inside wealth, using the inside wealth variable in Coles et al. (2006), is not a statistically significant additional source of pay premium once we control for the volatility of current pay. In contrast, the variance of pay remains significant, though still economically small, even after controlling for the variance of CEO inside wealth.

Section 2 offers a review of the related literature. Section 3 describes the simulation exercise used to estimate the variance of pay. Section 4 presents the data and Section 5 the results. Section 6 presents results using three alternative approaches to estimate the variance of pay, and Section 7 offers an array of other robustness tests. Section 8 concludes. Appendix A provides a theoretical justification for considering the variance of total pay. Appendix B details additional steps used in the simulations, and Appendix C contains the definitions of variables used in the empirical tests.

2 Related literature

A large literature studies the association between CEO pay and firm volatility, referred to as the risk-return trade off. While some studies find a positive association between firm volatility – commonly proxied by stock return volatility – and CEO pay, others find a negative association between the two (see for example Aggarwal and Samwick 1999, Core and Guay 2002, and Prendergast 2002). This paper examines a different trade-off – that of CEO pay and the conditional volatility of total pay. The volatility of total pay captures not only the volatility of stock returns – the focus of prior research – but also the volatility of accounting returns and other performance metrics, such as sales growth, that are commonly used in pay contracts. Moreover, it takes into account the covariance amongst these different performance metrics and their relevance to CEO-specific contract-target parameters in determining compensation. In addition, a positive association between total pay and the variance of pay in agency models does not depend on the sign of the relation between firm's stock return volatility and equity incentives. In fact, the two relationships (i.e., the association between total pay and the variance of pay, and the association between equity incentives and the volatility of firm returns) are different empirical questions with different theoretical underpinnings. For example, Cheng and Scheinkman (2015) argue that higher firm volatility not only is indicative of higher firm risk, but also of higher productivity. In their model, there is a trade-off between mean pay and volatility of pay implied by the agent's participation constraint, which is also used in our paper to motivate the analysis. However, in their model, equity incentives could either increase or decrease in the firm's return volatility depending on how strongly volatility affects firm productivity.

Using an early methodological contribution by Lambert and Verrecchia (1991), Conyon et al. (2011) and Fernandes et al. (2013) provide an estimate of the risk premium in equity pay. Our test differs from theirs in several respects. First, we take advantage of detail contract information to simulate all three components of incentive pay: bonus, stock, and option grants, and, from these simulations, calculate the estimated variance of pay. In contrast, their estimate of a risk premium solely considers equity incentives, and excludes volatility in pay from bonus. Our study allows us to speak to the magnitude of the premium on bonus uncertainty. Second, their analysis relies on assumptions about CEO's outside opportunity that we do not require. We also do not require any assumptions about CEO risk aversion and can therefore accommodate a premium that arises even when the agent is risk neutral, a point emphasized above. Third, differently from Conyon et al. (2011) and Fernandes et al. (2013), because our sample focuses on U.S. firms only, all CEOs are exposed to the same legal, taxation, and economic environment; these country-level characteristics impact the level and form of pay but may be hard to control for in cross-country studies such as theirs.

The last thirty years have seen an expansion of CEO pay in the U.S. that has led to much debate. This expansion has come mostly via an increase in incentive pay components as opposed to fixed pay (e.g., Conyon 2006, and Murphy and Jensen Murphy and Jensen). Assessing the level of incentive pay in CEO compensation as too high or too low requires understanding the optimality of the given level of pay-performance incentives (Core and Guay 2010). Past studies have documented potential benefits and costs of incentive pay as they relate, for example, to manager-shareholder conflicts (e.g., Hadlock 1998), risk-taking (Coles et al. 2006 and Hayes et al. 2012), short-termism behavior (Bebchuk and Fried 2006), earnings management (Bennett et al. 2017), and accounting fraud (Erickson et al. 2006). We contribute to this literature by being the first paper to estimate the increase in direct compensation that boards have to pay their CEOs for bearing extra incentive-pay uncertainty.

3 Empirical strategy

3.1 The regression model

We estimate an equation derived from the standard agency model with moral hazard and risk averse agents (Holmstrom and Milgrom 1987). Appendix A provides the derivation of this equation where total CEO pay, w_t, is linearly related to the variance of total pay, σ_t^2,

$$w_t = \lambda\sigma_t^2 + X_t'\beta + \epsilon_t, \tag{1}$$

and where X_t are control variables and β is the vector of sensitivities of pay to the control variables. We discuss the control variables in a later section of the paper.

The variance of pay, σ_t^2, and the sensitivity of pay to the variance of pay, λ, both determine the pay risk premium. We consider several approaches to estimate the variance of pay. The ability to estimate λ is also critical to our exercise. The parameter λ is identified and the OLS estimate is an unbiased estimator if the residual is uncorrelated with the variance of pay. Formally, we want variation in σ_t^2 to be uncorrelated with variation in ϵ_t so that the former can be used to identify λ (i.e., $E_t[\epsilon_t\sigma_t^2] = 0$). Intuitively, identification requires that variation in incentives is the exogenous driver shocking both the mean and variance of pay. Important to the interpretation of λ is that this variation in incentives does not also affect the realized value of ϵ_t, conditional on knowing σ_t^2, since that would give rise to a correlation between ϵ_t and σ_t^2, and would result in a biased estimator of λ. Under the null of the Holmstrom and Milgrom (1987) model, and ignoring other predetermined time-t variables, $E_t(w_t) = \lambda\sigma_t^2$ (see Appendix A). That is, the principal knows the conditional variance of pay, σ_t^2, at the beginning of time t, and conditions on its value to determine the agent's pay. Thus, $E_t[\epsilon_t\sigma_t^2] = E_t[\epsilon_t]\sigma_t^2 = 0$, as desired.

3.2 Simulated variance using CEO contract data

For every CEO-year, we use detailed contract information available at the beginning of each year to simulate the end-of-year CEO pay. From this simulation exercise, we obtain the simulated variance of pay as of the beginning of the year, σ_t^2. The procedure to simulate the variance of pay is described in this section, with additional information provided in the Appendix B for further clarification. In section 6, we discuss results obtained after we simulate pay packages using the Core and Packard (2022) assumptions, which include a range of different distributional assumptions relative to ours.

Firms use two types of incentive pay to reward their CEOs: time-vested incentive pay and performance-vested incentive pay. Time-vested incentive pay includes time-vested restricted stock units (RSU) and time-vested stock options.[4] Performance-vested incentive pay includes bonus, performance-vested RSU, and performance-vested stock options. Time-vested incentive grants are not linked to specific performance targets, but their value is linked to firm performance through the stock price. Performance-vested incentive grants and their value are both linked to firm performance: CEOs need to first meet the performance targets prescribed in the compensation contracts to earn the grants, and then the equity and option grants' values are further linked to firm performance through the stock price.

We simulate the value of time-vested and performance-vested incentive pay differently. For time-vested incentive pay, we simulate the stock price and apply the simulated stock price to RSU or options granted in the current year to get the dollar value of the newly granted equity incentive pay. For performance-vested incentive pay, we take two inputs for the simulation: compensation contract information collected by Incentive Lab from the plan-based awards table of the DEF 14, which describes the relation between contracted performance metrics and the corresponding performance-based compensation, and Compustat data on realizations of the different performance metrics over the previous years. Using this information, we estimate the mean and covariance matrix (between the previous year realization for the mean, and the previous five year values for the covariance matrix), and simulate performance for the current year.[5]

The contract information is available at the firm-year-grant-metric level. For each performance metric used, Incentive Lab collects the threshold, target, and maximum level of the performance metric, and the threshold, target, and maximum level of the corresponding performance-based compensation. The CEO earns no performance-based compensation when actual firm performance is below the threshold and earns the maximum amount of performance-based compensation when actual firm performance is above its maximum.

---

[4] In the paper, we use the terms stock grant, restricted stock grant, and RSU to identify the same component of pay.

[5] Holden and Kim (2017) offer valuation formulas for performance equity grants. Because we consider bonus and equity plans simultaneously, and need to obtain measures of conditional volatility of pay, we have to use simulation methods.

When the performance metric falls between its threshold and the maximum, the CEO earns performance-based compensation in an amount between its threshold and the maximum. We follow the firms' policies disclosed in the proxy statements (DEF 14A) and fit a piece-wise linear function between the threshold, the target, and the maximum to determine the award amount.

To simulate pay for a CEO in a given year, we first simulate the performance metrics used by the firm in all the grants awarded in that year. Firms often use more than one performance metric for a given grant and award several grants to the same CEO in a given year. We consider all metrics used for a given firm-year and simultaneously simulate all metrics for that year, while accounting for the joint distributional properties of the metrics. In particular, we assume a multivariate normal distribution for the *firm-year-specific* vector of performance metrics used.

For our main results, we set the mean of the multivariate normal distribution equal to last year's value of the respective performance metrics. This essentially assumes that the board uses a random walk model for the performance metrics (i.e. the performance metric will remain at its current level in expectation going forward). We conduct a second set of simulations (in the robustness analysis section) where we assume that the mean of the performance metrics equals their end-of-year-t value. This assumption requires the board to have perfect foresight, implying that the board forms its forecasts about the CEO's actions and the environment the CEO operates in with zero forecast error in expectation. We think of these two alternative assumptions as placing bounds on the information used by the board to determine the conditional mean of the performance metric, from least information (random walk) to most information (perfect foresight).[6] Importantly, these different assumptions lead to quantitatively very similar estimated sensitivities of pay to variance of pay, providing some assurance that the assumptions we employ in the paper are not driving our results. Bettis et al. (2018), Hayes et al. (2012), and Core and Packard (2022) (which we simulate) all assume the mean of the performance metrics grows at the risk free rate.

We set the covariance matrix of the distribution equal to the sample covariance matrix of the performance

---

[6] Under the agency model, the agent's action is simultaneously determined with the choice of incentive scheme, and jointly these determine mean pay and variance of pay. There is of course a model simplification that the choice of an action and the implementation of such action happen at the same time. Our simulation assumes the board designs the incentive contract to elicit an action from the CEO. Implicitly, we assume that the distributional assumptions we make are consistent with the actions the board wishes to elicit from the CEO through the incentive package as well as the consequences of those actions on the performance metrics themselves.

metrics using five years of data prior to the grant year.[7] We then simulate performance outcomes 10,000 times for each firm-year-grant-metric observation.

We calculate simulated compensation by fitting the simulated performance metrics to the compensation contracts. Since performance is simulated at the firm-year-grant-metric level, we calculate the simulated compensation at that same level. We then aggregate the metric-level compensation into the grant level based on information in Incentive Lab about the relation between the various performance metrics. Compensation contracts are either separable or non-separable contracts. Separable contracts allow CEOs to earn part of the bonus, RSU, or option grants even though some of the performance metrics do not meet their goal threshold, while non-separable contracts result in zero payout if any of the performance metric thresholds is not met. Further, following Incentive Lab, we add the equally-weighted pay from all metrics in separable contracts to get total simulated pay at the grant level. For a CEO with more than one grant in a given year, we add simulated pay from all her grants. We add salary, other compensation, and discretionary bonus –paid at the discretion of the board and not formally tied to performance– to the simulated pay values at the firm-year level and calculate the mean, variance, and skewness of pay across the simulated values.

4 Data

We use two main datasets, Incentive Lab by Institutional Shareholder Services and ExecuComp. Incentive Lab contains detailed compensation contract information for the 750 largest U.S. firms collected from proxy statements (DEF 14A) for CEOs and other executives starting from 1998. ExecuComp contains a combination of firms from S&P 500, S&P Midcap, and S&P Smallcap 600, plus backfilling of companies who were in one of the indices at some point, starting from 1992. For both datasets, we restrict our sample to CEOs serving a full year to ensure that we include only complete annual compensation and not partial year compensation to minimize estimates of pay volatility unrelated to risk. In addition, we obtain financial data from Compustat, stock return data from CRSP, data on board of directors from Institutional Shareholder Services, and institutional holdings data from Thomson Reuters Institutional (13F) Holdings. The variables used are described in Appendix C.

---

[7] To simulate the value of option grants we estimate the volatility of stock returns using the last five years of monthly data and cap volatility by the average volatility across all simulation years. Because stock prices are not stationary time series, we simulate the value of price to sales and then recover the price in the simulation. The ratio of price to sales is adjusted for stock splits using the lagged COMPUSTAT variable "ajex".

When using the Incentive Lab data, we restrict the sample period to 2006-2016. The year 2006 marks the availability of the plan-based awards table. We include bonus, RSU grants and option grants, both performance-vesting and time-vesting grants. We restrict attention to contracts with quantitative performance metrics and, in our main analysis, to contracts that use absolute performance metrics only. The first restriction is justified by the unavailability of data on qualitative performance metrics such as customer satisfaction to conduct a simulation exercise. As a consequence, our findings may not generalize to firms with pay packages that rely on such performance metrics. The second restriction is due to the lack of contract details for relative performance goals in Incentive Lab. We lift this restriction when we use the Core and Packard (2022) approach to simulate the variance of pay (see Section 6).

We identify the specific performance metrics used in each contract including whether a given metric is scaled (e.g., by shares outstanding or by sales) or is expressed as a growth rate. We also collect textual information available in Incentive Lab to more precisely describe the metric used (e.g., when Incentive Lab variable "metric" has the value of "Cashflow", Incentive Lab variable "metricOther" clarifies whether it is operating cash flow, free cash flow or net cash flow). We use this rich information for each compensation contract, but recognize the possibility of errors in Incentive Lab in describing the exact metric used. Core and Packard (2022) takes a different approach on measurement error on the definition of the performance metric by considering earnings per share as the only non-price metric.

Despite the large volume of metrics data in Incentive Lab, not all grants in ExecuComp have accompanying metrics data in Incentive Lab. We excluded firms from the simulation if they have actual bonus, RSU, or option payments information according to ExecuComp, but there is insufficient contract information available in Incentive Lab to perform the simulation. Thus, our sample uses only firm-year observations for which we can simulate *all* incentive compensation components, given the restrictions above. In a robustness exercise, we construct a larger sample that also includes firm-year observations for which we do not have complete contract information (e.g., we may have bonus contract details but not restricted stock details despite observing that the CEO received a restricted stock payment in that year, in addition to the bonus payment). While this sample is larger, it has the disadvantage that our estimates of the variance of pay carry measurement error linked to the absence of information on components of incentive pay. We report results using this sample in the robustness section.

