Are CEOs paid extra for riskier pay packages?

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This paper quantifies the cost of CEO incentive compensation by estimating an elasticity of pay to the variance of pay. Using US CEO compensation data and a variety of empirical approaches, we find that CEOs with riskier pay packages are paid more. However, increasing incentives by 20% is associated with an increase in expected pay of only 2%, on average. This small elasticity suggests that incentive pay is not too costly for firms as these seem to be able to substitute incentive pay for salary. In the context of a theorical model, we show that the small elasticity implies a low risk aversion coefficient for CEOs.

Keywords: CEO pay, incentives, Incentive Lab, realized variance, ARCH, contract theory, moral hazard, participation constraint, risk aversion.

JEL Classifications: D81, G30, J33, M52

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This paper quantifies the cost of CEO incentive compensation by estimating an elasticity of pay to the variance of pay. Using US CEO compensation data and a variety of empirical approaches, we find that CEOs with riskier pay packages are paid more. However, increasing incentives by 20% is associated with an increase in expected pay of only 2%, on average. This small elasticity suggests that incentive pay is not too costly for firms as these seem to be able to substitute incentive pay for salary. In the context of a theorical model, we show that the small elasticity implies a low risk aversion coefficient for CEOs.

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1. Introduction

The last thirty years have seen an expansion of CEO pay in the US that has led to much debate.[1] This expansion has come mostly via an increase in incentive pay components as opposed to fixed pay (e.g., Conyon, 2006, and Jensen and Murphy, 2018). Core and Guay (2010) argue that assessing the level of incentive pay in CEO compensation as too high or too low requires understanding the optimality of the given level of pay-performance incentives. Past studies have documented potential benefits and costs of incentive pay as they relate for example to manager-shareholder conflicts (e.g., Hadlock, 1998), risk-taking (Coles et al., 2006; Hayes et al. 2012), short-termism behavior (Bebchuk and Fried, 2006), earnings management (Bennett et al., 2017), and accounting fraud (Erickson et al., 2006). We contribute to this literature by quantifying the costs of incentive pay in the form of the increased direct compensation that risk-averse CEOs require for bearing extra incentive-pay risk.

We measure the costs of incentive pay by estimating, in the form of an elasticity, how much more firms have to compensate their CEOs when they offer them riskier compensation packages. Using this elasticity as a measure of the costs of incentive pay is anchored in the principal-agent moral hazard model (e.g., Holmstrom, 1979, Mirrlees, 1976, and Shavell, 1979). A fundamental hypothesis in this model is that risk averse CEOs require extra pay for riskier pay packages.[2] Incentive pay helps risk neutral shareholders reduce principal-agent conflicts with the CEO at the cost of the additional pay needed to compensate CEOs for the risk that incentive pay imposes on them.

While the elasticity is a simple estimate of the cost, we believe it is an important benchmark to consider as it is borne of the work-horse model of much of the empirical studies in executive compensation.[3] In the standard moral hazard model, a feasible contract between a principal and an

[1] The Economist (2020) provides yet again another article that questions the growth in executive pay in the US and the extent to which CEO pay is tied to performance.

[2] Conyon, Core and Guay (2011) call this hypothesis the "central tenet of agency theory and contracting" (p. 404). We discuss below how our paper relates to Conyon, Core and Guay (2011) and Fernandes, Ferreira, Matos, and Murphy (2013). We also discuss below why the trade-off between pay and pay risk is broader than the [or "trade-off between firm risk and incentive pay] question about how firm risk is linked to incentive pay.

[3] A parallel to this relation exists in some asset pricing models where expected returns are related to the variance of returns times risk aversion. Just as in the asset pricing literature, the trade-off between mean pay and variance of pay is not a causal relation because both variables are determined in equilibrium in the agency model. Rather, it defines a structural relation between the two variables: any shock to one of the variables must be met with a shock to the other that preserves their structural relation. The elasticity of pay to variance of pay gives this structural relation.

agent prescribes an action by the agent and a payment from the principal which, among other things, must respect the agent's participation constraint. According to this constraint, the agent's expected utility under the contract equals the agent's utility under an alternative opportunity (Grossman and Hart, 1983, prove that the participation constraint binds under general conditions). Up to a second order approximation of the utility function, the participation constraint implies a positive association between the conditional mean pay and the conditional variance of pay, the magnitude of which depends on the agent's risk aversion. Hence, under the null of the standard moral hazard model, changes in regulation and taxation, or any other change unrelated to risk aversion should not affect the measured elasticity.[4]

