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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 13.5 percent 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 influence 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

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

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Data Availability: Data are available from the public sources cited in the text.
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I. INTRODUCTION

This paper quantifies the premium paid to chief executive officers (CEOs) for the uncertainty associated with their annual incentive pay. We deviate from prior research by using information from actual CEO compensation contracts 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 data allow us to simulate the ex ante risk in total pay arising from all accounting- and price-based performance metrics.[1] For each CEO-year, we obtain an estimate of the variance of total pay using actual information from CEO compensation contracts. This study's direct estimation of the compensation CEOs require for the expected variance in their pay, i.e., the pay premium, is novel and a topic of interest to executive compensation designers and researchers.

No one disputes that CEO pay should reflect a premium for the risk in pay, but the size of that premium is unknown. Studies may have inaccurately estimated it because they rely on incomplete data to make these estimates. Due to the lack of detailed compensation contract data, prior studies have often assumed all firms rely on stock returns as a performance metric.[2] Yet prior findings suggest that this assumption is inaccurate and that evaluating the CEO pay premium is nontrivial because pay contracts are typically complex (Albuquerque et al. 2022). Pay volatility arises not only from stock return volatility but also from accounting performance metrics: the average firm in our sample uses 4.5 performance metrics per pay package, and on average, 99 percent of performance metrics in incentive contracts are accounting based.

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[1] We use the term "total pay" to refer to the annual flow compensation the CEO receives as captured by TDC1 in ExecuComp. We do not include the change in value of equity awards during the year in "total pay" but in later analyses we do consider CEO wealth, which includes the value of equity holdings.

[2] While the assumption that incentive pay relies exclusively on stock returns is probably a better fit to the data before FAS 123(R), compensation practices have changed significantly since then.

Consider a simple contract that includes only salary and a cash bonus and the implications of this contract for the association between the mean and variance of pay. The bonus may have a threshold payout of 100 percent of base salary, a target payout of 200 percent of base salary, and a maximum payout of 400 percent of base salary. The contract defines a metric—for example, net sales—and performance levels determining 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, using 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. Features of the contract have implications for the pay premium. In this example, the fact that bonus is zero if performance is low introduces a left truncation in pay that implies that the mean and variance of pay have a positive association, leading to a high estimated pay premium. In contrast, the right truncation resulting from the bonus ceiling when performance is high decreases the magnitude of that association, reducing the estimated pay premium.

Strictly speaking, we are not interested in how firms implement the association between total pay and the variance of pay but rather how large the trade-off, or the pay premium, is. CEO contracts may include bonus, stock, and option grants in any given year, and multiple grants of each kind are possible, with multiple performance metrics specified across grants and even within the same grant. Some of these contract terms may include contract convexity to encourage risktaking (Bettis et al. 2018). The performance metric targets may all have to be met to yield a payout, introducing nonlinearities in pay that may result in higher risk. Finally, these characteristics may evolve for the same firm-CEO pair. Using granular compensation data, we conduct detailed simulations to estimate the variance of total CEO pay for each CEO-year in our sample.

In our main results, we estimate the ex ante pay premium by regressing 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 that the premium in our sample is 13.5 percent of total pay.[3] We further decompose the premium into each of the main sources of pay uncertainty: cash bonus, stock grants, and option grants. Stock grants carry the highest pay premium; in the sample with greater availability of option grant data, we also find a large premium from option grants.

Studies hypothesize that CEOs value positively skewed payouts (Hemmer et al. 2000; Ross 2004; Chaigneau 2015); however, such studies are not designed to document supporting empirical evidence. We introduce an empirical test of this hypothesis using a measure of skewness in flow pay obtained from our simulation. Our estimates generally suggest that CEOs accept less compensation when offered more positively skewed incentive pay.

Our estimate of the pay premium can be motivated theoretically using the principal-agent model. Many models of optimal compensation predict that the variance of pay should relate positively to the level of pay through the agent's risk aversion. In the principal-agent moral hazard model, incentive pay helps risk-neutral shareholders reduce principal-agent conflicts at the cost

[3] Prior studies estimate 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 percent after the mandatory disclosure. Carter et al. (2019) find that executives changing employers are paid an additional 14 percent 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 of Conyon et al. (2011) (see their Table 5) because the premium estimated in the earlier study is calculated as a fraction of total CEO wealth in the firm.

of having to pay more to the risk-averse CEO (Holmstrom 1979; Mirrlees 1976; Shavell 1979; Grossman and Hart 1983). However, a finding of a positive pay premium in our regressions is also consistent with moral-hazard models with risk-neutral agents and limited liability. In these models, optimal pay packages are composed of call option contracts (Poblete and Spulber 2012; Tirole 2006), and the pay premium arises purely due to the convexity in the (option-based) pay package and not from the agent's risk aversion level.

To assess the extent to which risk aversion explains the variation of the risk premium in the cross-section, we modify our estimation by allowing the sensitivity of pay to the variance of pay to depend on proxies for risk aversion. Using several published proxies for risk aversion, we find that the premium is significantly higher for highly risk averse CEOs across all but one of the proxies. We also test whether wealthier CEOs (with presumed lower risk aversion) have lower sensitivity of pay to the variance of pay. Using the inside wealth variable of Coles et al. (2006), we find a negative relation between CEO inside wealth and the variance of pay, consistent with decreasing absolute risk aversion. These findings suggest that the pay-risk relation arises through the channel of an agent's risk aversion.

We then use our estimated sensitivity of pay to the variance of pay to derive an estimate of the implied risk aversion coefficient for comparison purposes. Using the standard agency model and a common assumption on preferences, we derive a coefficient of relative risk aversion around one. By comparison, Becker (2006) and Conyon et al. (2011) calibrate CEO relative risk aversion to two and three in their exercises; a value of relative risk aversion of three corresponds to a counterfactual elasticity of pay to variance of pay of one, over 16 times larger than our estimated value. This evidence suggests that the pay premium is economically small—despite being statistically significant—suggesting that compensation design incorporates other factors besides risk. On a similar note, the low premium is consistent with evidence from a recent survey of directors and investors that risk has little effect on the level of CEO pay (Edmans et al. 2023). Murphy and Jensen (2018) 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 by features of the tax code. Our evidence also complements that of Fernandes et al. (2013), Murphy and Vance (2019), 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. (2021) 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 factors other than risk diversification driving incentive levels.

One of our main contributions is to provide estimates of the variance of total pay. We provide three alternatives to our simulation to estimate the variance of total pay as a way to validate our estimated risk premium. First, we simulate pay packages using the approach 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 the variance of pay using their alternative simulation approach is quantitatively similar to our main estimate. Second, we estimate the variance of total pay using the 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 the sample variance of pay comport with the results using Incentive Lab contract data that explicitly address time variation in contract parameters and performance metrics. Third, we use a variant of Engle's (1982) autoregressive conditional heteroskedasticity (ARCH) model to jointly estimate the mean of total pay and the volatility of pay.[4] The ARCH-in-mean model simultaneously estimates an equation for the level

[4] 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.

of pay and an equation for the volatility of pay while incorporating the volatility as a factor in the equation for mean pay. This approach also generates results that comport with our main results.

Our main sample focuses only on contracts for which we believe we have complete data, which comes at the cost of losing data points. In an alternative sample, we simulate all the grants for which we have any contract data in Incentive Lab and redo our tests with this simulated variance of pay. We find that estimates of the sensitivity of pay to risk in pay in this larger sample are smaller, a possible sign of an attenuation bias from measurement error. As another way of validating our measures of pay risk premiums, we examine whether low pay for risk is associated with increased CEO turnover. Consistent with theoretical predictions, we find some evidence that CEOs are more likely to depart when their pay risk premiums fall below expectations. Finally, 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; Armstrong et al. 2015) by including the volatility of CEO wealth linked to firm performance. While there may be limitations to our analysis due to statistical power, we show that the inclusion of the volatility of CEO inside wealth 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.