From Incentive Lab, we obtain 55,076 compensation contracts at the firm-year-grant-metric level for bonus, RSU, and option grants. Excluding contracts with missing values for the performance metrics or payouts, contracts with incomplete metric information (i.e., not all metric information is available for a given grant), and contracts where information on actual compensation is not available, yields 20,524 compensation contracts at the firm-year-grant-metric level. We further exclude firm-years with incomplete compensation contract information. We are able to identify the existence of incomplete compensation contract data because information on actual compensation components paid out is available in a separate file in Incentive Lab as well as in ExecuComp.[8] After this exclusion, the sample has 939 firm-year observations with data available in Compustat on past performance required for the simulation. These 939 firm-year observations comprise 2,770 firm-year-grant-metric observations, of which 811 are for bonus, 880 for time-vested RSU, 251 for performance-vested RSU, 821 for time-vested options, and 7 for performance-vested options (see Table 1 panel A). Table 1 Panel A also shows that 466 firm-year observations pertain to CEOs that received bonus grants, 781 are with CEOs that received RSU grants, and 666 are with CEOs that received options grants.

While our sample is much smaller than the ExecuComp sample, it shows considerable similarity with this larger sample. In untabulated results, the average firm size and total pay of the sample firms is larger than that in the ExecuComp sample, which is partly a reflection of the fact that Incentive Lab tends to collect data on the larger firms. Otherwise, in many dimensions, including the mean and variance of stock and accounting returns, two important metrics of performance uncertainty, there are no statistical differences between the two samples.

Table 1 Panel A presents the distribution of performance metrics used in the compensation contracts at the metric level; Panel B presents descriptive statistics for the number of performance metrics per grant/year and the number of grants per CEO/year. Across all awarded contracts, the use of accounting-based performance metrics dominates that of stock price-based performance metrics, which suggests that past studies that focus solely on stock return volatility can significantly understate the extent of pay volatility the CEO is exposed to. After excluding time-vested contracts, which do not require performance metrics, we find that 99% of the

---

[8] In ExecuComp, the data item "nonequityincentives" includes the total value for possibly multiple bonuses grants paid during the year. We included in our sample firms that have nonmissing values for nonequityincentives in ExecuComp and nonmissing values for bonus grants in IncentiveLab. However, it is possible that our sample includes firms for which Incentive Lab has non-missing values for fewer bonus grant than the actual number of bonus grants paid.

performance metrics are accounting-based. Among the accounting-based performance metrics, EPS, sales, operating income, and cash flow are the four most commonly used performance metrics. On average, each bonus (restricted stock and option) contract uses 1.57 (1.07 and 1) performance metrics, and each CEO receives 1.11 (1.35 and 1.24) grants per year. The maximum number of performance metrics used in bonus (restricted stock and option) contracts is 4 (3 and 2).

Figure 1 plots the cross sectional means of actual pay (from ExecuComp) and simulated mean pay (using Incentive Lab data) over time for the same set of firms. For each component of pay (total, bonus, restricted stock and options), any missing values of a pay component are excluded from the respective cross-sectional average calculation. Overall, the simulation procedure comes reasonably close to matching the actual value of bonus, restricted stock, options, and total pay. ExecuComp bonus is the realized value of bonus and simulated bonus is its expected value, and as such, it is natural to expect yearly deviations that wash away with a large enough sample. For example, the actual bonus paid in 2008 is smaller than the simulated because the impact of the economic downturn in 2008 was not anticipated. Note that as mentioned above, we use the past-year realizations of the performance metrics to obtain their expected values. In the small time series we observe, realized bonus appears somewhat larger on average than simulated bonus. One possible explanation for the gap in bonus is that firms may adjust performance metrics to boost executive bonus compensation (Kim and Yang Kim and Yang). Another explanation, which can also apply to the other pay components discussed below, is that we are not able to estimate bonus components that rely on qualitative metrics (i.e, customer satisfaction, team work) or have relative performance conditions (excluding the firm-year observations that have RPE performance grants from the sample, the simulated and actual values for bonus come significantly closer). We find that simulated fair values of restricted stock grants using Incentive Lab data do not differ significantly from the values reported in financial statements.[9] We follow Core and Guay (2002) in calculating the value of option grants using Black-Scholes. We find that in the later part of the sample, the ExecuComp option values, which after 2006 use the fair value of options, are systematically above their simulated counterparts.

Figure 2 plots simulated and realized values of total compensation across industries. As in Figure 1, there is

---

[9] Our simulation results contrast with those in Bettis et al. 2018 who find a gap between actual and simulated values for restricted stock grants.

a gap between total realized pay and total simulated pay, but there are no apparent differences in this gap across industries. Overall, our simulated data appear to be largely consistent with realized pay, on average.

Table 2 provides descriptive statistics for our sample firms, including all the control variables. The average (median) CEO total annual compensation flow, TDC1, in the main sample is \$6.75 (\$5.38) million and for the ExecuComp sample, which we use later, is \$4.68 (\$2.76) million. We use the logarithm of one plus total annual compensation in the empirical analysis to mitigate the effect of skewness in compensation. In robustness tests, we use the inside wealth variable in Coles et al. (2006) to capture the lack of diversification that comes from past equity grants. The mean one-year stock return is 16 percent with a standard deviation of 46 percent. The mean ROA is somewhat smaller at 4 percent and also less volatile at 9 percent. The logarithm of market value for the average firm is 7.45, slightly higher than the median value, consistent with our sample being skewed towards larger firms. Sample firms have 56 percent of board members hired by the CEO (coopt) on average and have 68 percent of average institutional ownership. The CEOs in our ExecuComp sample are on average 56 years old and stay in that role for an average of 8.2 years. About 11 percent of our sample CEOs are founders of their firms. The mean (median) firm stock return volatility (i.e., variance of stock returns over the last 36 months) is 0.11 (0.10). The mean (median) log simulated CEO pay volatility is 14.32 (14.40).

A novel control in our regressions is skewness of pay (calculated from simulated pay). Hemmer et al. (2000), Ross (2004), and Chaigneau (2015), using a general utility specification, predict a preference for positive skewness. A prudent CEO prefers positive skewness in pay if she dislikes downside risk (Chaigneau 2015) and requires less mean pay if awarded a contract with convex payouts, say through option grants, which predicts a negative coefficient on pay skewness. However, Agren (2006) shows that there is an opposing effect of a preference for skewness for agents with cumulative prospect theory, which predicts that skewness should instead have a positive association with mean pay. Thus it is not clear whether CEO pay is positively or negatively associated with pay skewness. We also control for current and lagged own firm performance, following Himmelberg and Hubbard (Himmelberg and Hubbard) and Oyer (2004), to capture the impact that outside opportunities have on total pay. The assumption is that a better performing CEO will have better labor market opportunities and thus receive higher pay. In addition, we control for peer pay.[10] We also control for

---

[10] In untabulated results, we also control for outside opportunities using industry times year fixed effects, IPO activity as per Nickerson

CEO entrenchment, to capture the possibility of rent seeking by the CEO, using the co-opted board measure (Coles et al. (2014)) as well as the percentage ownership by institutional investors. There is evidence that CEOs overestimate the performance of their investments while underestimating the risks (e.g., Dittrich et al. 2005, Huang and Kisgen 2013, Kolasinski and Li 2013, Malmendier and Tate 2005, and Malmendier and Tate 2008). This overconfidence can be used by the shareholders to save on the costs of incentive provision by offering contracts that are incentive-intensive (Gervais et al. 2011). To control for this effect, we use the Humphery-Jenner et al. (2016) overconfidence indicator that is based on whether the CEO holds deep-in-the money options that have vested.

When the CEO's utility function is nonseparable in consumption and effort, incentives may be provided by reducing the marginal cost of effort (see Laffont and Martimort 2002). For example, higher CEO pay creates status enjoyed by the CEO that reduces her cost of effort. We therefore also control for cost-of-effort proxies: CEO age and log of CEO tenure, the volatility of stock returns, an indicator variable for when the CEO is the founder, and the lagged value of the firm's market capitalization.[11]

5 Results

5.1 Estimating the sensitivity of pay to variance of pay

Table 3 reports the results of panel regressions of the logarithm of TDC1 on the logarithm of simulated variance of pay using ordinary least squares. We present two main sets of regressions. Columns 1 through 3 report the results for the variance of total pay, without other controls (column 1), with only firm and year fixed effects (column 2), and with all controls including firm and year fixed effects (column 3). Inclusion of firm fixed effects allows us to examine how changes in the variance of pay within a firm, which are caused by changes in incentive compensation parameters, affect total pay. In columns 4 through 6, we replace the variance of total pay by its three components: the simulated variance of bonus grants, the simulated variance of equity grants, and the simulated variance of options grants. Because not all firms offer all three types of grants, the logarithm of (one plus the) the variance of, say, bonus is zero for firms that do not pay bonus. To account for the fact that some

---

(2017), and average industry ROA and find similar results to those shown above.

[11] As alternative measures of firm size, we also consider total assets and sales revenue. Our results are unaffected when using different measures of firm size and also when all of them are simultaneously included in the regressions.

of these zeros represent missing observations (i.e., non-awarded contracts), we add to these regressions dummy variables associated with each of the three grant types to control for this fact. These dummy variables take a value of one when the respective grant type is not offered by the firm. In column 7, we show the results of a regression of TDC1 on the controls alone as a benchmark. Standard errors are clustered by firm and year (see Abadie et al. 2023).

The coefficient on the logarithm of simulated variance of pay describes the sensitivity of pay to variance of pay. This coefficient is positive and statistically significant at the 1% level across all specifications. Including fixed effects impacts the economic magnitude of the sensitivity. The coefficient drops from 0.179 without fixed effects (column 1) to 0.072 when both firm and year fixed effects are included (column 2). This result indicates that the within firm sensitivity of pay to volatility of pay is smaller than that across firms: the premium paid when a firm increases its volatility of pay is significantly smaller than the premium that results from comparing two firms with different levels of volatility of pay. Allowing for firm fixed effects is important to ensure that the inference is not impacted by mechanical scale effects. Consider two pay packages from two different firms, one with a \$1 million salary and the other with a \$10 million salary with otherwise identical pay-for-performance grants. This salary distinction should not affect the estimate of λ since it does not affect the amount of risk in the pay package, which is the same. The inclusion of a firm fixed effect can absorb scale differences across firms such as the salary difference. When we further control for other commonly used economic determinants of compensation, the coefficient on the logarithm of simulated variance of pay slightly decreases to 0.059 (column 3). In subsection 5.2, we use this latter estimate to provide an assessment of the pay risk premium.[12, 13]

In columns 4 through 6, we replace the simulated variance of total pay by the simulated variances of bonus, stock, and option grants. Considering the results in column 6, the larger coefficient is the one associated with stock grants. The coefficients associated with bonus and option grants are about one third and one tenth

---

[12] In untabulated results we find similar estimates when fewer controls, which may be correlated with variance of pay, are used. These controls are simulated skewness, return and earnings volatility, and leverage. Indeed, removing these controls increases the estimated sensitivity of pay to variance of pay, though only marginally, to 0.069.

[13] In untabulated results, we estimate regression models where the logarithm of TDC1 is replaced by the logarithm of the simulated mean pay from Incentive Lab as the dependent variable. The regression results yield significantly higher parameter estimates for the sensitivity of pay to variance of pay. These estimates may be biased because of the possibility of correlated measurement error from the simulation in both the right-hand-side and left-hand-side variables. Along these lines, we point out that in these regressions the increase in point estimates is not accompanied by an increase in t-statistics, which means that the standard errors of the estimates also increase significantly.

smaller, respectively, of the value of the coefficient associated with stock grants. These later coefficients are also not statistically significant. It is possible that the lack of significant results for bonus and options grants has to do with the fact these are the components of pay with the largest percentage of missing observations for pay variance. In untabulated analysis, we confirm that stock grants have the lowest percentage of missing observations for pay variance.[14]

The effects from the control variables are largely consistent with previous literature (for completeness we regress the logarithm of TDC1 on the controls alone and display the results in column 7). We find that firms with better contemporaneous ROA and stock return performance pay more to their CEOs, though only the effect from stock performance is significant across all specifications; firm return volatility is associated with lower pay, but interestingly the effect is only present when we include the variance of pay in the regression; CEO pay is higher at larger firms and at firms where the CEO is not the founder; entrenchment measured by the variable "coopt" has a positive, though statistically insignificant, effect on pay; and, firms with high disclosed peer pay also pay more to their CEOs, consistent with prior studies that report a benchmark effect (e.g., Bizjak et al. 2008). The regressions include simulated skewness in pay, a variable that we believe has not been used previously. The estimated negative coefficient suggests that CEOs like positive skewness in pay and are willing to receive lower pay for it. The effect is, however, statistically insignificant in our sample.

A concern on the identification of the parameter λ is that of omitted correlated regressors. To assess how significant an issue this may be, we conduct the test proposed in Oster (2019) for omitted variables and coefficient bias. Using her proposed cut-off values, we find that in our data the explanatory power of the unobservable variables would have to be 2.036 greater than that of the observables to affect our estimated coefficient (i.e., Oster's delta=2.036). This seems unlikely as we have incorporated an extensive set of control variables in our study, which is grounded in prior literature explaining the determinants of executive compensation. Further, Oster (2019) proposes that the statistic delta should be larger than 1 to be able to assert that omitted variables do not drive the significance of the estimate. In our case delta is larger than 2, supporting the view that our estimated coefficient is stable to omitted variables.

---

[14] The evidence of a low sensitivity for options is surprising given potential contractual features linked to option grants that should push the estimates upward. Increases in firm return volatility increase average pay through the higher value of options and increase the variance of pay through the higher variance in the value of options.

5.2 Estimating the premium in incentive pay

In this subsection, we convert the estimated elasticity of pay to variance of pay into a pay risk premium. We further decompose the premium between the components attributable to cash bonus, stock grants, and option grants. The pay premium is calculated as the change in total pay induced by an increase in the volatility of pay of the amount $\Delta \log(\sigma^2)$. That is, the premium equals $(\exp[\lambda \Delta \log(\sigma^2)] - 1) * 100$ and is expressed as a percentage. In our calculations of the premium, we assume that the change in volatility of pay is equal to one sample standard deviation of the logarithm of the volatility of pay.

In Table 4, we presents estimates of the pay premium using the coefficients from Column 3 of Table 3. The estimate of the premium on total pay volatility is 15.3%, implying that total pay is expected to increase by roughly 15% when incentive-pay risk increases by one standard deviation. The estimated premium associated with bonus grants is 7.6%. In contrast, the estimated premium for restricted stock grants is 21.1%, and for option grants, it is 2.6%. Only the premium on stock grants is statistically significant. The economic magnitudes of these premiums are somewhat in line with how much each of these grants represent of total pay (on average bonus pay is 24% of total pay, whereas the average amount of stock grants is 29% of total pay, and the average amount of option grants is 15% of total pay, with the rest being salary). Thus, restricted stock appears to be the primary means through which CEOs are rewarded for pay risk, possibly because it also represents the largest component of their pay.