We use three empirical approaches to estimate the elasticity of pay to the variance of pay. The first approach uses Incentive Lab's detailed contract information on the relation between performance metrics and performance-based compensation (i.e., cash bonus, equity, and options grants) in actual CEO contracts. The main advantage of these rich data is that we can evaluate simultaneously, through a simulation exercise, the beginning-of-the-year expected value and variance of the CEO's end-of-year pay. We are therefore able to explicitly consider the underlying sources of the riskiness of CEO pay packages. Consider, for example, the simplest contract that includes salary plus a cash bonus grant. The bonus grant may have a threshold payout of 100% of base salary, a target payout of 200% of base salary, and a maximum payout of 400% of base salary. The contract defines a metric, say net sales, and performance levels that determine threshold, target, and maximum payouts. By simulating the performance metric, we are able to construct mean and variance of total pay.[5]

To peek into the full complexity of this simulation exercise note that CEO contracts may grant bonus, stock, and options in any given year, and multiple grants of each kind are possible, where multiple performance metrics may be specified across grants and even in the same grant. In addition, the performance metrics may or may not all have to be met to yield a payout. Finally,

[4] This risk-based constraint on incentive provision is born out of the participation constraint and requires only information about the agent's expected utility. Other model predictions, including the much-studied sensitivity of incentive pay to stock return volatility that we discuss below, not only rely on the participation constraint but also on other assumptions including the production function, the number of performance metrics used to incentivize the agent, and the principal's objective function.

[5] Bizjak, Kalpathy, Li, and Young (2018) state that compensation consultants often use simulations when presenting the valuation of the awards to the board of directors. So, it is conceivable that compensation committees at the beginning of the year use a similar approach to evaluate whether enough pay is being offered on average to the CEO to compensate for the risk in her compensation package.

these characteristics may change over time even for the same firm-CEO pair. In our regressions, we find a positive and statistically significant elasticity of conditional mean of pay to conditional variance of pay.

The second approach models the conditional variance of pay with realized variance of past CEO pay in the spirit of Schwert (1989) and Andersen and Bollerslev (1998). Using realized variance has the benefit that we can use the universe of ExecuComp firms, increasing the sample size considerably in both cross section and time series. However, it comes at the cost of having to assume that contract parameters are time invariant for each CEO, an assumption that is nonetheless standard in panel data studies estimating pay-for-performance parameters. The results using realized variance of total CEO pay are broadly consistent with the results using Incentive Lab data that explicitly deal with time variation in contract parameters.

The third approach uses a variant of Engle's (1982) autoregressive conditional heteroskedasticity (ARCH) model to jointly estimate the mean of pay and the volatility of pay.[6] The ARCH model estimates an equation for the level of pay and another equation for the volatility of pay. This simultaneous determination of mean and variance of pay is consistent with the theory and constitutes an advantage over the realized volatility approach. By estimating the model in the full panel of ExecuComp firms, we minimize the limitation of this approach of requiring a large time series of data. We use an ARCH-in-mean model where the conditional volatility of pay enters the equation of mean pay. This approach too generates results that are broadly consistent with the results using Incentive Lab data.

Across the three approaches, we find estimates of elasticity of average pay to variance of pay around 0.05. This estimate implies coefficients of risk aversion around one, arguably a low value. To understand the economic significance of this elasticity, we conduct a back-of-the envelope calculation in which we ask how much more pay is needed on average if the firm wishes to increase incentives. An increase in incentives by 20% is expected to increase mean pay by 2%. Consequently, we show that if the mean pay increases by only 2% when the incentive component of pay increases by 20%, then it must be the case that salary (non-incentive component of pay)

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[6] 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 time series behavior 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, Engle, and Wooldridge (1988). The last two papers, like ours, model the conditional mean of the dependent variable as a function of its conditional variance.

decreases. We conclude that incentive pay does not appear too costly for firms as these seem able to substitute incentive pay for salary.[7]

We study several reasons for this small elasticity. First, we consider the possibility that risk aversion varies in the cross section. Haubrich (1994) calibrates the agency model and shows that equity incentives increase sharply as CEO risk aversion decreases. This suggests that a low estimated elasticity could be due to the presence of a few CEOs with really low risk aversion. Using several proxies for risk aversion from the literature, we find no significant evidence that higher risk aversion is associated with a higher elasticity as predicted. Our evidence is consistent with Murphy and Vance (2019) who also do not find that diversification is the reason for the early exercise of options by CEOs.