II. RELATED LITERATURE

A large literature studies the association between CEO total pay and firm volatility—commonly proxied by stock return volatility—referred to as the risk-return trade off. While some studies find a positive association between firm volatility and CEO pay, others find a negative association (e.g., Aggarwal and Samwick 1999; Core and Guay 2002; Prendergast 2002). This paper examines a different trade-off: that of CEO total pay and its volatility. 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, commonly used in pay contracts. Moreover, it takes into account the covariance among these 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 returns) differ empirically and have different theoretical underpinnings. For example, Cheng and Scheinkman (2015) argue that higher firm volatility not only indicates higher firm risk but also 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 with the firm's return volatility, depending on how strongly volatility affects firm productivity. Following Lambert and Verrecchia (1991), Conyon et al. (2011) and Fernandes et al. (2013) estimate the risk premium in equity pay. Our test differs in several respects. First, we use contract information, not previously available, 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. Second, they rely on assumptions about CEO's outside opportunity that we do not require. Third, unlike Conyon et al. (2011) and Fernandes et al. (2013), our sample contains U.S. firms only, where CEOs face the same legal, taxation, and economic environment; these characteristics impact the level and form of pay and may be hard to control for in cross-country studies.

The last 30 years have seen an expansion of CEO pay in the U.S. that has led to much debate. This expansion is mostly in incentive pay as opposed to fixed pay (e.g., Conyon 2006; Murphy and Jensen 2018). 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; Hayes et al. 2012), short-termism (Bebchuk and Fried 2006), earnings management (Bennett et al. 2017), and accounting fraud (Erickson et al. 2006). We contribute to this literature by estimating the increase in direct compensation that boards must pay their CEOs for bearing extra incentive-pay uncertainty.

III. EMPIRICAL STRATEGY

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, relates linearly to the variance of total pay, σ_t^2,

$$w_t = \lambda\sigma_t^2 + X_t'\beta + \epsilon_t, \qquad (1)$$

and where X_t are control variables and β is the vector of sensitivities of pay to the control variables.

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 shock to 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.

The premium in pay that we estimate, $\lambda\sigma_t^2$, is an ex ante pay premium, even though we use the realization of pay, w_t, as a lefthand side variable. Formally, from Appendix A, $w_t = E_t(w_t) + \epsilon_t$. Empirically, we model $E_t(w_t) = \lambda\sigma_t^2 + X_t'\beta$, as shown in equation (1). Thus, $E_t(w_t)$, the expected pay, includes simulated variance among other controls, implying that, in our tests, we determine the impact that simulated variance has on the expected value of pay and thus the ex ante premium.

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, we obtain the simulated variance of pay as of the beginning of the year, σ_t^2.[5]

Firms use two types of incentive pay to reward their CEOs: time-vested and performance-vested. The former includes time-vested restricted stock units (RSU) and time-vested stock options.[6] The latter includes bonus, performance-vested RSU, and performance-vested stock options. Time-vested grants lack specific performance targets, but their values are linked to firm performance through the stock price. Performance-vested grants, on the other hand, require CEOs

[5] In Section VI, we discuss results obtained after we simulate pay packages using the Core and Packard (2022) assumptions, which include different distributional assumptions than ours.
[6] We use the terms "stock grant," "restricted stock grant," and "RSU" to identify the same component of pay.

to meet specific performance targets to earn the grants and their values may additionally be tied to firm performance through the stock price.

We simulate the value of time- and performance-vested incentive pay differently. For time-vested incentive pay, we simulate the stock price to obtain the dollar value of the RSU or options granted. For performance-vested incentive pay, we simulate the appropriate firm performance metric to calculate the corresponding award amount. We take two inputs for the simulation exercise: Incentive Lab data on compensation contract information, and Compustat data on past realizations of different performance metrics required to obtain the moments that characterize the distribution function to be simulated.[7] See Appendix B for specific details of the simulation.

The compensation contract information is available at the firm-year-grant-metric level. For each performance metric used, Incentive Lab collects the threshold, target, and maximum levels for both the performance metric and the corresponding performance-based compensation. The CEO earns no performance-based compensation when performance is below the threshold and earns the maximum amount when performance exceeds the maximum. Between threshold and maximum, CEO compensation is interpolated based on performance. We fit a piece-wise linear function between the threshold, the target, and the maximum to determine the award amount.[8]

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. Given that firms frequently employ multiple performance metrics for a single grant and may grant multiple awards to the same CEO within a year, we concurrently simulate all metrics for the firm-year, considering the joint distributional characteristics of these metrics. Specifically, we adopt a multivariate normal distribution

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[7] 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 must use simulation methods.

[8] We also consider a polynomial quadratic approximation and obtain similar results.

assumption for the vector of performance metrics specific to the firm-year. For our main results, the means of the multivariate normal variables are set to last year's values of the respective performance metrics. This assumes the board employs a random walk model, expecting the performance metrics to stay at their current levels. In untabulated results, we conduct an additional set of simulations with means equal to end-of-year-t values, assuming perfect foresight by the board in forecasting CEO actions and the operating environment. These two alternative assumptions establish bounds on the information used by the board to determine the conditional mean of the performance metric, ranging from least information (random walk) to most (perfect foresight).[9] Notably, these varied assumptions result in highly similar estimated sensitivities of pay to variance of pay, providing assurance that the differences in assumptions do not significantly affect our results. Previous studies by Bettis et al. (2018), Hayes et al. (2012), and Core and Packard (2022) assume the mean of performance metrics grows at the risk-free rate.

We set the covariance matrix equal to the sample covariance matrix of performance metrics using five years of pre-grant data, then run 10,000 simulations for each firm-year-grant-metric observation. We calculate simulated compensation by fitting the simulated performance metrics to the compensation contracts at the metric level. We then aggregate the metric-level compensation into the grant level using Incentive Lab data indicating whether the compensation contracts are separable or nonseparable. Separable contracts permit partial payouts even if some metrics miss goals, while nonseparable contracts result in zero payout if any threshold is unmet. We sum equally weighted pay from all metrics in a given grant to get total simulated pay at the grant level. For CEOs with multiple grants, we sum simulated pay from all grants. We add salary, other

[9] Under the agency model, the agent's action is simultaneously determined with the choice of incentive scheme, and jointly these determine mean and variance of pay. It is a model simplification that the choice of an action and the implementation of such action are concurrent. Our simulation assumes the board designs the incentive contract to elicit an action from the CEO. The distributional assumptions we make are consistent with the actions the board wishes to elicit from the CEO through the incentives as well as the consequences of those actions on the performance metrics.

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 10,000 simulated values for each firm-year.

IV. 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 compensation information for the S&P 1500. For both datasets, we restrict our sample to CEOs serving a full year to ensure that we include only complete annual 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. We define our variables in Appendix C.

When using 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 those 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 contracts that include such 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 VI).

We identify the 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 better 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.[10]

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 had actual bonus, RSU, or option payments information according to ExecuComp but there was 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.

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 unavailable, yields 20,524 compensation contracts at the firm-year-grant-metric level. We further exclude firm-years with incomplete compensation contract information, identified by comparing actual compensation components paid out in Incentive Lab to that in ExecuComp.[11] After this exclusion, the sample has 939 firm-year observations with data available

[10] Core and Packard (2022) take a different approach on measurement error by using earnings per share as the only nonprice metric.

[11] In ExecuComp, the data item "nonequityincentives" is the value of all cash incentive grants paid during the year. We exclude firm from our sample with nonmissing values of nonequityincentives in ExecuComp (indicating that cash incentive grants were paid by these firms) but that have missing values for contract parameters for these grants in

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 seven 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 to CEOs that received RSU grants, and 666 to CEOs that received options grants.

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. In our sample and across all awarded contracts, the use of accounting-based performance metrics dominates that of stock price-based performance metrics (Bettis et al. 2018 find a similar pattern for performance based equity grants), which suggests that studies focusing solely on stock return volatility may have significantly understated 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 percent of the performance metrics are accounting-based. Among the accounting-based metrics, EPS, sales, operating income, and cash flow are the four most common.