5.3 Risk aversion as a source of the pay premium

The standard agency model displayed in Appendix A assigns the risk premium to risk aversion. But, it is worth noting that even if the CEO is risk neutral, a positive association between mean pay and variance of pay can arise through the optimal contract's convexity features (see Poblete and Spulber 2012 and Tirole 2006), wich creates incentives for the CEO to take on additional risk leading to an increase in the variance of pay. In this subsection, we allow the sensitivity of pay to variance of pay to vary with a CEO's level of risk aversion to provide a cross-sectional test of the standard agency model with moral hazard.[15]

---

[15] Doing a conditional analysis using proxies for risk aversion serves yet another purpose. Haubrich (1994) shows that in the agency models of Grossman and Hart (1983) and Holmstrom and Milgrom (1987), equity incentives increase sharply as CEO risk aversion decreases. This observation on the nonlinearity of incentives and risk aversion suggests that the presence of a few low risk-averse CEOs may lead to an underestimation of the average sensitivity. By interacting the volatility of pay with risk aversion proxies this problem is

We consider several proxies for risk aversion. Bernile et al. (2017) show that CEOs' early-life exposure to fatal disasters is related to their risk-taking choices. Specifically, "CEOs who experience fatal disasters without extremely negative consequences lead firms that behave more aggressively" along corporate acquisitions and leverage choices among other corporate policies. We use their *Medium Fatality* variable as a proxy for CEO risk aversion encoded as a dummy variable. A large literature provides evidence consistent with females being less risk averse than males. For example, Barber and Odean (2001) show that women trade in their stock portfolios less than men do and argue that their results are consistent with a mixture of overconfidence and risk aversion. Borghans et al. (2009) conduct an experimental design and show that women value increasingly ambiguous options less than men do. We use a dummy variable that equals one for female CEOs and zero otherwise to proxy for risk aversion. Malmendier and Tate (2008) find that overconfident CEOs engage in more value-destroying mergers as they overestimate the returns from acquisitions. While they distinguish overconfidence from risk aversion, overconfident CEOs do not perceive risks in the same way as less overconfident CEOs and would therefore not require as much compensation. We use a dummy that equals one for values of overconfidence larger than the mean. Risk aversion appears to be inversely related to CEO tenure. Tufano (1996) shows that in the gold mining industry, long tenured CFOs manage less their company's exposure to gold price risk, consistent with these CFOs being less risk averse. Likewise, Bloom and Milkovich (1998) find evidence that longer tenure of CEOs is associated with increased firm equity risk, suggesting that they are less risk averse. We create a dummy for longer tenured CEOs (above median tenure) as a proxy for lower risk aversion.

In Table 5 we augment the regressions in Table 3 with an interaction between the variance of total pay and each of the proxies for risk aversion. We display a two-sided test of the joint significance of the coefficients associated with the variance of pay and with the interaction term. In the presence of firm fixed effects, we interpret the coefficient associated with the interaction term as capturing within firm changes on the variance of pay given the level of CEO risk aversion.

The evidence suggests that the premium is significantly higher for high risk averse CEOs across all proxies for risk aversion and for overconfidence. Starting with the Medium Fatality dummy, we see that only the risk averse CEOs require a premium, and for these, the sensitivity of pay to variance of pay is almost 50% higher

---

ameliorated.

than the unconditional sensitivity reported in column 3 of Table 3. Note that when using this proxy for risk aversion, we lose many observations as we lack data on Medium Fatality. For female CEOs, the sensitivity of pay to variance of pay for is 0.248 = 0.194 + 0.054, about 4.5 times larger than the sensitivity of pay to variance of pay for males. This evidence is consistent with female CEOs being significantly more risk averse than male CEOs. Our evidence is also consistent with Carter et al. (2017) who show that female executives are less willing to accept risky pay and get more salary. Non-overconfident CEOs have a sensitivity of pay to variance of pay equal to 0.082, more than twice the sensitivity of pay to variance of pay for overconfident CEOs (equal to 0.036 = 0.082 – 0.046). And finally, longer tenure CEOs estimated sensitivity of pay to variance of pay equals 0.034 = 0.089 – 0.055, which is less than half the sensitivity required by shorter tenured CEOs. The evidence from CEO overconfidence and tenure is also consistent with higher risk aversion CEOs having greater sensitivity of pay to variance of pay as predicted.

We provide one final test that suggests that the estimated sensitivity of pay to variance of pay depends on risk aversion. In the last column of Table 5, we report results from regressions where we interact the variance of pay with a dummy that equals one for high wealth CEOs, using the inside wealth variable in Coles et al. (2006). The hypothesis being tested using this proxy for risk aversion is that, under decreasing absolute risk aversion, CEOs with higher wealth exhibit lower levels of risk aversion. This is because higher wealth can dilute the disutility of uncertainty for them. The evidence supports this hypothesis. High wealth CEOs have estimated pay sensitivities that are 45% of the sensitivities for low wealth CEOs.

In summary, we find evidence that the pay premium is statistically significantly related to proxies for CEO risk aversion consistent with the standard agency model. Next, we assess the economic magnitude of the pay premium by using implied measures of CEO risk aversion.

5.4 Economic significance of the estimated pay premium

With the benefit of a structural model (see Appendix A and specifically equation (5) set with equality), the estimated elasticity of pay to variance of pay can be transformed into an estimate of the risk aversion coefficient. Let us consider utility with constant relative risk aversion, which is commonly used in economics and finance, and that CEO pay follows a lognormally distribution. We can show that the expected log pay (our dependent variable) equals the volatility of log pay (our independent variable is the log of the volatility of pay) times $(\gamma - 1)/2$, where $\gamma > 0$ is the coefficient of relative risk aversion.[16]

Estimates of the elasticity of pay to variance of pay in the regressions above with fixed effects are about 0.06, yielding estimates of risk aversion of approximately 1.12. To put this value into perspective, asset pricing studies typically assume that the coefficient of relative risk aversion is around 10! It is possible though that CEOs have lower risk aversion than the marginal investor. In calibrated models of CEO pay, Becker (2006) and Conyon et al. (2011) assume that CEO relative risk aversion is either 2 or 3. A risk aversion coefficient of 3 would be comparable to a sensitivity of pay to variance of pay of 1 (i.e., $\frac{3-1}{2}$), over 16 times larger than our estimated value. Even our higher estimated sensitivity of 0.248 for female CEOs is 1/4 of the value needed to generate a risk aversion of 3.[17]

We conclude that the pay premium implies a low risk aversion coefficient. While we do not reject the null hypothesis of the standard agency model since the pay premium that we estimate is statistically significant, the implied low risk aversion coefficient suggests that risk diversification is not a significant economic factor describing the cross section of CEO pay, especially given that on average over 70% of CEO pay is incentive based.

6 Alternative approaches to estimate the variance of pay

6.1 Simulating pay using the Core and Packard (2022) method

This subsection presents the results of simulating performance and pay outcomes using the method developed in Core and Packard (2022). We pursue this exercise for several reasons. First, their method has the advantage that it includes a simulation of RPE-based grants, under several assumptions, including that all RPE grants are solely based on stock returns. Simulating RPE-based grants is important because RPE allows greater incentives for CEOs by protecting their pay from variations in aggregate sources of risk. This feature is particularly relevant

---

[16] Let utility be given by $U(w) = \frac{w^{1-\gamma}}{1-\gamma}$, with $\ln w$ normally distributed with mean μ and variance σ^2. Then, $E(U(w)) = E(\exp^{(1-\gamma)\ln w})/(1-\gamma) = \exp^{(1-\gamma)\mu + 0.5(1-\gamma)^2\sigma^2}$, using the properties of the moment generating function for normally distributed variables. Using equation (5) in Appendix A, we have that $\mu = \frac{\gamma-1}{2}\sigma^2 +$ constants. Note that equation (6) in the same appendix was derived using a different utility specification that uses the less standard coefficient of absolute risk aversion.

[17] Like us, Armstrong et al. (2015) find that a low relative risk aversion coefficient is needed to explain why CEOs hold so much unrestricted equity.

in industries where common sources of risk in firm performance are more prevalent. Second, Core and Packard (2022) solve the problem of missing contract information in Incentive Lab by replacing the missing data with sample averages obtained from firms in the same industry (see their paper for details on the simulation). This allows for a significantly larger number of firm-year observations. Third, they make different distributional assumptions for the performance metrics; performance metrics are assumed to be normally distributed and to grow at the risk-free rate. Fourth, and in relation to the previous point, their approach for absolute performance metrics does not require the use of non-price contract details. Instead, they only simulate earnings-per-share, their proxy for all non-price performance measures, and stock price. The main drawback of their simulation method is the use of imputed data, and for this reason, we choose to conduct our primary analysis using the smaller sample based on actual contract information. However, we use their simulation method to replicate our results, which serves as a quasi-out-of-sample test of our hypothesis.

Table 6 reports estimates of the sensitivity of pay to variance of pay using the Core and Packard's simulation method to estimate the variance of pay (columns 1 through 3). The table also presents the results obtained from our main sample, where we incorporate the simulated values of RPE grants using Core and Packard's method in our simulation (columns 4 through 6). Overall, we find that the results obtained from this larger sample, which includes a greater number of pay grants and RPE-based grants, are quantitatively similar to those obtained from our main specifications. Interestingly, we observe a statistically significant preference for positive skewness when using simulated skewness from Core and Packard's approach.

6.2 Variance of pay estimated using realized variance

As an alternative to using Incentive Lab data and the rich contract information, we estimate the realized variance of pay using past CEO-firm pay data. We use the last five years of total CEO pay, w_t, to compute realized variance of pay,

$$\text{Realized Variance}_t = \frac{1}{5}\sum_{s=1}^{5}(w_{t-s} - \bar{w}_t)^2, \tag{2}$$

where $\bar{w}_t$ is the 5-year sample mean.[18]

---

[18] This estimator is similar to Roussanov and Savor (1989)'s estimate of conditional monthly return volatility that uses daily data and to Andersen and Bollerslev (1998)'s estimate of conditional daily return volatility that uses intraday data. The 5-year conditional volatility is a smooth function of the past 1-year conditional volatility. As such, it may introduce an upward bias on the estimated sensitivity of pay to the variance of pay. Preempting our results, the fact that we estimate a small slope coefficient, suggests that this

To motivate this estimator, note that if pay were a function of stock returns alone, then this estimator would be a consistent estimator of the conditional volatility of pay. To see this point, evaluate the estimator in Equation (2) applied to data generated by a model similar to Holmstrom and Milgrom (1987), where pay is a linear function of the firm's stock return, r_t, that is $w_t = m_0 + m_1 r_t$, and m_0 and m_1 are optimal contract parameters. Then, Realized Variance$_t = m_1^2 \frac{1}{5} \sum_{s=1}^{5} (r_{t-s} - \bar{r}_t)^2$. Andersen and Bollerslev (1998) show that under general properties for stock returns, the estimator above converges to the conditional variance of pay in the model, i.e., $m_1^2 V_t(r_t)$, where $V_t(r_t)$ is the conditional volatility of stock returns, if we are allowed to sample returns at increasingly higher frequencies. Thus, we expect realized variance to work well as an estimator under the null that pay evolves linearly with stock returns. Intuitively, if contract parameters remain constant overtime, any changes in pay can be attributed to variations in the level of performance metrics, which can be captured by past data realizations. The realized volatility of pay and the realized volatility of stock returns may not be directly proportional to each other since the realized variance of pay incorporates the variances of other performance metrics and their covariances. This is likely to be the case since, as shown in Table 1 Panel A, most firms use accounting-based performance measures instead of stock returns as performance metrics in their incentive contracts, as revealed by the detailed contract information from Incentive Lab.

Realized variance offers a significant advantage over Incentive Lab's simulated variance, as it allows for the use of a much larger sample size (from ExecuComp), thereby eliminating the need to exclude firms or grant types, including those with qualitative performance metrics. The main disadvantage is that the realized variance is potentially a less efficient way to estimate ex-ante volatility if contract parameters are time varying. Although the extent to which this is a limitation for the realized variance approach is uncertain, we note that assuming time-invariant contract parameters is a common assumption in empirical models of CEO pay that rely on panel data regressions.[19] There is another disadvantage of using realized variance and actual total pay (measured by ExecuComp variable TDC1) relative to using simulated variance and total pay. TDC1 uses the fair value of options and time-vested restricted shares. This implies that two CEOs, one receiving every year \$1 million salary and no other compensation, and another receiving every year \$1 million of time-vested options and no

---

bias is not severe.

[19] In addition, some evidence in rigidity in contract parameters can be found in Shue and Townsend (2017).

other compensation, will display zero realized volatility over time when in fact the riskiness of their contracts is very different. This is likely to bias downwards any estimate of the sensitivity of pay to variance of pay.

Table 7 repeats the same regressions as in Table 3, but uses realized variance of pay as the measure of the conditional volatility of pay, a proxy that is obtained from compensation data in ExecuComp. The dependent variable is as before, the logarithm of TDC1. As in Table 3, standard errors are clustered by firm and year. Across all specifications (columns 1 through 3), the estimated coefficients using realized variance of pay are positive and significant at 1%. Analyzing the results of the regressions with fixed effects and other controls (column 3), the sensitivity of pay to variance of pay is 0.028, half the size of that in Table 3. This sensitivity translates into a pay premium of 7.39% of pay (untabulated), about half of the pay premium estimated using the Incentive Lab data and simulated variance of pay. The statistical significance associated with the remaining control variables does not change significantly with some notable exceptions: skewness becomes strongly negatively associated with total pay; firm return volatility is no longer statistically significant but earnings volatility is; Founder loses its significance; overconfidence becomes strongly positively related to total pay.

Table 7 columns 4 through 6, reports the sensitivities of pay to the variances of bonus, RSU and options grants. When fixed effects and other controls are introduced, the magnitude of these coefficients drops considerably as they do in Table 3. The coefficients on bonus variance and RSU variance remain highly statistically significant even after we add the remaining control variables. The pay premium associated with bonus grants is 5.07% and that associated with stock grants is 3.99%, somewhat lower than those estimated using the Incentive Lab data and simulated variance of pay, especially for stock grants.

Overall, these tests confirm our main findings that there is a positive, but low pay premium from pay at risk.

6.3 Variance of pay estimated using an ARCH model

We consider a third alternative approach to estimating the variance of pay that uses the autoregressive conditional heteroskedasticity (ARCH) model. To the best of our knowledge, this is the first paper that estimates an ARCH model for CEO pay. Empirically, we assume that variance of pay, σ_t^2, can be modeled using

$$\sigma_t^2 = \alpha + \sum_{j=1,...,p} \delta_j \epsilon_{t-j}^2. \tag{3}$$

with the parameters $\alpha, \delta_j \geq 0$, and $j = 1, ..., p$ indexes the number of ARCH terms. We estimate Equation (3) jointly with Equation (1) for total pay as an ARCH-in-mean model.