Second, we consider a wide array of factors that may affect the relation between mean pay and variance of pay: CEO's outside market opportunities Oyer (2004); CEO preference for positively skewed payouts (Hemmer, Kim and Verrecchia, 2000, Ross, 2004, and Chaigneau, 2015); CEO overconfidence (Malmendier and Tate, 2005 and 2008); CEO power (Bebchuk and Fried, 2003); and shocks to the CEO's marginal disutility of effort (Laffont and Martimort, 2002). We find that these characteristics do not significantly affect our finding of a low elasticity of mean to volatility of pay.

Third, an interpretation for our finding is that CEOs appear to be saturated with incentives. While Conyon (2006) suggests that in the 1990s growth in pay accompanies growth in incentive pay as predicted by the agency model, 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. Instead, Murphy and Jensen (2018) point to the deductibility rules of Section 162(m) of the IRS code (see also Rose and Wolfram, 2002), which have kept salaries capped at around $1 million for CEOs and restricted growth in pay to occur solely through incentive pay.[8]

Our evidence suggests that while there is a link between the level of incentive pay (and volatility in pay) and mean pay, the economic magnitude of this link appears too low to be

[7] Dittmann and Maug (2007) assume that risk in pay comes only from stock and options. In calibrated versions of their model, they find that many firms would benefit from increasing incentive pay to their CEOs. We do not discuss the optimality of incentive pay since we are only measuring the costs of incentives.

[8] According to Rose and Wolfram (2002), Section 162(m) of the IRS Code appears to have kept CEO salaries capped at around $1 million over the last two decades causing the growth in pay to come from incentive pay, which was the component of pay not affected by the Section. As a result, the tax code may have created an inefficiency in pay by overexposing CEOs to risk for which they were not compensated.

explained by risk diversification. In this way, our evidence is complementary to Fernandes et al. (2013), Murphy and Vance (2019), and Murphy and Sandino (2020) who all argue that risk sharing cannot fully explain the level of incentives observed in the U.S. Conyon et al. (2011) and Fernandes et al. (2013) are the first to provide a direct test of the prediction that the provision of incentives is expensive. Our test differs from theirs in several respects. First, we simulate bonus, restricted stock and options grants, and, from the simulation, calculate the estimated variance of pay. Their estimate of a risk premium from incentives excludes volatility in pay from bonus grants, which is an important component of pay at risk for CEOs accounting for approximately 20-25% of pay. Second, they do not use the wealth of detailed contractual data that we have, which forces them to make assumptions that we do not require. To estimate the risk premium, they are required to assume that the CEO's outside opportunity is fully diversified. Such an assumption may lead to an overestimation of the risk premium. In particular, if a CEO's outside opportunity is to join another firm and be equally under-diversified, then the risk premium should be small. Our simulation of variance does not require this additional assumption. Third, because our sample focuses on one country, all CEOs are exposed to the same legal, taxation, and economic environment, characteristics that may be hard to control in cross-country studies such as theirs.

There is a large literature linking firm volatility to equity incentives in CEO pay, referred to as a risk-return trade off. This literature has produced somewhat inconclusive results. While some studies find a positive association between firm stock return volatility and equity incentives, others find a negative association between the two (see for example Aggarwal and Samwick, 1999, Core and Guay, 2002, and Prendergast, 2002). The risk and reward trade-off we study is not equivalent to the hypothesis that equity incentives decrease with firm stock return volatility, partly because the trade-off we address is about mean and volatility of CEO pay, not the volatility of firm stock returns, nor the equity incentive component of pay alone. This distinction is important. Cheng, Hong, and Scheinkman (2015) argue that there may be benefits from higher firm volatility, specifically that firms with higher volatility may also be more productive. In their model, there is a trade-off between mean pay and volatility of pay implied by the agent's participation constraint as in our paper. However, whether equity incentives increase or decrease in firm's return volatility in their model depends on how firm's return volatility affects firm productivity (see Raith, 2003, for another model where incentives vary positively with firm risk and yet total pay co-moves positively with variance in pay). In short, a positive association between the mean and variance of pay in agency models does not depend on the sign of the relation between firm volatility and equity incentives. We study a trade-off, which to date, has only been considered theoretically.