Recall that Conyon et al. (2011) and Fernandes et al. (2013) evaluate risk in equity incentives, and that part of our contribution is to consider the risk that arises also from bonus pay, a component that represents about 25 percent of total pay on average. Table 1 shows that CEOs receive fewer bonus grants on average (1.11) than stock grants (1.35), but bonus grants are more complex in that

Incentive Lab (i.e., these grants were paid, but cannot be simulated). A different issue concerns firms for which Incentive Lab has nonmissing values of contract parameters for fewer cash incentive grants than the actual number of cash incentive grants paid. As we do not observe in ExecuComp how many grants were given leading to the reported dollar value of these grants, we cannot determine if the contract information parameters in Incentive Lab are for all of the grants or just a subset of them.

they have 1.57 performance metrics per grant versus 1.07 for stock grants. Table 1 also shows that in our sample the vast majority of stock grants are time vested whereas none of the bonus grants are time vested. These two features suggest that the risk associated with bonus grants can be significant as compared to that of stock grants. Lastly, Table 1 shows that for performance-vesting grants, bonus grants have a similar distribution of performance metrics as stock grants.

Figure 1 plots the cross-sectional mean of reported pay (from ExecuComp) and of 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 approximates the reported value of bonus, restricted stock, options, and total pay. ExecuComp bonus is the reported 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 bonus paid in 2008 is smaller than the simulated one because the impact of the economic downturn in 2008 was unexpected. 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, reported bonus appears somewhat larger on average than simulated bonus. One possible explanation for this is that firms may adjust performance metrics to boost executive bonus compensation (Kim and Yang 2014). Another explanation, which can also apply to the other pay components discussed below, is that we cannot 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.[12] We follow Core and Guay (2002) in calculating the value of option grants using Black-Scholes. In the latter part of the sample, which after 2006 use the fair value of options, the ExecuComp option values systematically exceed their simulated counterparts.

Table 2 provides descriptive statistics for our sample firms, including all the control variables. The average (median) CEO total annual flow compensation, 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 pay in the empirical analysis to mitigate the effect of skewness in compensation. In robustness tests, we use the inside wealth variable of Coles et al. (2006) to capture the lack of diversification stemming 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 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 the size distribution being positively skewed. 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).[13]

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,

[12] Our simulation results contrast with those of Bettis et al. (2018), who find a gap between actual and simulated values for restricted stock grants.

[13] While our sample is much smaller than the ExecuComp sample, it shows considerable similarity. In untabulated results, the average firm size and total pay of the sample firms are larger than those in the ExecuComp sample, which partly reflects 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.

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 unclear whether CEO pay is positively or negatively associated with pay skewness.

The remaining controls used in our regressions are standard in the literature. We control for current and lagged own firm performance to capture outside opportunities (Himmelberg and Hubbard 2000, and Oyer 2004), peer pay to capture the benchmark effect (e.g. Bizjak et al. 2008), the co-opted board measure of Coles et al. (2014) as well as the percentage ownership by institutional investors to capture CEO entrenchment and the possibility of rent seeking by the CEO, and the Humphery-Jenner et al. (2016) overconfidence indicator based on whether the CEO holds deep-in-the money options that have vested to control for CEO overconfidence. Overconfident 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; 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).

When the CEO's utility function is inseparable in consumption and effort, incentives may be provided by reducing the marginal cost of effort (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, log of CEO tenure, an indicator variable for when the CEO is the founder, and the lagged value of the firm's market capitalization. Our results are unaffected when using different measures of firm size such as total assets and sales revenue.

V. MAIN RESULTS

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. Column 4 contains the return volatility and earnings volatility in addition to all the controls included in Column 3. We consider the volatility of these performance metrics separately because they are regularly used as controls in regressions of CEO pay, but in our exercise their effect should be observed through the variance of pay. In columns 5 through 7, 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 variance of, say, bonus is zero for firms that do not pay a bonus. To account for the fact that some of these zeros represent missing observations (i.e., non-awarded contracts), we add to these regressions indicator variables associated with each of the three grant types to control for this fact. These indicator variables take a value of one when the respective grant type is not offered by the firm. Column 8 contains return volatility and earnings volatility in addition to all the controls included in Column 7. Standard errors are clustered by firm and year (Abadie et al. 2023).

We find a positive and statistically significant sensitivity of pay to variance of pay at the 1 percent 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 the 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. Including firm fixed effects ensures that the inference is not affected by mechanical scale effects arising from firms that pay higher salary, independent of the incentives granted. When we further control for other economic determinants of compensation, the coefficient on the variance of pay slightly decreases to 0.052 (Column 3). Adding the volatilities of firm performance metrics does not significantly change the point estimate of the coefficient associated with the variance of pay (Column 4). The regressions shown in the remaining tables do not include the volatilities of the performance metrics, but results are similar when they are included. 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 will accept lower pay for it. The effect is, however, statistically insignificant in our main sample.[14] The effects from the control variables are largely consistent with the literature and we omit their discussion.[15]

Because we estimate an ex ante pay premium, in untabulated results, we estimate regression models where we replace the logarithm of TDC1 with the logarithm of the simulated mean pay

[14] The Online Appendix contains a table that summarizes all the skewness results in this paper.

[15] In addition, in untabulated results, we control for outside opportunities using industry times year fixed effects, IPO activity following Nickerson (2017), and average industry ROA and find similar results to those in the main analysis. We find similar estimates also when fewer controls are used. These controls, which may be correlated with variance of pay, are simulated skewness and firm leverage. Removing these controls increases the estimated sensitivity of pay to variance of pay, though only marginally.

from Incentive Lab as the dependent variable and find significantly higher parameter estimates for the sensitivity of pay to variance of pay. These estimates may be biased due to the possibility of correlated measurement error from the simulation in both the right hand-side and left hand-side variables. Also suggesting correlated measurement error is that, in these regressions, the increase in the point estimates is not accompanied by an increase in *t*-statistics, which means that the standard errors of the estimates also increase significantly.[16]

In columns 5 through 8, we replace the simulated variance of total pay with the simulated variances of bonus, stock, and option grants. Considering the results in Column 7, the largest coefficient is associated with stock grants. The coefficients associated with bonus and option grants are about one-third and one-twentieth smaller, respectively, of the value of the coefficient associated with stock grants. They are also not statistically significant. 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 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. The lack of significant results for bonus and options grants may have to do with the fact these are the components of pay with the largest percentage of missing observations for pay variance (untabulated). The results in section VI where we extend the sample significantly are consistent with this hypothesis.

A concern on the identification of the parameter λ is that of omitted correlated regressors. To assess the significance of this, we conduct the test proposed by Oster (2019) for omitted variables and coefficient bias. Using her proposed cutoff values, the explanatory power of the unobservable

[16] To avoid the issue of correlated measurement error, we use simulated pay from the Core and Packard (2022) simulation, a procedure described below. In untabulated results, we find that the coefficient estimates across the various regression specifications for the main sample resemble those reported in Table 3. The results are consistent with our approach for providing a measure of the ex ante premium.

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 an extensive set of control variables in our study, which is grounded in the literature explaining the determinants of executive compensation. Further, Oster (2019) proposes that the statistic delta should exceed one to be able to assert that omitted variables do not drive the significance of the estimate. In our case, the delta is larger than two, supporting the view that our estimated coefficient is stable to omitted variables.

Estimating the premium in incentive pay

We convert the estimated elasticity of pay to variance of pay into an ex ante pay risk premium. 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 present estimates of the pay premium using the coefficients from Column 3 of Table 3. The estimate of the premium on total pay volatility implies that total pay is expected to increase by 13.5 percent when incentive-pay risk increases by one standard deviation. The estimated premium associated with bonus grants is 7.6 percent. In contrast, the estimated premium for restricted stock grants is 20 percent, and, for option grants, it is 1.3 percent. 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 percent of total pay, whereas the average amount of stock grants is 29 percent of total pay, and the average amount of option grants is 15 percent of total pay, with the rest being salary.)