The estimation uses pooled data and so the parameters α and δ_j in the volatility equation and the parameters in the mean Equation (1) are assumed identical across firms. The estimation of these models is done in an unrestricted fashion and we check ex-post the non-negativity constraints on the variance-equation parameters, $\alpha, \delta_j \geq 0$. In addition to the non-negativity of the parameters, the ARCH approach does require that the variance of pay be stationary, that is $\delta_1 + ... + \delta_p < 1$. The empirical approaches using Incentive Lab data and the ARCH model have the advantage over the realized variance approach of not requiring the assumption of time invariant contract parameters, though the ARCH model requires an assumption of stationarity of variance of pay. From an implementation point of view, the ARCH model requires longer time series, which we partly accommodate by estimating the model on pooled data and imposing the same coefficients across firms. We are unable to run the model estimation with the decomposition of the premiums.

The results are reported in Table 8 for the variance of total pay. In contrast to the specifications in Tables 3 and 7, the dependent variable in Table 8 is the level, not the logarithm, of TDC1. This way, the ARCH-in-mean model incorporates the logarithm of the volatility of the dependent variable (i.e., TDC1) into the pay equation. To interpret the coefficient on variance of pay as a sensitivity as before, we divide the estimated slope coefficient by the mean of pay. We use year fixed effects, and industry fixed effects as opposed to firm fixed effects, because the ARCH estimation in Stata cannot handle the large number of firm-specific indicator variables. We also include all the other controls as before. Table 8 shows that the sensitivity of mean pay to variance of pay is positive and statistically significant at 1% across all specifications. In column 3, the coefficient is 131.7, which dividing by the mean of TDC1 of \$4,680 (the unit of TDC1 is thousands) gives an elasticity of 2.8%. This estimate is remarkably similar to the effect using the realized variance described above and presented in Table 7. The ARCH coefficients across the three specifications in Table 8 are all positive as expected so that variance is positive throughout. The regression in column 3 of Table 8 includes realized skewness as a determinant of pay. The estimated coefficient associated with realized skewness is negative but not statistically significant.

7 Robustness

7.1 Alternative sample using Incentive Lab data

While there is a significant amount of metrics data available in Incentive Lab, it's important to note that not all grants in ExecuComp come with accompanying metrics data in Incentive Lab. Some firm-year observations in ExecuComp show actual bonus, equity grants, or option payments, but lack sufficient contract information in Incentive Lab for the simulation. To test the robustness of our findings, we create an alternative sample that includes observations where we do not have complete contract information for the CEO in a given year. For example, we may have access to bonus contract details, but not to restricted stock details, even though we observed in ExecuComp that the CEO received both restricted stock and a bonus payment that year.[20] The results (untabulated) from this larger sample produce statistically significant, but lower magnitudes of the estimated coefficients, perhaps because of the associated measurement noise.

7.2 Pay premium and CEO turnover

To validate the measurement of the premium for pay at risk, we examine CEO turnover. Theory predicts that the participation constraint must be met, meaning that if a CEO is being paid below her reservation wage, she should be more likely to leave the firm. We therefore predict that if the premium for pay at risk falls below expectations, we should observe greater voluntary turnover among CEOs.

One challenge with this test is that the CEO-specific participation constraint is unobservable, making it difficult to measure whether the pay is too little to meet their participation constraint. To estimate whether the pay risk premium is below its expected value, we estimate a regression of log expected simulated pay on the simulated variance of pay, with industry and year fixed effects included to control for industry-level and time varying economic differences in pay. We then obtain a CEO-year specific measure of deviation from expected compensation for pay risk (*deviation*) using the residual from that estimation. Negative values of deviation indicate a tighter participation constraint for these CEOs, meaning that their reservation utility is barely being met or even is being violated, which increases the probability that they will leave the firm for another opportunity.

---

[20] Bettis et al. (2018) also simulate pay from contract data in Incentive Lab. Their focus is on the valuation of equity grants only, while ours is on estimating annual outcomes across all performance grants, which makes our simulation procedure more complex. As a result, our data requirements are more stringent, which leads to a smaller sample size. Likewise, in their simulations, Core and Packard (2022) assume that EPS is the sole non-price measure for all awards, allowing them to obtain a larger sample size.

A second challenge is that CEOs who have opportunities to move to other firms will have a higher reservation utility than those who do not have such opportunities. Thus, a CEO that is not ‘marketable’ or has limited labor market opportunities, say due to age, or some other characteristic, should have a lower participation constraint compared to the average CEO even before considering the level of pay risk premiums. Moreover, for CEOs with limited labor market opportunities, the influence of a low pay risk premium is likely a second-order effect. To deal with this measurement issue, we condition our sample on CEOs that, after leaving the firm, show up later in the sample as CEOs of another firm. These constitute a sample of CEOs with good, comparable, outside job market opportunities, where the participation constraint is more relevant. In our sample period of 2006-2016, 3,176 unique CEOs had one or more turnovers in ExecuComp. Of these, 305 CEOs become CEO for a different firm on ExecuComp after the turnover. We merge the CEOs who switched firms (i.e., CEOs who worked as CEOs for at least two different firms in ExecuComp) to our simulated pay sample and drop non-switching CEOs. The merged sample is much smaller than its original counterpart due to the infrequency of turnover. However, it offers the advantage of enabling the identification of CEOs whose reservation utility requires evaluation of comparable jobs. We construct an indicator variable, labeled as “switchfirm”, which assumes the value of one when the switching CEO experiences a turnover in the current year or the next year, and zero otherwise. The variable *switchfirm* equals one for 15% of our main sample (13% for both the alternative sample and the Core and Packard sample). We believe this sample captures the group of CEOs for which a low pay risk premium may contribute to not meeting a participation constraint. We therefore predict that CEOs with lower values of deviation will have a higher likelihood of switchfirm.

In Table 9, we present results from regressing CEO turnover on *deviation* using four different samples: the main sample (column 1), the main sample where we added the RPE grants (column 2), the larger alternative sample (column 3), and the largest sample using the Core and Packard simulation (column 4). While we find no predictable relation in the first two samples, likely due the lack of power with their limited size (only 52 observations), in the remaining two samples we find the predicted relation at significance levels of 10% (one-tailed or better). The negative coefficient on *deviation* suggests that CEOs are more likely to leave the firm when expected pay is relatively low compared to pay variance, consistent with the prediction that the participation constraint is more likely to being violated for these CEOs at that time.

In sum, this analysis reveals evidence consistent with the idea that pay risk premium that fails to meet the participation constraint is associated to a greater probability of turnover among CEOs with a high reservation utility. Moreover, it helps to validate our estimations of premiums for pay at risk.

7.3 Volatility from CEO wealth

The literature dating back to Jensen and Murphy (1990) and Hall and Liebman (1998) suggests that incentive risk is not only driven by annual pay but also by CEOs' prior stock and option holdings. Therefore, a potential issue with our risk premium calculation is that variations in annual pay may only account for a small fraction of the incentive risk faced by the typical CEO (e.g., Core and Guay 2002 and Armstrong et al. 2015). Table 10 displays the results testing how the CEO's equity wealth in the firm influences the estimates of pay sensitivity to pay volatility. We include the volatility of CEO wealth linked to the firm's equity holdings as a control variable using the inside wealth variable in Coles et al. (2006). The number of observations in columns 1 and 2 of this table drops significantly compared to Table 3 because we calculate the realized volatility of CEO wealth using five years of past data. Regardless of whether we include the variance of total pay in the regression (column 1) or not (column 2), the results show that the volatility of CEO inside wealth is not a statistically significant contributor to the risk premium. However, this conclusion should be interpreted with the caveat our test may be of low power. Importantly, it is worth noting that the variance of pay continues to remain significant.

7.4 Other robustness exercises

We estimate our model using two separate subsamples, firm-year observations with salary under $\$900,000$ and firm-year observations with salary above $\$900,000$. This exercise is intended to capture the lack of flexibility in increasing salary due to Section 162(m) of the tax code. During our sample period, the tax code caps the deductibility of salary at $1 million while allowing any amount of performance based pay to be tax deductible. This differential treatment may limit firms' ability to compensate CEOs for the risk associated with incentive pay. Presumably, this restriction is less active for those firms that have yet to reach the cap of $1 million. Using Incentive Lab data, we find no significant economic difference in pay sensitivity to pay variance across the two sub-samples or when using a dummy variable that identifies firm-year observations with salaries below $\$900,000$ interacted with the variance of pay (untabulated).

Next, we include in our regressions a proxy for risk of turnover to address the concern that turnover risk may be an omitted correlated variable. In untabulated results, we find that the estimated sensitivity of pay to variance of pay is virtually unchanged when we include this additional control. We suspect that the reason for the similarity in results with regards to the sensitivity is the small unconditional probability of CEO forced turnover in the U.S. (Peters and Wagner 2014 show that it is just under 3%).

Finally, we rerun our simulations using concurrent (i.e. measured in time t) values of the respective accounting variables as the mean in the conditional distribution of the performance metrics. This specification presumes that the board has perfect foresight when designing the contracts, which is unrealistic but constitutes an upper bound on the board's information set. Overall, the results on the sensitivity of pay to variance of pay are largely unchanged as are the estimates of the various pay risk (untabulated).

8 Conclusion

We estimate the premium in CEO incentive pay in the U.S. We conduct this exercise by simulating payouts on bonus, stock, and option grants using detailed contract data from Incentive Lab. We construct a simulation-based measure of the variance of CEO pay for every CEO-year in the sample. We show that the estimated premium is 15%. The premiums from cash bonus grants and option grants are significantly smaller than that from stock grants. We show that premium associated with variance in pay increases with proxies for risk aversion. Using a structural model, we derive an implied risk aversion coefficient equal to 1.12. The relatively small estimate of the risk aversion coefficient aligns with the findings of Murphy and Jensen (Murphy and Jensen), which suggest that the growth in incentive pay in the U.S. is unrelated to economic incentives and risk and reward arguments. It is also consistent with survey evidence from Edmans et al. (2021), which shows that risk diversification is not a major concern for CEOs. We investigate several alternatives to explore any potential measurement bias in the pay premium. However, none we considered alter the quantitative nature of our results.

This paper focuses on estimating the cost of providing incentives resulting from the uncertainty in the realization of firm performance. However, the broader question of what motivates incentive pay and what constitutes an optimal level of incentives still remain. Future research could explore additional methods to identify and quantify the benefits of incentive provision.

While the estimate of the pay risk premium may be interesting as a benchmark to compensation consultants, framing the issue of incentives in terms of the variance of pay and compensation for risk has the benefit of generating new questions that can be addressed in future research. For example, as firms have numerous levers at their disposal—which metric to use, which target and payout schemes to implement—it would be interesting for future research to explore which of these levers can more effectively manage pay risk, while still providing adequate incentives to the CEO. As another example, how do contract terms change over time for the same firm, for an industry, even for the same CEO/firm pair? Do they adjust to changes in the volatility of performance metrics? Or are the changes in contract terms a reflection of how competitors are changing, or of how the firm's strategic goals change say along the business cycle? We believe that by emphasizing the variance of pay as an important aspect of compensation packages—besides the almost-exclusively-studied mean of pay— our evidence can generate interesting research questions for future work.

References

Abadie, A., S. Athey, G. W. Imbens, and J. Wooldridge (2023). When should you adjust standard errors for clustering? *Quarterly Journal of Economics 138*, 1–35.

Aggarwal, R. K. and A. A. Samwick (1999). The other side of the trade-off: The impact of risk on executive compensation. *Journal of Political Economy 107*, 65–105.

Agren, M. (2006). Prospect theory and higher moments. Working paper.

Albuquerque, A., M. E. Carter, M. Guo, and L. Lynch (2022). Complexity in compensation contracts. Working paper.

Andersen, T. G. and T. Bollerslev (1998). Answering the skeptics: Yes, standard volatility models do provide accurate forecasts. *International Economic Review 39*, 885–905.

Armstrong, C. S., J. E. Core, and W. R. Guay (2015). Why do ceos hold so much equity? Working paper.

Ball, R. and E. Bartov (1996). How naive is the stock market's use of earnings information? *Journal of Accounting and Economics 21*(3), 319–337.

Barber, B. M. and T. Odean (2001). Boys will be Boys: Gender, Overconfidence, and Common Stock Investment*. *The Quarterly Journal of Economics 116*, 261–292.

Bebchuk, L. A. and J. M. Fried (2006). Pay without performance: Overview of the issues. *Academy of Management Perspectives 20*, 5–24.

Becker, B. (2006). Wealth and executive compensation. *Journal of Finance 61*, 379–397.

Bennett, B., C. Bettis, R. Gopalan, and T. Milbourn (2017). Compensation goals and firm performance. *Journal of Financial Economics 124*, 307–330.

Bernile, G., V. Bhagwat, and P. R. Rau (2017). What doesn't kill you will only make you more risk-loving: Early-life disasters and ceo behavior. *Journal of Finance 72*, 167–206.

Bettis, J. C., J. Bizjak, J. Coles, and S. Kalpathy (2018). Performance-vesting provisions in executive compensation. Working paper.

Bizjak, J., S. Kalpathy, Z. F. Li, and B. Young (2022, 04). The Choice of Peers for Relative Performance Evaluation in Executive Compensation. *Review of Finance 26*(5), 1217–1239.

Bizjak, J. M., M. L. Lemmon, and L. Naveen (2008). Does the use of peer groups contribute to higher pay and less efficient compensation? *Journal of Financial Economics 90*(2), 152–168.

Bloom, M. and G. T. Milkovich (1998). Relationships among risk, incentive pay, and organizational performance. *The Academy of Management Journal 41*, 283–297.

Bollerslev, T., R. F. Engle, and J. M. Wooldridge (1988). A capital asset pricing model with time-varying covariances. *Journal of Political Economy 96*, 116–131.

Bolton, P., J. Scheinkman, and W. Xiong (2006). Executive Compensation and Short-Termist Behaviour in Speculative Markets. *The Review of Economic Studies 73*, 577–610.

Borghans, L., B. H. H. Golsteyn, J. J. Heckman, and H. Meijers (2009). Gender differences in risk aversion and ambiguity aversion. *Journal of the European Economic Association 7*, 649–658.

Cadman, B., M. E. Carter, and X. Peng (2020). The participation constraint and ceo equity grants. *The Accounting Review forthcoming*.

Carter, M. E., F. Franco, and M. Gine (2017). Executive gender pay gaps: The roles of female risk aversion and board representation. *Contemporary Accounting Research 34*, 1232–1264.

Carter, M. E., F. Franco, and I. Tuna (2019). Matching premiums in executive labor markets. *The Accounting Review 94*, 109–136.