The paper proceeds with a theoretical justification for the fact that the elasticity of pay to the variance of pay represents as a way to capture the cost of incentive pay. Section 3 describes three approaches to estimate the variance of pay. Section 4 presents the data and section 5 presents the results including tests that control for alternative hypotheses. Section 6 offers an array of robustness tests and Section 7 concludes with directions for future work. The Appendix contains details associated with the simulation exercise using Incentive Lab data, and the definition of variables used in the empirical tests.

2. Empirical Strategy

This section motivates using the variance of pay as a way to evaluate the level of uncertainty the CEO is exposed to in the various components of incentive pay. Using the standard principal-agent model, we discuss how the elasticity of pay to the variance of pay is an appropriate metric to measure the cost of incentive pay.

2.1 Variance of pay as an aggregator of risk in performance grants

In the static, 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 $E\big(U(w,e)\big)$, 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 is a general point that can be illustrated using the static version of Holmstrom and Milgrom (1987) with normal shocks, exponential utility and separability between consumption and effort. In that model,

$$\log E\big(U(w,e)\big) = E(w) - \frac{\gamma}{2}V(w) - \text{cost of effort}, \qquad (1)$$

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 aggregates the risk the CEO is exposed to through the different performance-based components of pay and different performance measures.

2.2 Elasticity of mean pay to variance of pay

The variance of pay summarizes, in utility terms, the risk associated with not meeting different performance targets in performance-based components of pay. Because utility is an abstract concept, we use the elasticity of pay to variance of pay as a benchmark for the cost of providing incentives. The elasticity of pay to variance of pay is defined as the firm's marginal increase in CEO pay for every marginal increase in the variance of pay in order to retain the CEO in the firm.

In the static version of Holmstrom and Milgrom (1987), and in many other models, 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. Our paper focuses on the participation constraint

$$E\big(U(w,e)\big) \geq \bar{U}, \tag{2}$$

with $\bar{U}$ being 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). Under the Holmstrom and Milgrom assumptions, taking logarithms on both sides of constraint (2), and combining with (1), obtains

$$E_t(w_t) = \frac{\gamma}{2} V_t(w_t) + \text{cost of effort}_t + \bar{u}_t, \tag{1}$$

with $\bar{u} = \log(\bar{U})$.[9] Time subscripts are added so as to clarify that the information set used to compute the conditional moments refers to information available at the time when contracts are written, i.e., the beginning of period t, and w_t is the total pay realization through period t.

The elasticity describes the cost associated with incentive provision as it measures the additional mean pay the firm must give to the risk averse CEO so that she accepts the volatility associated with incentive pay. Any less mean pay implies that the participation constraint is violated and cannot be supported as an equilibrium outcome of the optimal contract. The origin of the elasticity of pay to variance of pay in Holmstrom and Milgrom (1987) is a risk and reward trade off that leaves the CEO indifferent between staying in the firm or leaving it.

This cost to the firm described by the elasticity relies on the inability of the CEO to diversity her exposure to own-firm risk, a restriction that firms are keen on guaranteeing or else the incentives would be useless. Because the participation constraint is a fundamental component of the workhorse principal-agent model that guides almost all empirical investigations of CEO pay, we view the elasticity of pay to the variance of pay as a natural proxy for the cost of incentives to firms.

To estimate the elasticity of pay to 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

$$\varepsilon_t \equiv w_t - E_t(w_t). \tag{2}$$

By construction, $E_t(\varepsilon_t) = 0$, and the variance of ε_t conditional on beginning of period t information is $V_t(\varepsilon_t) = V_t(w_t) \equiv \sigma_t^2$ (see Taylor, 2013, for a similar specification of the residual). From (3) and (4), we obtain our regression specification

$$w_t = \lambda\sigma_t^2 + X_t'\beta + \varepsilon_t. \tag{3}$$

[9] The tradeoff between mean pay and volatility of pay is derived with the assumptions of exponential utility and of normality of shocks. 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 as we discuss in Section 5.3 below.

In this model, $\lambda = \frac{\gamma}{2}$, $V_t(\varepsilon_t) = \sigma_t^2$, and the vector X_t and the slopes β capture the drivers of the cost of effort and of outside opportunities.