Risk aversion as a source of the pay premium

In this section, we allow the sensitivity of pay to variance of pay to vary with CEO risk aversion, providing a cross-sectional test of the standard agency model with moral hazard.[17] We consider several proxies for risk aversion. First, there is evidence consistent with females being more risk averse than males (e.g. Barber and Odean 2001, and Borghans et al. 2009). We use an indicator variable that equals one for female CEOs and zero otherwise to proxy for risk aversion. Malmendier and Tate (2008) suggest that overconfident CEOs do not perceive risks in the same way as other CEOs and would therefore not require as much compensation. We use an indicator that equals one for values of overconfidence above the mean. Risk aversion appears to relate inversely to CEO tenure (e.g. Tufano 1996, and Bloom and Milkovich 1998). We create an indicator for longer tenured CEOs (above median tenure) as a proxy for lower risk aversion. Bernile et al. (2017) show that CEOs' early-life exposure to fatal disasters relates to their risk-taking. Specifically, their 'medium fatality' CEOs 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-taking encoded as an indicator variable.

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. 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 but one of the proxies for risk aversion. For female CEOs, the sensitivity of pay to variance of pay is 0.236 = 0.188 + 0.048, about 5 times larger than the sensitivity of pay to the

[17] 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 ameliorated.

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 that of Carter et al. (2017), who show that female executives are less willing to accept risky pay and receive more salary. Less confident CEOs have a sensitivity of pay to variance of pay equal to 0.075, more than twice the sensitivity of pay to variance of pay for overconfident CEOs (equal to 0.03 = 0.075− 0.045). The estimated sensitivity of pay to the variance of pay for longer tenured CEOs equals 0.026 = 0.084–0.058, which is less than half the sensitivity required by shorter tenured CEOs. The evidence from CEO overconfidence and tenure is also consistent with more risk averse CEOs having greater sensitivity of pay to variance of pay as predicted. "Medium Fatality" CEOs should be more risk loving and have a lower pay-for-risk premium. However, we find a positive and significant coefficient associated with this indicator variable. Note that, when we use this proxy for risk aversion, we lose many observations, as we lack data on *Medium Fatality*.

We provide one final test that suggests that the estimated sensitivity of pay to the 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 an indicator that equals one for high wealth CEOs, using the inside wealth variable of Coles et al. (2006). The hypothesis being tested is that, under decreasing absolute risk aversion, wealthier CEOs are less risk averse because higher wealth can dilute their disutility of uncertainty. The evidence supports this hypothesis. Wealthier CEOs have estimated pay sensitivities that are 41 percent of the sensitivities of less wealthy CEOs.

In summary, we find evidence that the pay premium is statistically significantly related to all but one proxy for CEO risk aversion, consistent with the standard agency model.

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 assume that CEO pay follows a log-normal 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.[18] Estimates of the elasticity of pay to variance of pay in the regressions with fixed effects are about 0.05, yielding estimates of risk aversion of approximately 1.10. Putting this value into perspective, asset pricing studies typically assume a coefficient of relative risk aversion of around ten. CEOs, in general, may 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 two or three. A risk aversion coefficient of three would be comparable to a sensitivity of pay to the variance of pay of one (i.e., $\frac{3-1}{2}$), about 20 times larger than our estimated value. Even our higher estimated sensitivity of 0.236 for female CEOs is one-quarter of the value needed to generate a risk aversion of three.[19]

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 percent of CEO pay is incentive based.

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[18] 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 μ=$\frac{\gamma-1}{2}\sigma^2$+ 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.

[19] 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.

VI. ALTERNATIVE APPROACHES TO ESTIMATE THE VARIANCE OF PAY

One of our main contributions is the construction of the variance of total pay and this section explores alternative approaches. The first approach is borrowed from Core and Packard (2022) and uses different assumptions in the simulation. The last two approaches are not simulations and allow for the use of the full cross-section of firms in ExecuComp data, thus providing a larger sample and generalization of the results. They are also simpler approaches that other researchers can use to incorporate the variance of pay in their exercises.

Simulating pay using the Core and Packard (2022) method

We first simulate performance and pay outcomes using the method developed by Core and Packard (2022). We do this 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 matters because RPE allows greater incentives for CEOs by protecting their pay from variations in aggregate sources of risk. This feature is particularly relevant in industries where common sources of risk in firm performance prevail. Second, Core and Packard (2022) solve the problem of missing contract information in Incentive Lab by replacing missing data with sample averages obtained from firms in the same industry. (See their paper for details of the simulation.) This allows for significantly more firm-year observations. Third, they make different distributional assumptions for the performance metrics; they assume performance metrics are normally distributed and 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 nonprice contract details. Instead, they only simulate earnings-per-share, their proxy for all nonprice performance measures, and stock price. The main drawback of their method is the use of imputed data. Overall, there is a benefit of a larger dataset that must be weighed against the potentially less precise estimates of the variance of pay. We choose to conduct our primary analysis using the smaller sample based on actual contract information, because, as the first researchers to estimate the ex ante variance of total pay, we believe precision is critical to defend our exercise. However, we use the Core and Packard simulation method to replicate our results, which serves as a quasi-out-of-sample test of our hypothesis. We refer to the sample that results from their simulation as the "replication sample."

Table 6 Panel A reports estimates of the sensitivity of pay to the variance of pay in the replication sample (columns 1 through 3). In Column 4 we consider the variances of the three components of the pay. 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 5 through 7). The results obtained from these larger samples resemble those obtained in our main analysis. This outcome is consistent with a high correlation between simulated pay using our simulation and that of Core and Packard of 0.7 and a correlation between the simulated variance of pay using our simulation and that of Core and Packard of 0.45 (untabulated). When we include RPE grants to our main sample, these correlations increase (to 0.79 and 0.54, respectively), which is to be expected, since RPE grants are simulated using the Core and Packard approach in both samples. Of note, in the replication sample skewness of pay is negatively associated with pay: a one standard deviation increase in skewness in pay is associated with a drop in pay of 3.4 percent.

Table 6 Panel B reports the pay premium using columns 3 and 4 of Panel A. The premium on the variance of total pay is 11.6 percent, slightly below the 13.5 percent premium using the main sample reported above. Regarding the premium on the components of pay, the replication sample yields a premium on bonus (RSU grants) of 3 percent (19.4 percent), that's approximately half (the same) of the premium on the main sample. The largest difference in results occurs for option grants. The premium on option grants is 49 percent in the replication sample, almost 40 times larger than the one estimated using the main sample. This last result is consistent with our prior conjecture that the low premium on the main sample was due to lack of data on option grants.

Variance of pay estimated using sample variance of pay

As an alternative to using Incentive Lab data and the rich contract information, we estimate the variance of pay using past CEO-firm pay data. We use the last five years of total CEO pay, proxied by TDC1 and referred to as w_t, to compute the sample variance of pay, as follows:

$$\text{Sample variance of pay}_t = \left(\frac{1}{5}\right)\sum_{s=1}^{5}(\mathrm{w}_{t-s} - \bar{\mathrm{w}}_t)^2, \tag{2}$$

where $\bar{\mathrm{w}}_t$ is the 5-year sample mean.[20]

If pay were a function of stock returns alone, this estimator would be a consistent estimator of the conditional volatility of pay. To see this, evaluate the estimator in Equation (2) applied to data generated by a model similar to that of 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, the sample variance of pay$_t$ = $m_1^2 \frac{1}{5}\sum_{s=1}^{5}(r_{t-s} - \bar{r}_t)^2$. Andersen and Bollerslev (1998) show that, under general properties for stock returns and if we are allowed to sample returns at increasingly higher frequencies, the estimator above converges to $m_1^2 V_t(r_t)$, i.e., the conditional variance of pay in the model, where $V_t(r_t)$ is the conditional volatility of stock returns. Thus, we expect this estimator of the variance to work well as an estimator under the null that pay evolves linearly with stock returns. Intuitively, if contract parameters (i.e., m_1) remain constant, any changes in pay can be attributed to variations in performance metrics, which can be captured by past data realizations. However, the variance of pay and the variance of stock returns

[20] This estimator resembles Roussanov and Savor's (1989) estimate of conditional monthly return volatility that uses daily data and to Andersen and Bollerslev's (1998) estimate of conditional daily return volatility that uses intraday data. The five-year sample variance is a smooth function of the past one-year variance. 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 bias is not severe.

may not be directly proportional to each other, since the sample 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 in our sample use accounting-based performance measures, instead of stock returns, as performance metrics in their incentive contracts (see also Bettis et al. 2018).