Chaigneau, P. (2015). Risk aversion, prudence, and compensation. *European Journal of Finance 21*, 1357–1373.

Cheng, Ing-Haw, H. H. and J. A. Scheinkman (2015). Yesterday's heroes: Compensation and risk at financial firms. *Journal of Finance 70*, 839–879.

Coles, J. L., N. D. Daniel, and L. Naveen (2006). Managerial incentives and risk-taking. *Journal of Financial Economics 79*, 431–468.

Coles, J. L., N. D. Daniel, and L. Naveen (2014). Co-opted boards. *The Review of Financial Studies 27*, 1751–1796.

Conyon, M., J. Core, and W. Guay (2011). Are u.s. ceos paid more than u.k. ceos? inferences from risk-adjusted pay. *Review of Financial Studies 24*, 402–438.

Conyon, M. J. (2006). Executive compensation and incentives. *Academy of Management Perspectives 20*, 25–44.

Core, J. and W. Guay (2002). Estimating the value of employee stock option portfolios and their sensitivities to price and volatility. *Journal of Accounting Research 40*, 613–630.

Core, J. and W. Guay (2010). Is ceo pay too high and are incentives too low? a wealth-based contracting framework. *Academy of Management Perspectives 24*, 5–19.

Core, J. E. and H. A. Packard (2022). Non-Price and Price Performance Vesting Provisions and CEO Incentives. *The Accounting Review*.

Dittrich, D., W. Guth, and B. Maciejovsky (2005). Overconfidence in investment decisions: An experimental approach. *European Journal of Finance 11*, 471–491.

Edmans, A., T. Gosling, and D. Jenter (2021). Ceo compensation: Evidence from the field. Working paper.

Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of united kingdom inflation. *Econometrica 50*, 987–1007.

Erickson, M., M. Hanlon, and E. L. Maydew (2006). Is there a link between executive incentives and accounting fraud? *Journal of Accounting Research 44*, 113–143.

Fernandes, N., M. A. Ferreira, P. Matos, and K. J. Murphy (2013). Are u.s. ceos paid more? new international evidence. *Review of Financial Studies 26*, 323–367.

Gervais, S., J. Heaton, and T. Odean (2011). Overconfidence, compensation contracts, and capital budgeting. *Journal of Finance 66*, 1735–1777.

Gipper, B. (2021). The economic effects of expanded compensation disclosures. *Journal of Accounting and Economics*.

Grossman, S. J. and O. D. Hart (1983). An analysis of the principal- agent problem. *Econometrica 51*, 7–45.

Hadlock, C. J. (1998). Ownership, liquidity, and investment. *Rand Journal of Economics 29*, 487–508.

Hall, B. J. and J. B. Liebman (1998). Are ceos really paid like bureaucrats? *Quarterly Journal of Economics 113*, 653–691.

Haubrich, J. G. (1994). Risk aversion, performance pay, and the principal-agent problem. *Journal of Political Economy 102*, 258–276.

Hayes, R. M., M. Lemmon, and M. Qiu (2012). Stock options and managerial incentives for risk taking: Evidence from fas 123r. *Journal of Financial Economics 105*, 174–190.

Hemmer, T., O. Kim, and R. E. Verrecchia (2000). Introducing convexity into optimal compensation contracts. *Journal of Accounting and Economics 28*, 307–327.

Himmelberg, C. P. and R. G. Hubbard. Incentive pay and the market for ceos: An analysis of pay-for-performance sensitivity. Working paper.

Holden, C. W. and D. S. Kim (2017). Performance share plans: Valuation and empirical tests. *Journal of*

Corporate Finance 44, 99–125.

Holmstrom, B. (1979). Moral hazard and observability. *The Bell Journal of Economics 10*, 74–91.

Holmstrom, B. and P. Milgrom (1987). Aggregation and linearity in the provision of intertemporal incentives. *Econometrica 55*, 303–328.

Holmström, B. and J. Tirole (1993). Market liquidity and performance monitoring. *Journal of Political Economy 101*, 678–709.

Huang, J. and D. Kisgen (2013). Gender and corporate finance: Are male executives overconfident relative to female executives? *Journal of Financial Economics 108*, 822–839.

Humphery-Jenner, M., L. L. Lisic, V. Nanda, and S. Silveri (2016). Executive overconfidence and compensation structure. *Journal of Financial Economics 119*, 533–558.

Jensen, M. C. and K. J. Murphy (1990). Performance pay and top-management incentives. *Journal of Political Economy 98*, 225–264.

Kim, D. S. and J. Yang. Beating the target: Performance management around the annual incentive target. Working paper.

Kolasinski, A. and X. Li (2013). Can strong boards and trading their own firm's stock help ceos make better decisions? evidence from acquisitions by overconfident ceos. *Journal of Financial and Quantitative Analysis 48*, 1173–1206.

Laffont, J.-J. and D. Martimort (2002). *The Theory of Incentives*. Princeton University Press, Princeton, NJ.

Lambert, R. A., L. D. and R. Verrecchia (1991). Portfolio considerations in valuing executive compensation. *Journal of Accounting Research 29*, 129–149.

Malmendier, U. and G. Tate (2005). Ceo overconfidence and corporate investment. *Journal of Financial Economics 60*, 2661–2700.

Malmendier, U. and G. Tate (2008). Who makes acquisitions? ceo overconfidence and the market's reaction. *Journal of Financial Economics 89*, 20–43.

Mirrlees, J. A. (1976). The optimal structure of incentives and authority within an organization. *The Bell Journal of Economics 7*, 105–131.

Murphy, K. J. and M. C. Jensen. The politics of pay: The unintended consequences of regulating executive compensation. Working paper.

Murphy, K. J. and T. Sandino (2020). Compensation consultants and the level, composition, and complexity of ceo pay. *The Accounting Review 95*, 311–341.

Murphy, K. J. and M. Vance. Why do employees exercise stock options early? working paper.

Nickerson, J. (2017). Market forces and ceo pay: Shocks to ceo demand induced by ipo waves. *Review of Financial Studies 30*, 2272–2313.

Oster, E. (2019). Unobservable selection and coefficient stability: Theory and evidence. *Journal of Business & Economic Statistics 37*(2), 187–204.

Oyer, P. (2004). Why do firms use incentives that have no incentive effects? *Journal of Finance 59*, 1619–1650.

Peters, F. S. and A. F. Wagner (2014). The executive turnover risk premium. *Journal of Finance 69*, 1529–1563.

Poblete, J. and D. Spulber (2012). The form of incentive contracts: agency with moral hazard, risk neutrality, and limited liability. *The RAND Journal of Economics 43*, 215–234.

Prendergast, C. (2002). The tenuous trade-off between risk and incentives. *Journal of Political Economy 110*, 1071–1102.

Ramey, G. and V. A. Ramey (1995). Cross-country evidence on the link between volatility and growth. *The American Economic Review 85*, 1138–1151.

Ross, S. (2004). Compensation, incentives, and the duality of risk aversion and riskiness. *Journal of Finance 59*, 207–225.

Roussanov, N. and P. Savor (1989). Why does stock market volatility change over time? *Journal of Finance 44*, 1115–1153.

Shavell, S. (1979). Risk sharing and incentives in the principal and agent relationship. *The Bell Journal of Economics 10*, 55–73.

Shue, K. and R. Townsend (2017). Growth through rigidity: An explanation for the rise in ceo pay. Technical report.

Taylor, L. A. (2013). Ceo wage dynamics: Estimates from a learning model. *Journal of Financial Economics 108*, 79–98.

Tirole, J. (2006). *The theory of corporate finance*. Princeton University Press. Publisher Copyright: © 2006 by Princeton University Press. All Rights Reserved.

Tufano, P. (1996). Who manages risk? an empirical examination of risk management practices in the gold mining industry. *The Journal of Finance 51*, 1097–1137.

Table 1. Frequency Distribution of Performance Metrics

Panel A reports the frequency distribution of the performance metrics used in compensation contracts at the metric level. Panel B reports descriptive statistics for the number of performance metrics per grant/year, and the number of grants per CEO/year.

Panel A. Metric Level Information

	(1) Bonus	(2) Restricted Stock	(3) Options	(4) Combined
Book Value	0	2	0	2
Cashflow	87	23	0	110
EBIT	31	7	0	38
EBITDA	62	13	0	75
EBT	37	13	0	50
EPS	194	56	4	254
Earnings	60	19	0	79
FFO	8	1	0	9
Operating Income	76	20	0	96
Profit Margin	14	3	0	17
ROA	18	4	0	22
ROE	41	22	1	64
ROI	4	1	0	5
ROIC	47	38	0	85
Sales	130	26	1	157
Stock Price	2	3	1	6
Time	0	880	821	1.701
Total (metric level)	**811**	**1,131**	**828**	**2,770**
Firm-year observations	466	781	666	939

Panel B. Grant Level and CEO Level Information

	(1) Bonus	(2) Restricted Stock	(3) Options	(4) Combined
Number of performance metrics per grant/year				
Min	1	1	1	1
Mean	1.57	1.07	1	1.15
Std. Dev.	0.71	0.27	0.03	0.43
Skewness	1.18	3.98	28.71	3.24
Max	4	3	2	4
Number of grants per CEO/year				
Min	1	1	1	1
Mean	1.11	1.35	1.24	2.57
Std. Dev.	0.38	1	1.23	1.61
Skewness	4.52	6.81	7.67	3
Max	4	13	12	13

Table 2. Descriptive Statistics

N is the number of observations, and P_x is the percentile x value of the sample distribution, with x=25, 50 (median), and 75. As in the regressions, compensation variables are in thousands of U.S. dollars; all other variables are in millions of U.S. dollars. The appendix gives detailed definitions of each variable, data source and time availability.

VARIABLES	N	Mean	Std. Dev.	P25	P50	P75
Total compensation (TDC1; main sample)	939	6,750	5,427	3,282	5,384	8,489
Total compensation (TDC1; ExecuComp sample)	37,322	4,679	5,434	1,288	2,763	5,873
ln of CEO wealth	29,567	9.90	1.44	8.93	9.83	10.79
RET	32,344	0.16	0.46	-0.11	0.11	0.35
ROA	32,399	0.04	0.09	0.01	0.04	0.08
Firm return volatility	32,308	0.11	0.06	0.07	0.10	0.14
Firm earnings volatility	32,344	0.05	0.10	0.01	0.03	0.06
ln of market value	32,836	7.45	1.64	6.35	7.35	8.47
MTB	32,341	1.91	1.23	1.14	1.49	2.16
Leverage	32,341	0.40	0.25	0.20	0.36	0.58
Overconfidence indicator	37,320	0.34	0.47	0.00	0.00	1.00
Co-opted board (coopt)	20,905	0.56	0.32	0.29	0.55	0.88
CEO age (age)	36,495	55.82	7.38	51.00	56.00	60.00
CEO tenure	34,731	8.23	7.39	2.92	5.92	10.92
Founder indicator (founder)	37,322	0.11	0.32	0.00	0.00	0.00
Percent of institutional ownership	29,852	0.68	0.22	0.54	0.70	0.83
ln of simulated variance of CEO pay	939	14.32	2.60	12.83	14.40	15.98
ln of simulated variance of bonus	939	5.92	6.30	0.00	0.00	12.57
ln of simulated variance of restricted stocks	939	10.48	5.40	9.18	12.07	14.05
ln of simulated variance of options	939	9.43	6.58	0.00	12.00	14.43
Simulated skewness of CEO pay	939	0.77	0.85	0.10	0.64	1.19
ln of TDC1 of disclosed peers	800	8.84	0.52	8.52	8.85	9.20
ln of TDC1 of industry-size peers	30,796	8.17	0.79	7.57	8.13	8.76

Table 3. Sensitivity of Pay to Variance of Pay

This table presents results from regressions of the natural log of TDC1 on the natural log of simulated variance of pay using Incentive Lab data and compensation contract information available at the beginning of each year. All columns, except for columns 1 and 4, report results with firm and year fixed effects. Robust t-statistics are reported in parentheses, clustered by firm and year. Significance at 1%, 5%, and 10% is indicated by ***, **, and *, respectively.

	log of TDC1						
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log simulated variance of pay	0.179***	0.072***	0.059***				
	(10.42)	(4.59)	(4.57)				
Log simulated variance of bonus				0.013	0.019**	0.012	
				(1.07)	(2.26)	(1.26)	
Log simulated variance of RSU				0.086***	0.021*	0.039***	
				(4.24)	(2.01)	(3.31)	
Log simulated variance of opt				0.061***	0.016	0.004	
				(4.83)	(1.61)	(0.46)	
Bonus miss				-0.170	0.091	-0.081	
				(-1.17)	(0.66)	(-0.65)	
RSU miss				0.625**	-0.050	0.116	
				(2.40)	(-0.31)	(0.91)	
Opt miss				0.513**	-0.083	-0.219	
				(2.54)	(-0.58)	(-1.41)	
Simulated skewness			-0.014			-0.025	
			(-0.58)			(-1.35)	
RET			0.338***			0.268**	0.308***
			(3.30)			(2.87)	(3.31)
Lag RET			0.142**			0.107*	0.117**
			(2.54)			(2.05)	(2.55)
ROA			0.705			0.660*	0.645
			(1.60)			(1.85)	(1.58)
Lag ROA			0.235			0.229	0.062
			(0.68)			(0.70)	(0.18)
Firm return volatility			-1.398**			-0.829**	-0.510
			(-3.07)			(-2.47)	(-1.34)
Firm earning volatility			0.438			0.376	0.299
			(0.64)			(0.49)	(0.41)
Log lag market value			0.227**			0.224**	0.270**
			(2.42)			(2.39)	(2.63)
Market to book			-0.054			-0.022	-0.057
			(-1.26)			(-0.54)	(-1.52)
Leverage			0.553			0.361	0.406
			(1.61)			(1.08)	(1.16)
Coopt			0.086			0.085	0.127
			(0.41)			(0.48)	(0.56)
Coopt miss			0.005			-0.112	-0.014
			(0.03)			(-0.68)	(-0.07)
Institutional holding %			0.132			0.150	0.280
			(0.58)			(0.65)	(1.21)
Founder			-0.187			-0.246**	-0.118
			(-1.55)			(-2.73)	(-1.18)
Age			0.005			0.002	0.008
			(0.46)			(0.23)	(0.70)
Log CEO tenure			0.036			0.077	0.014
			(0.37)			(1.02)	(0.14)
Overconfidence			0.004			-0.003	0.001
			(0.06)			(-0.05)	(0.01)
Log disclosed peer pay			0.131*			0.111*	0.127
			(1.99)			(1.89)	(1.72)
Intercept	5.954***	7.499***	4.102***	6.810***	8.016***	4.743***	4.324***
	(22.96)	(33.45)	(3.29)	(32.87)	(42.03)	(3.85)	(3.29)
Observations	939	769	569	939	769	569	569
Adj. R-squared	0.322	0.805	0.798	0.253	0.799	0.810	0.779
Firm + Year FE	NO	YES	YES	NO	YES	YES	YES
Cluster s.e.	Firm/Year	Firm/Year	Firm/Year	Firm/Year	Firm/Year	Firm/Year	Firm/Year

Table 4. Pay Premium Estimates

This table shows the economic significance of the estimated sensitivity of pay to variance of pay from Table 3 column 3. Dollar values are in thousands.