Sample variance of pay 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 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 is uncertain, we note that assuming time-invariant contract parameters is common in empirical models of CEO pay that rely on panel data regressions.[21] Another disadvantage of using sample variance of pay, relative to using simulated variance of pay, is that TDC1 uses the fair value of options and time-vested restricted shares grants. This implies that two CEOs, one receiving only $1 million annually in salary and another receiving only $1 million annually of time-vested options, will display zero sample variance of pay when in fact the riskiness of their contracts differs, likely downward biasing any estimate of the sensitivity of pay to the variance of pay.

Table 7 repeats the same regressions as in Table 3 but uses the sample variance of pay as the measure of the conditional volatility of pay. 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 sample variance of pay are positive and significant at 1 percent. Analyzing the results from column 3, the sensitivity of pay to variance of

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

pay is 0.028, half the size of that in Table 3. This sensitivity translates into a pay premium of 7.4 percent of pay (untabulated), about half of the pay premium estimated using the Incentive Lab data and the simulated variance of pay. The statistical significance associated with the remaining control variables does not change significantly, with the exception of skewness: a one standard deviation increase in skewness in pay is associated with a drop in pay of 2 percent.

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 it does in Table 3. The coefficients on bonus variance and RSU variance are statistically significant, even after we add the remaining control variables. The pay premium associated with bonus grants is 5.1 percent, and that associated with stock grants is 4 percent, somewhat lower than those estimated using the Incentive Lab data and the simulated variance of pay, especially for stock grants (untabulated).

Overall, we confirm our main findings of a positive but low pay premium from pay at risk.

Variance of pay estimated using an ARCH model

Our third approach to estimating the variance of pay uses the autoregressive conditional heteroskedasticity (ARCH) model. The ARCH model has the advantage over the sample variance of pay approach of not requiring the assumption of time invariant contract parameters, though the ARCH model requires an assumption of stationarity of the variance of pay. To the best of our knowledge, this is the first paper estimating an ARCH model for CEO pay. The ARCH-in-mean model estimates Equation (1) for total pay jointly with an equation for the variance of pay, σ_t^2,

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

with the parameters α, $\delta_j \geq 0$, and $j = 1, \dots, p$ indexes the number of ARCH terms.

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 nonnegativity constraints on the variance-equation parameters, α, $\delta_j \geq 0$. In addition to the nonnegativity of the parameters, the ARCH approach does require that the variance of pay be stationary; that is, $\delta_1 + ... + \delta_p < 1$. 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 cannot 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, 6, 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 the variance of pay is positive and statistically significant at 1 percent across all specifications. In Column 3, the coefficient is 137.4, which dividing by the mean of TDC1 of $4,680 (the unit of TDC1 is thousands) gives an elasticity of 2.9 percent. This estimate is remarkably similar to the effect using the sample variance of pay 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 includes sample skewness as a determinant of pay, and shows that its estimated coefficient is negative but not statistically significant.

VII. ADDITIONAL TESTS

Alternative sample from Incentive Lab

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 firm-year observations where we lack complete contract information for the CEO in a given year. For example, we may have bonus contract details but not restricted stock details, even though we observed in ExecuComp that the CEO received both restricted stock and a bonus payment that year.[22] In this case, the firm-year observations are obtained after simulating only the grants for which we have complete contract data. Sample details on metric and grant-level information can be found in the Online Appendix. The results (untabulated) from this larger sample produce statistically significant but lower magnitudes of the estimated coefficients, perhaps because of the associated measurement noise.

Pay premium and CEO turnover

Agency 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 pay premium falls below expectations, voluntary turnover among CEOs should increase. One challenge in implementing this test is that the CEO-specific participation constraint is unobservable, impeding measurement of whether the pay is too low to meet the 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.

[22] 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 nonprice measure for all awards, allowing them to obtain a larger sample.

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 either just met or being violated, increasing the probability of leaving the firm for another opportunity.

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 these opportunities. Thus, a CEO who is less marketable or has limited labor market opportunities, say due to age or poor performance, 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 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 other firms. These constitute a sample of CEOs with comparable outside 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 after the turnover. We merge this turnover sample with that of Gentry et al. (2021) to increase the sample size. 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 nonswitching 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 percent of our main sample (13 percent for both the alternative sample and the Core and Packard sample). Because we only have full-year CEOs, *switchfirm* is activated only the year prior to leaving the firm. The control group to a departing CEO is composed of other CEOs of similar age, tenure, and firm size, before they depart. This sample captures the group of CEOs for whom a low pay 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 switching firms.

In Table 9, we present results from regressing CEO turnover on *Deviation* using two different samples: the larger alternative sample (Column 1), and the largest sample using the Core and Packard simulation (Column 2). We find the predicted negative relation at significance levels of 10 percent (one-tailed or better).[23] 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 participation constraint being more likely violated for these CEOs at that time.

In sum, this analysis provides evidence that a pay risk premium that fails to meet the participation constraint is associated with a greater probability of turnover among CEOs with a high reservation utility.

Volatility from CEO wealth

Jensen and Murphy (1990) and Hall and Liebman (1998) suggest 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 account for only a fraction of the incentive risk faced by the typical CEO (e.g., Core and Guay 2002; Armstrong et al. 2015). In untabulated results, we test whether 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 of Coles et al. (2006). Regardless of whether we include the variance of total pay in the regression or not, we find that

[23] Using our main sample and our main sample with RPE grants, we find a negative relation. However, the relation is not significant likely due to the low number (only 55) of observations.

the volatility of CEO inside wealth is not a significant contributor to the pay premium. However, this conclusion should be interpreted with the caveat that our test may be of low power. Importantly, the coefficient associated with the variance of pay continues to remain low and significant.

VIII. CONCLUSION

We estimate the ex ante premium in CEO incentive pay in the U.S.. First, we simulate payouts on bonus, stock, and option grants using detailed contract data from Incentive Lab to construct a simulation-based measure of the variance of CEO pay for every CEO-year in the sample and show that the estimated premium is 13.5 percent. We show that the premium associated with the variance in pay increases with proxies for risk aversion. Using a structural model, we derive an implied risk aversion coefficient equal to 1.10. The relatively small estimate of the risk aversion coefficient aligns with the findings of Murphy and Jensen (2018), which suggest that the growth in incentive pay in the U.S. is largely unrelated to economic incentives and risk and reward arguments. It is also consistent with Edmans et al. (2023), which documents that risk diversification is not a major concern for CEOs. The low implied risk aversion in our study suggests the possibility that CEO risk aversion coefficients are lower than previously assumed and that further research is needed along this line.

Second, we explore alternative ways to estimate the pay premium to validate our simulation results. We simulate the variance of pay using the Core and Packard (2022) approach, which replaces missing values with industry peers' sample averages. We also estimate the variance of total pay using the variance of past CEO pay and we use a variant of the ARCH model to jointly estimate the mean of total pay and the volatility of pay. We obtain consistent results using these different methods.

Bizjak et al. (2022) state that compensation consultants often use simulations when presenting the valuation of the awards to the board of directors. Whether boards and CEOs emphasize the pay risk that results from those simulations when setting compensation plans is an open question for future research. Our approach, however, provides consultants, boards, and academics with a way to combine all of the effects from pay at risk in a single metric—the variance of total pay—and a benchmark to evaluate how much more pay is needed when greater incentives are offered to the CEO—the pay premium. As firms have numerous levers at their disposal— different metrics, targets and payout schemes, and discretionary bonuses or ex-post adjustments to performance metrics —it would be interesting for future research to explore which of these is used to more effectively manage pay risk while still motivating the CEO. Other examples of open questions for future research are: How do contract terms evolve within a firm, across industries, or within a specific CEO/firm pair? Do they adjust to changes in performance metrics volatility? We believe that by highlighting the significance of variance of pay as an important aspect of compensation packages—beyond the predominantly examined pay mean—our findings can generate interesting avenues for future research.

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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 from incentive pay. 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

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

where $\overline{U}$ 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 $\bar{u} = \ln(\overline{U})$. w_t is the total pay realization through period t and E_t is the expectation using information available at the beginning of period t, when contracts are written.

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). 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. The vector X_t and the slopes β capture the drivers of the cost of effort and of outside opportunities.

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.

APPENDIX B
Details of the simulation exercise using Incentive Lab data

This appendix details the simulation exercise using Incentive Lab data, where expected pay and pay variance for the current year are simulated based on information available at the beginning of the year. Time-vested grants do not require CEOs to meet performance targets; only their valuation is linked to firm performance through stock price. In contrast, performance-vested grants require CEOs to meet performance targets before earning them, and their valuation is additionally tied to firm performance reflected in the stock price. For time-vested incentive pay, we simulate stock prices and multiplying simulated prices by the number of RSU or options granted to determine the expected dollar value of the RSU or options. For performance-vested incentive pay, we simulate expected firm performance, which we fit to predetermined compensation contracts to estimate the amount of bonus or the number of RSU or options granted.

We use two inputs for performance-vested incentive pay simulation: compensation contract details from Incentive Lab and past five years' actual performance from Compustat, whose variance is utilized for simulating the current year's performance. Compensation contracts are obtained from Incentive Lab, which include the chosen performance metrics, the threshold, target, and maximum levels of performance, and corresponding compensation levels.[24]

In cases where actual firm performance is below the contract-specified threshold, the CEO receives no performance-based compensation. If actual performance meets the target, the CEO earns the target compensation; meeting or exceeding the maximum performance leads to the maximum compensation. When actual performance falls between the threshold and maximum, the CEO's incentive compensation is interpolated between the threshold and maximum level of incentive compensation based on actual performance.[25] For firms with non-missing contract details (threshold, target, maximum for performance metric and compensation), we fit contracts with a piece-wise linear (two linear slopes) interpolation (we use a quadratic specification in a robustness test). We exclude firm-year observations lacking threshold or maximum values from our main sample due to inability to estimating contracts under these circumstances.

We implement the contract estimations in four steps. In the first step, we create a sample of compensation contracts for bonus, RSU, and option grants for CEOs that include all performance-vested grants using absolute performance metrics and time-vested grants. We exclude grants using relative performance metrics from our main sample for tractability. In the main paper, we supplement our main sample by including grants with relative performance metrics using Core and Packard (2022)'s approach for simulating incentive grants with relative performance metrics. In the second step, we categorize each firm-year into seven groups based on contract types: bonus only, RSU only, options only, both bonus and RSU, both bonus and options, both RSU and options, and all three types of bonus, RSU, and options. This categorization ensures simultaneous

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[24] We simplify our simulation by considering only the current year for performance metrics realization (i.e., with 'periodid' equal to 1). This simplication impacts 10 percent of the main sample that uses multi-year performance metrics. While the simplification may introduce measurement error, it is unlikely to significantly affect the sensitivity of pay to variance of pay. Regression results, including an indicator for multi-year performance metrics, remain unchanged.

[25] We assume interpolation for all compensation contracts to avoid adding further complication to the simulation exercise. The field 'interpolation' in Incentive Lab can take one of three values, 'Y' for yes, 'N' for no, and 'NC' for not clear. The distribution (in percents) across all firms and grants is, 21 'Y', 3 'N', 67 'NC', and the remaining 9 percent is missing. Regression results, including an indicator for interpolated pay, remain unchanged.

simulation of all performance metrics used in all grants for the same CEO-year.[26] In the third step, we identify the performance metrics used in each contract from Incentive Lab variables including metric name, whether the chosen metric is scaled by common stocks or sales, measured as growth rate, and additional textual information. We consider various combinations of these indicators and text to determine the specific performance metric used by the firm. In the fourth step, for firms with non-missing contract details, we fit contracts using a linear interpolation across threshold, target, and maximum of performance level and compensation level.

Performance Simulation: Using actual performance from the past five years in Compustat, we simulate current year performance. Incentive Lab contract details are at the firm-year-grant-metric level, allowing for multiple metrics and multiple grants for a CEO in a year. Simultaneously considering all metrics for a CEO-year, we assume a multivariate normal distribution. The mean is set to the previous year's actual values, and the covariance matrix is derived from the past five years' actual performance metrics. With these assumptions, we generate 10,000 paths for each firm-year-grant-metric to estimate simulated compensation. In our primary analysis, we standardize dollar-based performance metrics to ensure comparability with other scaled metrics (i.e., metrics expressed as a rate or ratio such as growth rate, margin, per share value, ROA, etc.). For unscaled sales metric, we simulate sales growth rate for deriving simulated sales (simulated $\text{sales}_t = \text{sales}_{t-1} \times (1+\text{simulated sales growth rate}_t)$). For metrics with potential negative values (e.g., operating income, profits before tax, net income, cash flow, etc.,), we simulate the metric scaled by lagged total assets for deriving the simulated metric value (simulated performance metric_t = total assets_{t-1} × simulated scaled performance metric_t).[27] We simulate the level of EPS, not its growth, based on Ball and Bartov's (1996) recommendation for annual data and then backout EPS using past levels. Because stock prices are not stationary time series, we simulate price (adjusted for stock splits) to lagged sales ratio for deriving simulated stock price (simulated $\text{price}_t = \text{sales}_{t-1}$ × simulated price to lagged sales ratio_t). For CEOs with restricted stock or option grants, the covariance matrix incorporates the price-to-lagged sales ratio alongside actual performance metrics used in the compensation contracts.[28]

Compensation Simulation: Simulating compensation involves fitting the simulated performance to estimated contracts at the firm-year grant-metric level. After calculating metric-level simulated compensation, we aggregate it to the grant level using "performanceGrouping" information. Contracts fall into two types: (i) separable, where partial compensation is possible if not all metrics are met, and (ii) non-separable, where any unmet metric results in zero compensation. In separable contracts, each metric is assumed to have equal weight, and total simulated pay at the grant level is the sum of weighted metric-level pay. For CEOs with multiple grants, we aggregate pay from all grants. Non-separable contracts impose an additional condition: if any metric fails to meet the goal threshold, the grant-level simulated pay is zero. With 10,000 simulated pay paths at the firm-year level, we compute mean, variance, and skewness for each firm-year. To align simulated flow pay with TDC1, expected flow pay includes salary, mean simulated pay, other compensation, and non-performance-based bonus.

[26] To construct our main sample, we follow specific procedures for each group. For example, the "bonus only" group consists of firms with only bonus contracts in Incentive Lab and only bonus payment in ExecuComp, i.e., firms with only bonus contracts in Incentive Lab but RSU or option payment in addition to bonus payment in ExecuComp are excluded from this group. We repeat similar exclusions for other groups to ensure a comprehensive and reliable sample for analysis. We lift this exclusion for constructing a larger alternative sample in robustness check.

[27] In a robustness check, we directly simulate dollar amounts without scaling. Results remain consistent.