Economic Impact for Estimates in Table 3 Panel A - Clean Sample Simulated Volatility

	Coef.	Std. of log volatility	Increase in pay	Mean pay	Median pay	Change in mean pay	Change in median pay
Log volatility of total pay	0.059	2.60	15.3%	$6,749	$ 5,384	$ 1,035	$ 826
Log volatility of bonus	0.012	6.30	7.6%	$6,749	$ 5,384	$ 510	$ 407
Log volatility of RSU	0.039	5.40	21.1%	$6,749	$ 5,384	$ 1,421	$1,134
Log volatility of options	0.004	6.58	2.6%	$6,749	$ 5,384	$ 178	$ 142

Table 5. Cross Sectional Variation in Risk Aversion

This table presents results examining the effect of cross-sectional variation in risk aversion. The dependent variable is the natural log of TDC1. Variance of pay is estimated from the simulation exercise using the Incentive Lab compensation contract information. Proxies for CEO risk aversion are: medium fatality (Column 1; female (Column 2); over-confidence (Column 3); tenure (Column 4); and high wealth (Column 4). All control variables are included (not tabulated for brevity). All regressions include firm and year fixed effects. Robust t-statistics are reported in parentheses, clustered by firm and year. Significance at 1%, 5%, and 10% is indicated by ***, **, and * for two-sided test, respectively. The p-value on the test of the sum of coefficients associated with variance of pay and the interaction term is for a two-sided test.

	Overconfident CEO	Longer Tenure	Medium Fatality	Female CEO	High Wealth
VARIABLES	(1)	(2)	(3)	(4)	(5)
Log simulated variance of pay	0.082***	0.089***	-0.007	0.054***	0.073***
	(3.65)	(4.07)	(-0.30)	(4.39)	(4.04)
Subgroup indicator	0.649*	0.820**	-0.186	-3.742***	0.567*
	(1.90)	(2.63)	(-0.27)	(-4.89)	(2.06)
Log simulated variance of pay	-0.046*	-0.055**	0.086**	0.194***	-0.040*
xSubgroup Indicator	(-1.93)	(-2.57)	(2.43)	(4.05)	(-2.15)
Testing log simulated variance of pay + log simulated variance of pay x subgroup indicator = 0					
t-statistic	3.73	3.15	3.60	6.17	2.89
p-value	0.004	0.010	0.005	0.000	0.020
Observations	569	569	154	569	449
Adj. R-squared	0.802	0.804	0.828	0.804	0.794
Firm + Year FE	YES	YES	YES	YES	YES
Cluster s.e.	Firm/Year	Firm/Year	Firm/Year	Firm/Year	Firm/Year

Table 6. Sensitivity of Pay to Variance of Pay Using Core and Packard Approach

This table presents results from regressions of the natural log of TDC1 on the natural log of simulated variance of pay, where simulated variance of pay is estimated using the Core and Packard (2022) Approach. All columns, except for columns 1 and 4, report results with firm and year fixed effects. Robust t-statistics are reported in parentheses, clustered by firm and year. Significance at 1%, 5%, and 10% is indicated by ***, **, and *, respectively.

	log of TDC1					
	Replication Sample			Clean Sample with RPE Included		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Log simulated variance of pay	0.141***	0.057***	0.041***	0.179***	0.068***	0.061***
	(16.95)	(9.54)	(7.68)	(10.54)	(5.10)	(4.79)
Simulated skewness			-0.004***			0.008
			(-4.77)			(0.40)
RET			0.195***			0.276**
			(6.68)			(2.75)
Lag RET			0.094***			0.127*
			(3.95)			(2.18)
ROA			0.291**			0.746
			(3.09)			(1.75)
Lag ROA			-0.080			0.180
			(-0.88)			(0.57)
Firm return volatility			-0.353			-1.377**
			(-1.53)			(-2.96)
Firm earning volatility			-0.023			0.401
			(-0.10)			(0.58)
Log lag market value			0.198***			0.211**
			(8.26)			(2.36)
Market to book			-0.002			-0.030
			(-0.11)			(-0.83)
Leverage			0.062			0.530
			(0.76)			(1.46)
Coopt			-0.030			0.169
			(-0.71)			(0.78)
Coopt miss			-0.082**			0.032
			(-2.46)			(0.17)
Institutional holding %			-0.011			0.119
			(-0.34)			(0.51)
Founder			-0.063			-0.052
			(-1.64)			(-0.34)
Age			-0.002			0.003
			(-1.09)			(0.22)
Log CEO tenure			0.126***			0.053
			(6.60)			(0.57)
Overconfidence			-0.023			-0.034
			(-1.10)			(-0.52)
Log disclosed peer pay			0.131***			0.113
			(5.38)			(1.63)
Intercept	6.365***	7.760***	5.096***	5.905***	7.538***	4.380***
	(41.02)	(77.11)	(18.44)	(23.02)	(38.81)	(3.70)
Observations	8,319	8,248	6,201	939	769	569
Adj. R-squared	0.262	0.752	0.782	0.348	0.804	0.802
Firm + Year FE	NO	YES	YES	NO	YES	YES
Cluster s.e.	Firm/Year	Firm/Year	Firm/Year	Firm/Year	Firm/Year	Firm/Year

Table 7. The Sensitivity of Pay to Variance of Pay Using Realized Conditional Volatility

This table presents results from regressions of the natural log of TDC1 on realized conditional volatility of pay. The measures of conditional variance of pay are lagged to reflect the information known at the beginning of the period and are based on TDC1. All columns, except for columns 1 and 5, report results without firm and year fixed effects. Robust t-statistics are reported in parentheses, clustered by firm and year. Significance at 1%, 5%, and 10% is indicated by ***, **, and *, respectively.

	log of TDC1						
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Lag log realized variance of pay	0.246***	0.046***	0.028***				
	(36.89)	(6.28)	(3.79)				
Lag log realized variance of bonus				0.015***	0.005***	0.004***	
				(9.93)	(9.73)	(4.41)	
Lag log realized variance of RSU				0.018***	0.004***	0.003***	
				(12.88)	(6.65)	(3.73)	
Lag log realized variance of opt				0.013***	0.002***	0.001	
				(8.75)	(3.83)	(1.13)	
Lag realized skewness			-0.042***			-0.024*	
			(-3.28)			(-1.88)	
RET			0.299***			0.289***	0.303***
			(9.70)			(9.41)	(14.23)
Lag RET			0.128***			0.118***	0.095***
			(7.78)			(7.19)	(6.20)
ROA			0.374**			0.360**	0.359***
			(2.54)			(2.44)	(4.31)
Lag ROA			0.138			0.127	0.022
			(1.30)			(1.20)	(0.23)
Firm return volatility			-0.169			0.013	0.046
			(-0.69)			(0.05)	(0.25)
Firm earning volatility			-0.401**			-0.423**	-0.086
			(-2.10)			(-2.19)	(-0.67)
Log lag market value			0.263***			0.273***	0.320***
			(8.88)			(9.25)	(15.20)
Market to book			-0.010			-0.003	-0.016
			(-0.59)			(-0.17)	(-1.29)
Leverage			0.155			0.130	0.221**
			(1.34)			(1.09)	(2.73)
Coopt			0.091*			0.101*	0.034
			(1.86)			(2.03)	(0.93)
Coopt Miss			0.030			0.032	0.014
			(0.60)			(0.64)	(0.51)
Institutional holding %			0.070			0.070	0.123**
			(0.95)			(1.01)	(2.41)
Founder			-0.059			-0.050	-0.082**
			(-1.34)			(-1.15)	(-2.29)
Age			-0.004			-0.004	-0.004**
			(-1.61)			(-1.65)	(-2.13)
Log CEO tenure			0.012			0.010	0.044**
			(0.43)			(0.35)	(2.49)
Overconfidence			0.069***			0.077***	0.057***
			(2.91)			(3.17)	(3.05)
Log industry-size peer pay			0.060***			0.062***	0.053***
			(3.66)			(3.69)	(3.92)
Intercept	4.789***	7.541***	5.264***	7.337***	7.788***	5.391***	5.050***
	(48.06)	(76.05)	(19.90)	(147.23)	(1009.38)	(20.35)	(25.12)
Observations	16,769	16,522	12,162	37,322	37,177	12,162	22,428
Adj. R-squared	0.405	0.760	0.797	0.194	0.693	0.797	0.773
Firm + Year FE	NO	YES	YES	NO	YES	YES	YES
Cluster s.e.	Firm/Year	Firm/Year	Firm/Year	Firm/Year	Firm/Year	Firm/Year	Firm/Year

Table 8. The Sensitivity of Pay to Variance of Pay Using ARCH Conditional Volatility

The table presents estimates of ARCH-in-mean models on TDC1. The estimations assume an ARCH(1) model for the conditional heteroskedasticity; industry fixed effects are from one-digit SIC; the ARCH-in-mean term is the natural logarithm of the estimated variance of the left-hand side variable; t-statistics are computed using White robust standard errors; the residuals follow a student-t distribution and the priming values are obtained from the estimated variance of the residuals from OLS. Significance at 1%, 5%, and 10% is indicated by ***, **, and *, respectively.

	TDC1		
VARIABLES	(1)	(2)	(3)
Lag log var(TDC1)	128.0***	150.0***	131.7***
	(12.02)	(12.41)	(7.43)
Lag realized skewness			-40.18
			(-1.09)
Constant	-87.0	-2242.3***	-14950***
	(-0.52)	(-3.39)	(-28.06)
Industry and Year FE	NO	YES	YES
Controls	NO	NO	YES
ARCH(1) coefficient	2.16***	2.42***	1.73***
	(22.33)	(20.10)	(14.18)
ARCH constant	2.57***	2.37***	2.30***
(in millions)	(18.67)	(16.26)	(13.11)
Observations	37,322	37,322	12,433

Table 9. Turnover Tests Using Different Samples

This table presents results from regressions of turnover on the deviation of the pay risk premium from its expected value using different samples. The deviation is the residual from regression of log simulated pay on log simulated variance of pay and industry and year fixed effects. All columns report results with industry and year fixed effects. Robust t-statistics are reported in parentheses, clustered by firm and year. Significance at 1%, 5%, and 10% two-tailed (one-tail) is indicated by ***, **, and * (#), respectively.

	Switchfirm			
	Clean Sample	Clean Sample with RPE	Alternative Sample	Replication Sample
VARIABLES	(1)	(2)	(3)	(4)
Deviation	-0.139	0.024	-0.040#	-0.043*
	(-0.67)	(0.10)	(-1.66)	(-2.12)
Lag indadjret	0.053	0.102	-0.031	-0.021
	(0.38)	(0.77)	(-0.54)	(-0.65)
Lag indadjroa	-0.183	-0.010	0.007	0.092
	(-0.18)	(-0.01)	(0.03)	(0.35)
Simulated skewness	-0.097	0.060	-0.005	-0.001
	(-0.97)	(0.68)	(-1.34)	(-0.41)
Log lag market value	0.072	-0.008	-0.013	-0.017
	(0.57)	(-0.06)	(-1.59)	(-1.64)
Lag market to book	0.001	0.006	0.030	0.029
	(0.01)	(0.05)	(1.50)	(1.67)
Lag leverage	0.203	0.008	0.071	0.056
	(0.53)	(0.02)	(0.98)	(0.95)
Founder	-0.237	-0.346*	-0.051	-0.010
	(-1.13)	(-1.97)	(-1.01)	(-0.36)
Age	-0.015	-0.019	-0.008**	-0.009***
	(-1.13)	(-1.63)	(-2.84)	(-3.70)
Log CEO tenure	-0.004	-0.001	-0.001	0.001
	(-0.39)	(-0.08)	(-0.27)	(0.39)
Intercept	0.465	1.344	0.648***	0.710***
	(0.33)	(0.93)	(3.21)	(4.56)
Observations	52	52	649	825
Adj. R-squared	-0.050	-0.064	0.066	0.072
Industry + Year FE	YES	YES	YES	YES
Cluster s.e.	Firm/Year	Firm/Year	Firm/Year	Firm/Year

Table 10. CEO Wealth and the Sensitivity of Pay to the Variance of Pay

This table evaluates the effect of CEO wealth on the sensitivity of pay to variance of pay using regressions of the natural log of TDC1 on the natural log of simulated conditional variance of pay from the Incentive Lab sample. All regressions include firm and year fixed effects. Robust t- statistics are reported in parentheses, clustered by firm and year. Significance at 1%, 5%, and 10% is indicated by ***, **, and *, respectively.

	log of TDC1	
VARIABLES	-1	-2
Log variance of pay	0.045***	
	(3.48)	
Lag log variance of CEO wealth	-0.000	0.009
	(-0.01)	(0.51)
Skewness of pay	-0.028	-0.027
	(-0.92)	(-0.80)
RET	0.310**	0.330**
	(2.59)	(2.57)
Lag RET	0.123*	0.118*
	(2.20)	(1.97)
ROA	1.299**	1.031**
	(2.57)	(2.27)
Lag ROA	0.474	0.403
	(1.03)	(0.88)
Firm return volatility	-3.930***	-3.376***
	(-4.38)	(-3.53)
Firm earning volatility	2.674*	2.312
	(2.04)	(1.82)
Log lag market value	0.079	0.102
	(0.61)	(0.70)
Market to book	-0.015	-0.017
	(-0.27)	(-0.31)
Leverage	0.809	0.781
	(1.65)	(1.49)
Coopt	0.141	0.215
	(0.34)	(0.51)
Coopt Miss	-0.310	-0.323
	(-0.82)	(-0.76)
Institutional holding %	0.218	0.301
	(0.73)	(1.10)
Founder	-0.539***	-0.459**
	(-4.76)	(-3.00)
Age	-0.037	-0.038
	(-1.35)	(-1.37)
Log CEO tenure	0.228*	0.177
	(1.98)	(1.53)
Overconfidence	-0.143	-0.123
	(-1.60)	(-1.37)
Log peer pay	0.299**	0.346**
	(2.62)	(3.02)
Intercept	6.113***	5.979***
	(3.90)	(3.48)
Observations	295	295
Adj. R-squared	0.854	0.844
Firm + Year FE	YES	YES
Cluster s.e.	Firm/Year	Firm/Year