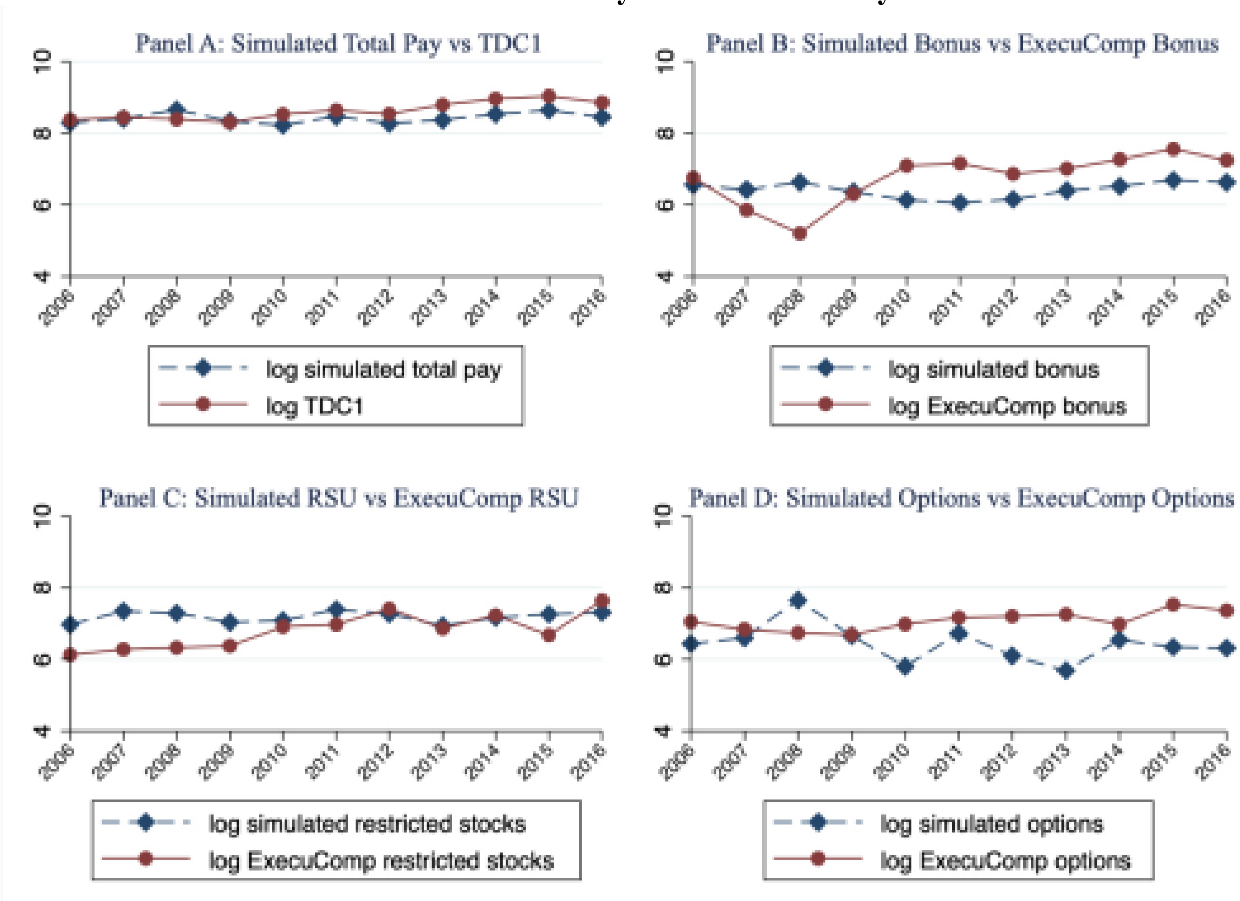
[28] To simulate the value of option grants, we estimate the volatility of stock returns using the last five years of monthly data and cap volatility by the average volatility across all simulation years.

APPENDIX C
Variable Definitions

Total Pay	Total annual flow compensation for the CEO (TDC1) from ExecuComp. This variable is presented in millions of U.S. dollars in Table 2.
Log of TDC1	The natural logarithm of total flow 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).
Return Volatility	The standard deviation of firm level monthly stock returns calculated using the last 38 months.
Earnings Volatility	The standard deviation of the firm's 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).
MTB	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.
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 Sample Variance of Pay	The natural logarithm of the variance of CEO flow pay (TDC1) calculated over the last 5 years.
Log of Sample 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 Sample 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 Sample 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 OP TION_AWARDS_BLK_VALUE prior to 2006, and OPTION_AWARDS_FV from 2006 onwards.
Log of Sample 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.
Sample Skewness of CEO Pay	Skewness of CEO flow pay (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.
Bonus miss	Indicator variable equal to one for missing values of simulated bonus for firms not granting bonus to the CEOs in the current year; zero otherwise.
RSU miss	Indicator variable equal to one for missing values of simulated restricted stock grants for firms not granting RSU to the CEOs in the current year; zero otherwise.
Options miss	Indicator variable equal to one for missing values of simulated options for firms not granting options to the CEOs in the current year; zero otherwise.

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.

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	1.00	1.00	1.00	1.00
Mean	1.57	1.07	1.00	1.15
Std. Dev.	0.71	0.27	0.03	0.43
Skewness	1.18	3.98	28.71	3.24
Max	4.00	3.00	2.00	4.00
Number of grants per CEO/year				
Min	1.00	1.00	1.00	1.00
Mean	1.11	1.35	1.24	2.57
Std. Dev.	0.38	1.00	1.23	1.61
Skewness	4.52	6.81	7.67	3.00
Max	4.00	13.00	12.00	13.00

TABLE 2

Descriptive Statistics

N is the number of observations, and *Px* 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 flow compensation (TDC1; main sample)	939	6,750	5,427	3,282	5,384	8,489
Total flow 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
Return volatility	32,308	0.11	0.06	0.07	0.10	0.14
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 (Co-opt)	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 the variance of simulated 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)	(8)
Log variance of	0.179***	0.072***	0.052***	0.059***				
simulated pay	(10.42)	(4.59)	(4.18)	(4.57)				
Log variance of					0.013	0.019**	0.012	0.012
simulated bonus					(1.07)	(2.26)	(1.34)	(1.26)
Log variance of					0.086***	0.021*	0.037***	0.039***
simulated RSU					(4.24)	(2.01)	(3.28)	(3.31)
Log variance of					0.061***	0.016	0.002	0.004
simulated options					(4.83)	(1.61)	(0.26)	(0.46)
Bonus miss					-0.170	0.091	-0.091	-0.081
					(-1.17)	(0.66)	(-0.79)	(-0.65)
RSU miss					0.625**	-0.050	0.098	0.116
					(2.40)	(-0.31)	(0.78)	(0.91)
Options miss					0.513**	-0.083	-0.241	-0.219
					(2.54)	(-0.58)	(-1.58)	(-1.41)
Skewness of			-0.021	-0.014			-0.029	-0.025
simulated pay			(-0.88)	(-0.58)			(-1.55)	(-1.35)
RET			0.245**	0.338***			0.200**	0.268**
			(2.47)	(3.30)			(2.24)	(2.87)
Lag RET			0.089	0.142**			0.072	0.107*
			(1.63)	(2.54)			(1.44)	(2.05)
ROA			0.735	0.705			0.695*	0.660*
			(1.62)	(1.60)			(1.95)	(1.85)
Lag ROA			0.100	0.235			0.166	0.229
			(0.32)	(0.68)			(0.57)	(0.70)
Return volatility				-1.398**				-0.829**
				(-3.07)				(-2.47)
Earnings				0.438				0.376

volatility				(0.64)				(0.49)
Log lag market			0.217**	0.227**			0.212**	0.224**
value			(2.46)	(2.42)			(2.56)	(2.39)
MTB			-0.022	-0.054			-0.004	-0.022
			(-0.60)	(-1.26)			(-0.11)	(-0.54)
Leverage			0.334	0.553			0.212	0.361
			(0.83)	(1.61)			(0.56)	(1.08)
Co-opt			0.075	0.086			0.083	0.085
			(0.36)	(0.41)			(0.49)	(0.48)
Co-opt miss			-0.062	0.005			-0.151	-0.112
			(-0.32)	(0.03)			(-0.90)	(-0.68)
Institutional			0.142	0.132			0.143	0.150
holding %			(0.61)	(0.58)			(0.62)	(0.65)
Founder			-0.171	-0.187			-0.242**	-0.246**
			(-1.38)	(-1.55)			(-2.66)	(-2.73)
Age			0.006	0.005			0.003	0.002
			(0.51)	(0.46)			(0.26)	(0.23)
Log CEO			0.051	0.036			0.084	0.077
tenure			(0.51)	(0.37)			(1.10)	(1.02)
Overconfidence			-0.004	0.004			-0.006	-0.003
			(-0.06)	(0.06)			(-0.13)	(-0.05)
Log disclosed			0.127*	0.131*			0.108*	0.111*
peer pay			(2.12)	(1.99)			(1.94)	(1.89)
Intercept	5.954***	7.499***	4.177***	4.102***	6.810***	8.016***	4.864***	4.743***
	(22.96)	(33.45)	(3.72)	(3.29)	(32.87)	(42.03)	(4.43)	(3.85)
Observations	939	769	569	569	939	769	569	569
Adj. R-squared	0.322	0.805	0.794	0.798	0.253	0.799	0.809	0.810
Firm + Year FE	NO	YES	YES	YES	NO	YES	YES	YES
Cluster s.e.	Firm/Year	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 columns 3 and 7. Dollar values are in thousands.