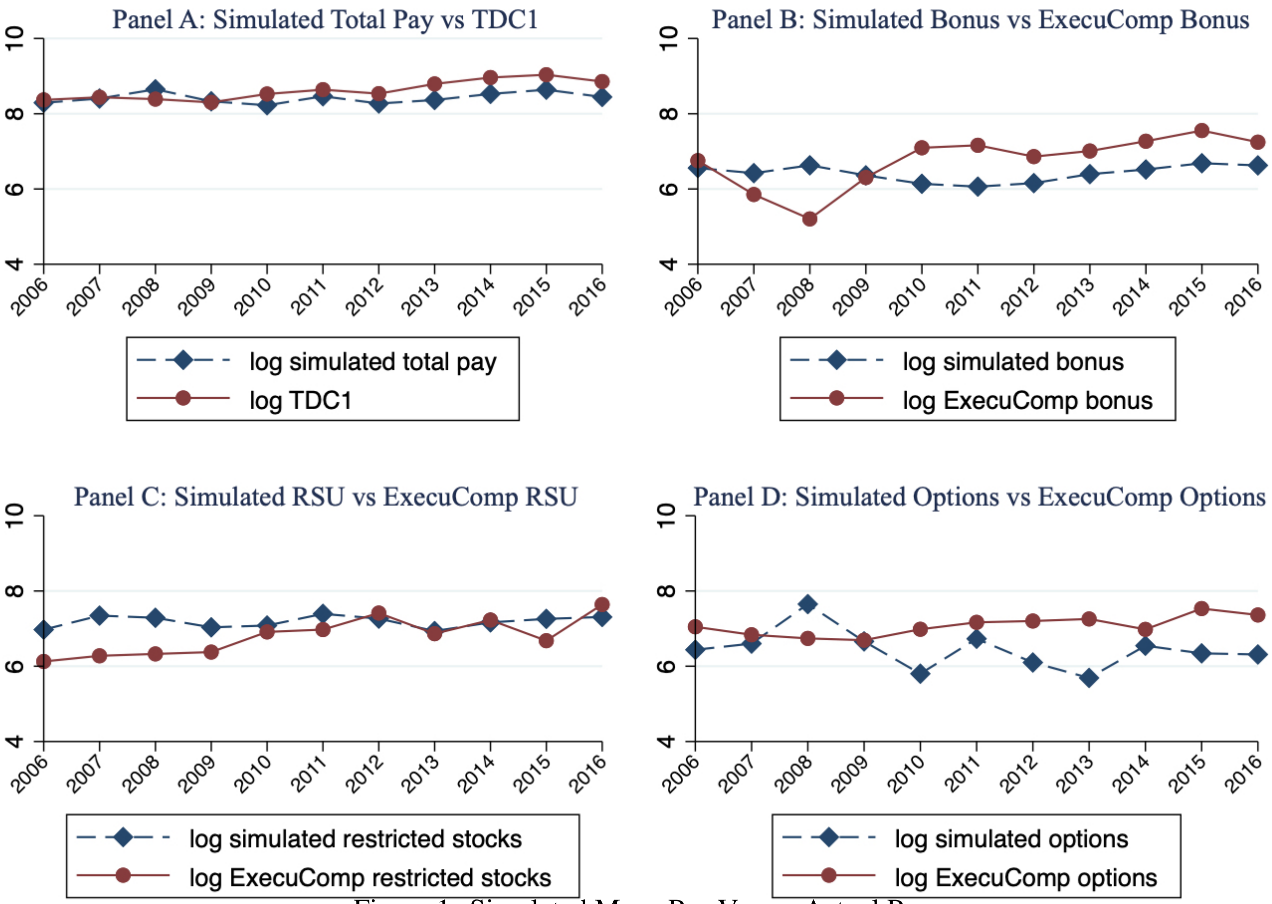

Figure 1: Simulated Mean Pay Versus Actual Pay

Note: The figure depicts the cross-sectional averages of the logarithm of simulated mean pay and of the logarithm of actual pay. Missing values of a pay component are excluded from its cross-sectional average calculation.

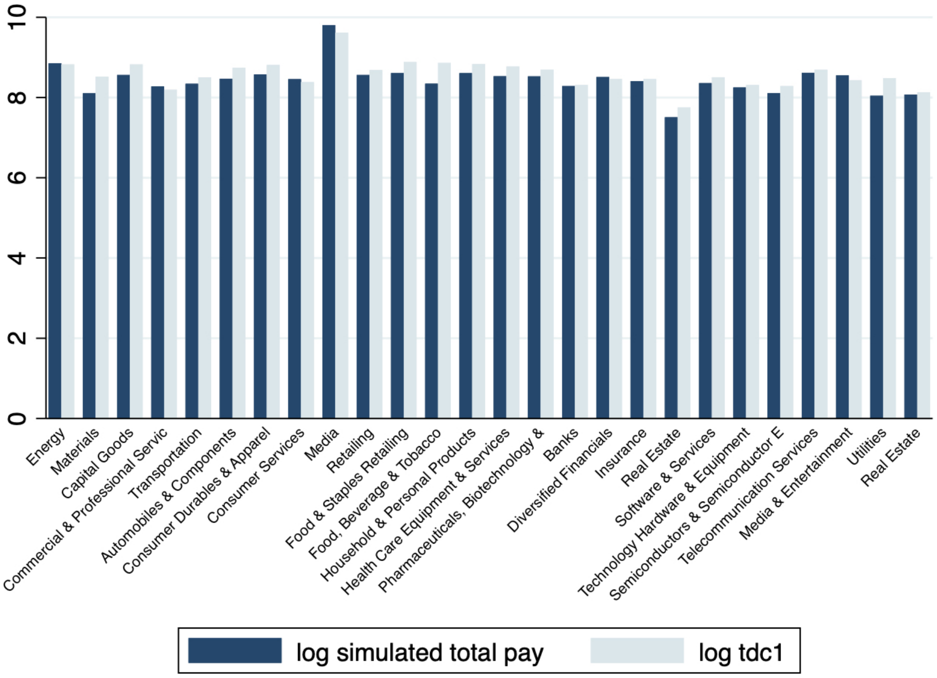

Figure 2: Simulated Mean Pay Versus Actual Pay by Industry

Note: The figure shows the cross-sectional averages of the logarithm of simulated mean pay and of the logarithm of actual pay by industry. Industry classification is based on the four-digit Global Industry Classification System (GICS).

Appendix A Derivation of the risk premium in the agency model

This appendix presents a theoretical justification for the model to be estimated that includes the variance of pay as a dependent variable and can then be used to estimate a pay premium. In the standard principal-agent model, the principal (i.e., shareholder) offers a compensation package, w, to the agent (i.e., CEO) which can vary with the agent's performance. The agent evaluates this compensation package with her expected utility $E[U(w, e)]$, where U is the agent's utility, e is the agent's effort, and E is the expectations operator. A risk averse agent prefers compensation packages with high average pay but dislikes compensation packages with high variance of pay. This can be illustrated using the static version of Holmstrom and Milgrom (1987) with normal shocks, exponential utility and separability between consumption and effort (examples of other models that also emphasize the risk-incentives trade-off for CEOs are cited above and include Holmström and Tirole 1993 and Bolton et al. 2006). In that model,

$$\ln E[U(w, e)] = E(w) - \frac{\gamma}{2}V(w) - \text{cost of effort}, \tag{4}$$

where $\gamma > 0$ is the constant absolute risk aversion coefficient, and $E(w)$ and $V(w)$ are, respectively, the mean and variance of pay. The variance of pay summarizes the (utility) risk associated with not meeting different performance targets in performance-based components of pay or the fluctuation in market valuation of the newly awarded equity grants for the current year. The principal chooses a pay package to maximize operating profits, net of the pay to the CEO. This maximization is subject to an incentive compatibility constraint and a participation constraint. Consider the implications of the participation constraint

$$E[U(w, e)] \geq \bar{U}, \tag{5}$$

where $\bar{U}$ is the agent's utility under her best outside employment opportunity. Under general conditions, the optimal pay contract makes the participation constraint bind (Grossman and Hart 1983). Taking logarithms on both sides of constraint (5), and combining with (4), obtains

$$E_t(w_t) = \frac{\gamma}{2}V_t(w_t) + \text{cost of effort}_t + \bar{u}_t, \tag{6}$$

with $\bar{u} = \ln(\bar{U})$. Time subscripts are added so as to clarify that the information set used to compute the conditional moments refers to information available at the time when contracts are written, i.e., the beginning of period t, and w_t is the total pay realization through period t.

To estimate the sensitivity of pay to the variance of pay, we define the error term, ϵ_t, as the unpredictable residual in pay given information available at the beginning of period t

$$\epsilon_t \equiv w_t - E_t(w_t). \tag{7}$$

By construction, $E_t(\epsilon_t) = 0$, and the variance of ϵ_t conditional on beginning of period t information is $V_t(\epsilon_t) = V_t(w_t) \equiv \sigma_t^2$ (see Taylor 2013, for a similar specification of the residual).

The co-movement between mean and variance of pay is more general than the functional form and distributional assumptions in Holmstrom and Milgrom (1987) may appear to suggest. Absent these assumptions, a Taylor series expansion of utility as a function of pay shows that a tradeoff exists provided the utility function displays concavity –that is, the CEO is risk averse– though the utility function may also put weight on higher moments of pay, such as skewness of pay if there is a utility premium for convex payoffs. This result is important to illustrate that one of the main predictions in Holmstrom and Milgrom (1987) is not that CEO pay contracts should be linear in performance, but rather that they should have features that yield a positive relation between mean and variance of pay (see also the discussion of this point in subsection 5.4 that uses a different utility specification).

From (6) and (7), we obtain our regression specification (1),

$$w_t = \lambda\sigma_t^2 + X_t'\beta + \epsilon_t. \tag{8}$$

In this model, the pay premium is equal to $\lambda\sigma_t^2$. The pay premium is the portion of pay that arises because risk averse CEOs dislike variable pay (see subsection 5.2 for estimates of the pay premium). The vector X_t and the slopes β capture the drivers of the cost of effort and of outside opportunities.

A parallel to our exercise exists in the asset pricing literature where expected returns are related to the variance of returns times risk aversion. There, too, the lack of portfolio diversification imposes risk on the investor that then requires further compensation.

Appendix B Details of simulations using Incentive Lab data

This appendix provides further details on the simulation exercise using Incentive Lab data. We use information available at the beginning of the year to simulate mean pay and variance of pay for the current year.

Firms use two types of incentive pay to reward their CEOs: (i) time-vested incentive pay, and (ii) performance-vested incentive pay. Time-vested incentive pay includes time-vested restricted stock units (RSU) and time-vested options: a certain number of RSU or options is granted with the passage of time, regardless of actual firm performance. Performance-vested incentive pay includes bonus, performance-vested RSU, and performance-vested options: the amount of cash or the number of RSU or options granted depends on actual firm performance as prescribed in the compensation contracts. For time-vested incentive pay, the grant itself is not linked to specific performance targets; only the valuation of the equity grants is linked to firm performance reflected in stock price. For performance-vested incentive pay, both the grant itself and the valuation (of equity grants) are linked to firm performance: CEOs need to first meet the performance targets mentioned in the compensation contracts to earn the grants, and then the valuation of the equity grants is further linked to firm performance as reflected in the stock price.

For time-vested incentive pay, we conduct a one-step simulation exercise: we simulate future stock price, and then multiply the simulated stock price by the number of RSU or options granted to get the dollar value of expected equity incentive pay. For performance-vested incentive pay, we conduct a two-step simulation exercise: first we simulate expected firm performance; then we fit expected firm performance to the pre-determined compensation contracts to estimate the amount of bonus or the number of RSU/options granted; for RSU and options, we also simulate expected stock price to convert expected number of RSU/options into dollar values. We provide details of the two-step simulation exercise for performance-vested incentive pay below.

For performance-vested incentive pay, we take two inputs for the simulation: (i) compensation contract information from Incentive Lab, which describes the relationship between the chosen performance metric (metrics) and the corresponding performance-based compensation (i.e., cash bonus or equity grants), and (ii) actual performance in the past five years from Compustat, the variance (covariance) of which is used to estimate simulated performance for the current year. We then fit the simulated performance from (ii) to the compensation contracts estimated in (i) to generate simulated pay. Since we simulate 10,000 times for each firm-year-grant, we can calculate the expected pay and variance of pay from the 10,000 simulations for each firm-year.

Compensation contract fitting. We estimate the compensation contracts using the Incentive Lab data, which provides information on: (i) the performance metrics used in the compensation contracts (variable name: "metric"), (ii) the threshold, target, and maximum level of each performance metric (variable names: "goalThreshold", "goalTarget", and "goalMax"), and (iii) the threshold, target, and maximum level of the compensation (variable names: "nonEquityThreshold", "nonEquityTarget", and "nonEquityMax" for bonus, and "equityThreshold", "equityTarget", and "equityMax" for equity grants).[21]

When actual firm performance is below the threshold of the performance metric indicated in the contract, the CEO does not earn any performance-based compensation; when actual firm performance equals the target performance metric indicated in the contract, the CEO earns the target amount of performance-based compensation; when actual firm performance is above the maximum of the performance metric indicated in the contract, the CEO earns the maximum amount of performance-based compensation; when actual performance falls between the threshold and the maximum of the performance metric indicated in the contract, the CEO earns performance-based compensation in the amount between the threshold and the maximum of the performance-based compensation indicated in the contract.

For firms with no missing values of the contract details (i.e., threshold, target, and maximum for the performance metric and the performance-based compensation), we can fit the compensation contracts using either (i) piece-wise linear estimation (i.e., two linear slopes: one between the threshold and the target, the other between the target and the maximum), or (ii) quadratic estimation. We drop firms with missing values of the threshold or the maximum, because the missing values make it impossible to estimate the contracts.

We implement the contract estimations in four steps. In the first step, we construct a sample of compensation contracts that meets the following three criteria: (i) either using absolute performance metrics only, or not using any performance metrics (i.e., time-vested), (ii) including cash and equity compensation contracts only, and

---

[21] We simulate current year realization of the chosen performance metrics and do not incorporate the multi-year horizon of the metrics (only "periodid=1" is kept in our sample for each performance metric). It is a simplification we make given the complexity of our estimation procedure, but we note that it only affects 10% of our main sample (94 out of 939 firm-year observations). While this simplification may result in measurement error for our estimation, it is also likely that the annual variance of the performance metric is low relative to the metric's target and threshold, so overall we expect this assumption to produce an underestimation of both pay and variance of pay with no reason to believe that it will impact the estimated sensitivity of pay to variance of pay one way or the other.