Economic Impact for Estimates in Table 3 - Main Sample Volatility of Simulated Pay

	Coef.	Std. of log volatility	Increase in pay	Mean pay	Median pay	Change in mean pay	Change in median pay
Log volatility of simulated pay	0.052	2.60	13.5%	$ 6,749	$ 5,384	$ 912	$ 728
Log volatility of simulated bonus	0.012	6.30	7.6%	$ 6,749	$ 5,384	$ 510	$ 407
Log volatility of simulated RSU	0.037	5.40	20.0%	$ 6,749	$ 5,384	$ 1,348	$ 1,076
Log volatility of simulated options	0.002	6.58	1.3%	$ 6,749	$ 5,384	$ 89	$ 71

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 simulated pay is estimated from the simulation exercise using the Incentive Lab compensation contract information. Proxies for CEO risk aversion are: female (Column 1); over-confidence (Column 2); long tenure (Column 3); medium fatality (Column 4); and high wealth (Column 5). 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 *, respectively.

	Log of TDC1				
	Female CEO	Overconfident CEO	Longer Tenure	Medium Fatality	High Wealth
	(1)	(2)	(3)	(4)	(5)
Log variance of simulated pay	0.048***	0.075***	0.084***	-0.006	0.066***
	(4.11)	(3.51)	(4.06)	(-0.24)	(3.73)
Subgroup indicator	-3.692***	0.629*	0.856**	-0.145	0.535
	(-5.03)	(1.91)	(2.87)	(-0.23)	(1.83)
Log variance of simulated pay×Subgroup Indicator	**0.188*** **	**-0.045***	**-0.058*** **	**0.082*** **	**-0.039***
	(4.05)	(-1.94)	(-2.80)	(2.41)	(-1.93)
Testing log variance of simulated pay + log variance of simulated pay×subgroup indicator = 0					
t-statistic	5.94	3.08	2.51	3.40	2.12
p-value	0.000	0.012	0.031	0.007	0.067
Observations	569	569	569	154	449
Adj. R-squared	0.801	0.798	0.801	0.831	0.787
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

Panel A presents results from regressions of the natural log of TDC1 on the variance of simulated pay, where variance of simulated pay is estimated using the Core and Packard (2022) approach for all incentive grants (the Core and Packard approach for grants with relative performance metrics and our approach for grants with absolute performance metrics) in columns 1—4 (columns 5—7). All columns, except for columns 1 and 5, 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. Panel B presents the economic significance of the estimated sensitivity of pay to variance of pay from Panel A columns 3 and 4. Dollar values are in thousands.

Panel A. Sensitivity of Pay to Variance of Pay Using Core and Packard Approach

	log of TDC1						
	Replication Sample				Main Sample with RPE		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log variance of simulated pay	0.141***	0.057***	0.041***		0.179***	0.068***	0.056***
	(16.95)	(9.54)	(7.67)		(10.54)	(5.10)	(4.54)
Log variance of simulated bonus				0.005**			
				(2.51)			
Log variance of simulated RSU				0.031***			
				(7.20)			
Log variance of simulated options				0.068***			
				(7.91)			
Bonus miss				0.053			
				(1.12)			
RSU miss				0.106*			
				(1.87)			
Options miss				0.807***			
				(7.17)			
Skewness of simulated pay			-0.005***	-0.003***			0.008
			(-5.01)	(-4.25)			(0.39)
Intercept	6.365***	7.760***	5.009***	4.333***	5.905***	7.538***	4.255***
	(41.02)	(77.11)	(19.42)	(15.01)	(23.02)	(38.81)	(4.06)
Controls	YES	YES	YES	YES	YES	YES	YES
Observations	8,319	8,248	6,201	6,201	939	769	569
Adj. R-squared	0.262	0.752	0.782	0.805	0.348	0.804	0.800
Firm + Year FE	NO	YES	YES	YES	NO	YES	YES
Cluster s.e.	Firm/Year	Firm/Year	Firm/Year	Firm/Year	Firm/Year	Firm/Year	Firm/Year

Panel B. Economic Impact for Estimates in Panel A - Replication Sample Volatility of Simulated Pay

	Coef.	Std. of log volatility	Increase in pay	Mean pay	Median pay	Change in mean pay	Change in median pay
Log volatility of simulated pay	0.041	2.83	11.6%	$ 7,998	$ 6,415	$ 928	$ 744
Log volatility of simulated bonus	0.005	5.99	3.0%	$ 7,998	$ 6,415	$ 240	$ 192
Log volatility of simulated RSU	0.031	6.26	19.4%	$ 7,998	$ 6,415	$ 1,552	$ 1,245
Log volatility of simulated options	0.068	7.24	49.2%	$ 7,998	$ 6,415	$ 3,938	$ 3,158

TABLE 7

The Sensitivity of Pay to Variance of Pay Using Sample Variance of Pay

This table presents results from regressions of the natural log of TDC1 on the volatility of sample pay. The measures of variance of sample 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 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)
Lag log sample variance of pay	0.246***	0.046***	0.028***			
	(36.89)	(6.28)	(3.63)			
Lag log sample variance of bonus paid				0.015***	0.005***	0.004***
				(9.93)	(9.73)	(4.49)
Lag log sample variance of RSU paid				0.018***	0.004***	0.003***
				(12.88)	(6.65)	(3.71)
Lag log sample variance of options paid				0.013***	0.002***	0.001
				(8.75)	(3.83)	(1.09)
Lag sample skewness of pay			-0.041***			-0.023*
			(-3.23)			(-1.85)
Intercept	4.789***	7.541***	5.237***	7.337***	7.788***	5.395***
	(48.06)	(76.05)	(19.60)	(147.23)	(1009.38)	(20.35)
Controls	YES	YES	YES	YES	YES	YES
Observations	16,769	16,522	12,177	37,322	37,177	12,177
Adj. R-squared	0.405	0.760	0.796	0.194	0.693	0.796
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 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.

VARIABLES	(1) TDC1	(2) TDC1	(3) TDC1
Lag log var(TDC1)	128.023***	149.996***	132.557***
	(12.02)	(12.41)	(7.40)
Lag sample skewness			-40.179
			(-1.09)
Constant	-86.998	-2242.261***	-14822.520***
	(-0.52)	(-3.39)	(-28.16)
Controls	NO	NO	YES
Industry and Year FE	NO	YES	YES
ARCH(1) coefficient	2.157***	2.417***	1.732***
	(22.33)	(20.10)	(14.11)
ARCH constant	2.572***	2.372***	2.310***
(in millions)	(18.67)	(16.26)	(13.06)
Observations	37,322	37,322	12,434

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 variance of simulated 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% is indicated by ***, **, and *, respectively, for two-sided tests, and for one-sided test at 5% is indicated by ##.

		Switchfirm	
VARIABLES	Predicted Sign	Alternative Sample (1)	Replication Sample (2)
Deviation	–	-0.034##	-0.033*
		(-1.67)	(-1.88)
Lag indadjret		-0.054	-0.040
		(-1.12)	(-1.22)
Lag indadjroa		0.046	0.098
		(0.22)	(0.47)
Skewness of simulated pay		-0.002	-0.000
		(-0.62)	(-0.25)
Log lag market value		-0.021**	-0.023**
		(-2.46)	(-2.47)
Lag MTB		0.033*	0.036*
		(1.98)	(1.94)
Lag leverage		0.051	0.048
		(0.70)	(0.73)
Founder		-0.091	-0.046
		(-1.75)	(-1.57)
Age		-0.007**	-0.008**
		(-2.46)	(-2.85)
Log CEO tenure		-0.003	-0.002
		(-1.20)	(-0.92)
Intercept		0.677***	0.713***
		(3.63)	(4.45)
Observations		691	876
Adj. R-squared		0.065	0.070
Industry + Year FE		YES	YES
Cluster s.e.		Firm/Year	Firm/Year

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