(iii) including contracts for CEOs only. In particular, we start with the Absolute Performance Goals Data ("GpbaAbs" in Incentive Lab) to get all compensation contracts using absolute performance metrics. We drop firms that use relative performance metrics (i.e., the variable "numRelative" has a positive value). We then limit the sample to cash and equity compensation contracts by merging the Grants of Plan-Based Awards Table (referred to as "GpbaGrant"): we keep contracts where the "AwardType" variable in GpbaGrant has the value of "cashShort", "cashLong", "Option", or "rsu". We then add the time-vested RSU and option grants from GpbaGrant (i.e., the variable "performancetype" has the value of "Time"). Next, we limit the sample to include contracts for CEOs only by merging the Participant Data by Fiscal Year (referred to as "ParticipantFY"): we keep contracts where the "currentCEO" variable in ParticipantFY has the value of one.

In the second step, we classify each firm-year into one of seven groups: (i) firm-years with bonus contracts only, (ii) firm-years with RSU contracts only, (iii) firm-years with option contracts only, (iv) firm-years with bonus and RSU contracts only; (v) firm-years with bonus and option contracts only; (vi) firm-years with RSU and option contracts only, and (vii) firm-years with bonus, RSU, and option contracts. We separately examine the seven groups because we need to ensure contract details are available for simultaneously simulating all performance metrics for a given firm-year. Some firms may have an actual compensation component without disclosing sufficient contract details. For example, a firm may have reported values of RSU grants in ExecuComp, but lack contract details on Incentive Lab (either not listed in GpbaAbs or showing missing values of the contract details in GpbaAbs); these firms are dropped. In constructing our sample, we first use Incentive Lab contract information to classify the seven groups of firms described above. We then merge this sample with actual compensation from ExecuComp to construct our sample.[22]

---

[22] We use the following procedures to construct our sample consisting of seven groups of firms described before. (i) The "bonus only" group sample consists of firms that only have bonus contract information in Incentive Lab (i.e., no RSU or option contract information available). To get from the "bonus only" group sample to the "bonus only" group in our sample, we exclude firms having actual RSU payment or actual option payment or both as indicated in ExecuComp. (ii) The "RSU only" group sample consists of firms that only have RSU contract information in Incentive Lab (i.e., no bonus or option contract information available). To get from the "RSU only" group sample to the "RSU only" group in our sample, we exclude firms having actual bonus payment or actual option payment or both as indicated in ExecuComp. (iii) The "options only" group sample consists of firms that only have option contract information in Incentive Lab (i.e., no bonus or RSU contract information available). To get from the "options only" group sample to the "options only" group in our sample, we exclude firms having actual bonus payment or actual RSU payment or both as indicated in ExecuComp. (iv) The "bonus and RSU only" group sample consists of firms that only have bonus and RSU contract information in Incentive Lab (i.e., no option contract information available). To get from the "bonus and RSU only" group sample to the "bonus and RSU only" group in our sample, we exclude firms having actual option payment as indicated in ExecuComp. (v) The "bonus and options only" group sample consists of firms that only have bonus and option contract information in Incentive Lab (i.e., no RSU contract information available). To get from the "bonus and options only" group sample to the "bonus and options only" group in our sample, we exclude firms having actual RSU

In the third step, we pinpoint the specific performance metrics used in each contract. In particular, "GpbaAbs" has five relevant variables for this task: (i) the variable "metric" lists the name of the performance metric, (ii) the indicator variable "metricIsPerShare" describes whether the performance metric is scaled by the number of common stocks; (iii) the indicator variable "metricIsMargin" describes whether the performance metric is scaled by sales; (iv) the indicator variable "metricIsGrowth" describes whether the performance metric is measured as the growth rate; and (v) the variable "metricOther" provides additional textual information about the performance metric. For example, when "metric" has the value of "Cashflow", several possibilities exist: if all three indicator variables equal zero, it means the performance metric used in the contract is the dollar amount of cash flow; if "metricIsPerShare" equals one, "metricIsMargin" equals zero, and "metricIsGrowth" equals one, it means the performance metric used in the contract is the growth rate of cash flow per share. In addition, the textual description in "metricOther" may indicate whether it is operating cash flow or free cash flow. We consider all possible combinations of the indicator variables as well as the additional information in the textual description from "metricOther" to pinpoint the performance metric used in each compensation contract.

In the fourth step, we fit the contract using linear or quadratic estimation. Specifically, and again for firms with no missing values for the contract details, i.e., firms with all three pairs of data points available: the threshold x1 and y1, the target x2 and y2, and the maximum x3 and y3 (x refers to performance and y refers to compensation), we use both methods to fit the same contract: piece-wise linear and quadratic. Once the contracts are estimated, we can then apply the simulated performance to get simulated compensation. We present results from the linear estimation in the paper; results from the quadratic estimation are available upon request.

Performance Simulation. We simulate current year performance using actual performance in the past five years from Compustat. The Incentive Lab contract information is presented at the firm-year-grant-metric level. It is possible for firms to use more than one performance metric for a given grant (contract). It is also possible for firms to set up several grants (contracts) for the same CEO in a given year. We consider all metrics used for

---

payment as indicated in ExecuComp. (vi) The "RSU and options only" group sample consists of firms that only have RSU and option contract information in Incentive Lab (i.e., no bonus contract information available). To get from the "RSU and option only" group sample to the "RSU and option only" group in our sample, we exclude firms having actual bonus payment as indicated in ExecuComp. (vii) The "bonus, RSU, and options" group sample consists of firms that have bonus, RSU, and option contract information in Incentive Lab.

a given firm-year and simultaneously simulate all metrics for that year. In particular, for each CEO and year, we assume a multivariate normal distribution for all performance metrics used for a given CEO-year; we set the mean of the joint normal distribution equal to the actual values in the previous year,[23] and set the covariance matrix for the joint normal distribution equal to the covariance matrix calculated from the actual values of the performance metrics in the past five years. Using these assumptions, we simulate 10,000 paths for each firm-year-grant-metric, which provides simulated performance for estimating simulated compensation.

In our main test, we convert the performance metrics stated in dollar amount into scaled variables to make the covariance matrix comparable with other scaled metrics (i.e., metrics expressed as a rate or ratio such as growth rate, margin, per share value, ROA, etc.). In particular, when the performance metric is the dollar amount of sales, we simulate the firm's sales growth rate, and then get the dollar amount of simulated sales as simulated sales_t = $\text{sales}_{t-1} \times (1+\text{simulated sales growth rate}_t)$; when the performance metric is operating income, profits before tax, net income, cash flow, etc., which can have negative values in the past five years, we simulate the corresponding performance metric scaled by lagged total assets, and get the dollar amount of the simulated performance metric as simulated performance metric_t = total $\text{assets}_{t-1} \times$ simulated scaled performance metric_t.[24] We use the distribution of the level of EPS as opposed to the growth in EPS because Ball and Bartov (1996) argue that this is a reasonable assumption when looking at annual data. To simulate the firm's stock price, and because the stock price is nonstationary, we choose to simulate the price to lagged sales ratio to get simulated price. In particular, simulated price_t = $\text{sales}_{t-1} \times$ simulated price to lagged sales ratio_t. For all CEOs with restricted stock grants or option grants or with time-vested incentive pay, the covariance matrix for the joint normal distribution includes the price to lagged sales ratio as an additional input variable besides the actual performance metrics used in the compensation contracts.

Compensation Simulation. We calculate simulated compensation by fitting the simulated performance to the estimated compensation contracts. Since the simulated performance is conducted at the firm-year-grant-metric level, we first calculate the simulated compensation at the firm-year-grant-metric level. We then collapse the metric level compensation into the grant level compensation based on information in the variable

---

[23] In a robustness check, we set the mean of the joint normal distribution equal to the actual values in the current year, and get qualitatively similar results.

[24] In a robustness check, we simulate the dollar amount of performance metrics directly without the scaled conversion. We obtain similar results whether the simulated performance is scaled or not.

"performanceGrouping", which describes the relationship between the various performance metrics.

The compensation contracts can be described in two overall patterns: (i) separable contracts, and (ii) non-separable contracts. While separable contracts allow CEOs to earn part of the bonus (or equity grant) when some of the performance metrics are not met, non-separable contracts result in zero bonus (or equity grant) if any of the performance metric is not met.

Incentive Lab assumes that the performance metrics in the separable or non-separable contracts are equal weighted (data on metric weights are not collected by Incentive lab). Take the example of a separable contract with three performance metrics, each metric is worth one third of the total compensation indicated in that contract. As a result, we assign the weight of one third to each simulated pay at the metric level, and add the weighted pay from all three metrics to get total simulated pay at the grant level. For CEOs with more than one grant in a given year, we add simulated pay from all grants for a given CEO. As explained before, if a contract is separable, it is possible for a CEO to miss some performance metrics and still earn some performance-based compensation.

For non-separable contracts, we impose an additional requirement for consolidating the metric level simulated pay to the grant level simulated pay: if any of the simulated performance metric does not meet the goal threshold set in the contract, then the total grant level simulated pay is zero.

Once we have 10,000 simulated pay paths at the firm-year level, we can calculate the mean, variance, and skewness of the simulated pay from the 10,000 simulated results for each firm-year. To make simulated total pay comparable to TDC1 in ExecuComp, we set expected total pay for the current year using information available at the beginning of the year to be the sum of: (i) salary, (ii) mean simulated pay from the procedures described above, (iii) other compensation (Compustat variable "othcomp"), and (iv) non-performance-based bonus (Compustat variable "bonus" after 2006). Since salary is constant for a given year, expected variance of total pay equals variance of simulated pay, and skewness of total pay equals skewness of simulated pay.

Appendix C Variable definitions

Total Compensation (TDC1)	Total annual compensation flow is calculated as the sum of salary, bonus, other annual compensation (e.g., gross-ups for tax liabilities, perquisites, preferential discounts on stock purchases), long-term incentive payouts, restricted stocks granted during the year (determined as market value of the date of the grant), the value of stock options granted (estimated using the Black-Scholes formula or total grant-date present value of options awarded when Black-Scholes is not available), and all other compensation (e.g., payouts for cancellation of stock options, 401K contributions, signing bonuses, tax reimbursements) before 2006. After 2006, annual compensation flow is calculated as the sum of salary, bonus, non-equity incentive plan compensation, the grant-date fair value of option awards, the grant-date fair value of stock awards, and other compensation. This variable is presented in millions of U.S. dollars in Table 2.
Log of TDC1	The natural logarithm of total compensation (TDC1).
CEO Inside Wealth	Value of the CEO's stock and option portfolio (in $000s) from Coles et al. (2006) plus salary, bonus, and other annual compensation (othcomp) before 2006; or value of the CEO's stock and option portfolio plus salary, bonus, non-equity incentive plan compensation, and other compensation after 2006.
Simulated Mean Pay	Simulated total annual compensation, calculated as the sum of (i) salary, (ii) the mean value of the sum of simulated bonus, simulated restricted stock, and simulated stock options across 10,000 simulations for each firm-year; (iii) other annual compensation (Compustat variable "othcomp"), and (iv) non-performance-based bonus (Compustat variable "bonus" after 2006).
Log of Simulated Mean Pay	The natural logarithm of simulated mean pay.
RET	The annual stock returns ending in the current fiscal year end calculated from monthly stock returns.
ROA	Return on assets, defined as net income (NI) divided by total assets (AT).
Firm Return Volatility	The standard deviation of monthly stock returns calculated using the last 38 months.
Firm Earning Volatility	The standard deviation of annual ROA calculated using the last 5 years.
Log of Market Capitalization	The natural logarithm of the market capitalization, calculated as number of shares outstanding multiplied by the firm's stock price at the end of fiscal year (in millions of dollars).
Market to Book	The ratio of market value of assets to book value of assets, calculated as the sum of market value of equity (PRCC_F×CSHO) and book value of liabilities (AT-CEQ) divided by total assets (AT).
Leverage	Book value of liabilities divided by market value of assets, calculated as the long-term liabilities (DLC + DLTT) divided by market value of assets (PRCC_F×CSHO+AT-CEQ).
Coopt	Indicator variable equal to one if the number of directors hired after the CEO took office is above the sample mean; zero otherwise.
Coopt Miss	Indicator variable equal to one for missing values of the variable Coopt; zero otherwise.
Institutional Holdings	Percentage of the firm's shares outstanding that are owned by all institutional investors. This is obtained from Thomson Reuters Institutional (13f) Holdings – Stock Ownership (variable INSTOWN_PERC).
Founder	Indicator variable equal to one if the CEO is also the founder of the firm; zero otherwise.
Age	The age of the CEO while in office.
Log of CEO Tenure	The natural logarithm of the number of years the CEO has been in office at the firm.

(continued)

Overconfidence	Indicator variable equal to one if the CEO has held options for at least two years in a row that are deep in the money, where deep in the money is defined as when the average value per option is at least 67
Log of Disclosed Peer Pay	The natural logarithm of mean total pay (TDC1) of the disclosed peer firms; disclosed peer firms are collected from Incentive Lab.
Log of Realized Variance of Pay	The natural logarithm of the variance of CEO total pay flow (TDC1) calculated over the last 5 years.
Log of Realized Variance of Bonus	The natural logarithm of the variance of CEO bonus calculated over the last 5 years; bonus is defined as BONUS+LTIP prior to 2006, and BONUS+NONEQ_INCENT from 2006 onwards.
Log of Realized Variance of RSU	The natural logarithm of the variance of CEO's restricted stock grant valuation calculated over the last 5 years; restricted stock grant valuation is defined as RSTKGRNT prior to 2006, and STOCK_AWARDS_FV from 2006 onwards.
Log of Realized Variance of Options	The natural logarithm of the variance of CEO's option grant valuation calculated over the last 5 years; option grant valuation is defined as OPTION_AWARDS_BLK_VALUE prior to 2006, and OPTION_AWARDS_FV from 2006 onwards.
Log of Realized Variance of CEO Wealth	The natural logarithm of the variance of CEO inside wealth calculated over the last 5 years.
Log of Simulated Variance of Pay	The natural logarithm of the variance of the sum of simulated bonus, simulated restricted stocks, and simulated stock options across the 10,000 simulations for each firm-year.
Log of Simulated Variance of Bonus	The natural logarithm of the variance of simulated bonus across the 10,000 simulations for each firm-year.
Log of Simulated Variance of RSU	The natural logarithm of the variance of simulated values of restricted stock grants across the 10,000 simulations for each firm-year.
Log of Simulated Variance of Options	The natural logarithm of the variance of simulated values of option grants across the 10,000 simulations for each firm-year.
Realized Skewness of CEO Pay	Skewness of CEO total pay flow (TDC1) calculated over the last 5 years.
Simulated Skewness of CEO Pay	Skewness of the sum of simulated bonus, simulated restricted stock, and simulated stock option across the 10,000 simulations for each firm-year.