The elasticity of pay to variance of pay is not identified from a causal relation because both variables are determined in equilibrium as is clear in equation (3). Rather, it defines a structural relation between the two variables: any shock to one of the variables must be met with a shock to the other to preserve their structural relation, otherwise the participation constraint in the model would be violated. The additional compensation in mean pay for a marginal increase in the variance of pay is dictated by the CEO's level of risk aversion. A parallel to our exercise exists in the asset pricing literature where expected returns are related to the variance of returns times risk aversion. There, too, the lack of portfolio diversification imposes risk on the investor that then requires further compensation.

Our exercise is related to the literature that measures pay for performance sensitivities. That literature assumes that the relevant performance metric is the stock price. Instead, as we show below, CEO compensation contracts use simultaneously a variety performance metrics including various accounting-based performance metrics. Pay-for-performance sensitivities therefore lack the ability to combine the risk that arises from all the different performance metrics and performance-based pay. The variance of pay parsimoniously aggregates all such risk.

3. Estimating the Variance of Pay

We use three approaches to estimate the regression model in equation (5), each with a different estimate of σ_t^2 that we describe next.

3.1 Conditional variance using simulated variance from contract data

For every CEO and every year, we use detailed contract information available at the beginning of each year to simulate the end-of-year distribution of CEO pay. From this simulation exercise, we obtain the expected mean and the variance of pay as of the beginning of the year.

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

We simulate the value of time-vested and performance-vested incentive pay differently. For time-vested incentive pay, we simulate the stock price and multiply the simulated stock price by the number of RSU or options granted to get the dollar value of equity incentive pay. For performance-vested incentive pay, we take two inputs for the simulation: (i) compensation contract information from Incentive Lab describing the relation between contracted performance metrics and the corresponding performance-based compensation (i.e., cash bonus, RSU grants, and options grants) and (ii) Compustat data on lagged realizations of the performance metrics. We describe the procedure next leaving the details to the Appendix.[10]

The Incentive Lab contract information is presented at the firm-year-grant-metric level. For each performance metric used, Incentive Lab gives the threshold, target, and maximum level of the performance metric, and the threshold, target, and maximum level of the corresponding performance-based compensation. The CEO earns no performance-based compensation when actual firm performance is below the threshold and earns the maximum amount of performance-based compensation when actual firm performance is above its maximum. When the performance metric falls between its threshold and the maximum, the CEO earns performance-based compensation in an amount between its threshold and the maximum. We follow the firm policies disclosed in the proxy statements (DEF 14A) and fit a piece-wise linear function between the threshold, the target, and the maximum to determine the award amount.

To simulate pay for a CEO in a given year, we first simulate the performance metrics used by the firm in all the grants awarded in that year. It is possible for firms to use more than one performance metric for a given grant and to award several grants to the same CEO in a given year. We consider all metrics used for a given firm-year-CEO and simultaneously simulate all metrics

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

for that year, while accounting for the joint distributional properties of the metrics. In particular, we assume a multivariate normal distribution for the vector of performance metrics used. For our main results, we set the mean of the multivariate normal distribution equal to last year's value of the respective performance metrics. We set the covariance matrix of the distribution equal to the sample covariance matrix of the performance metrics using five years of data prior to the grant year.[11] We then simulate performance outcomes 10,000 times for each firm-year-grant-metric observation.

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

3.2 Conditional variance using realized variance of pay

In the second empirical approach, we estimate σ_t^2 using past CEO-firm pay data. Specifically, we use the last 5 years of w_t to compute realized variance of pay,

$$RealizedVariance_t = \frac{1}{5}\sum_{s=1}^{5}(w_{t-s} - \overline{w}_t)^2, \tag{6}$$

[11] 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. The ratio of price to sales is adjusted for stock splits using the lagged COMPUSTAT variable "ajex".

where $\bar{w}_t$ is the 5-year sample mean. This estimator of the 5-year conditional volatility of pay is similar to Schwert'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 5-year conditional volatility is a smooth function of the past 1-year conditional volatilities, which may introduce an upward bias on the estimated slope coefficient in equation (3). Preempting our results, the fact that we estimate a small slope coefficient, suggests that this bias is not severe.

If pay is a function of stock returns alone, then this estimator is a consistent estimator of the conditional volatility of pay. To see this point, evaluate the estimator in equation (6) applied to data generated by a model similar to Holmstrom and Milgrom (1987), where pay is a linear function of the firm's stock return, r_t, that is $w_t = m_0 + m_1 r_t$, and m_0 and m_1 are optimal contract parameters. Then

$$RealizedVariance_t = m_1^2 \frac{1}{5} \sum_{s=1}^{5} (r_{t-s} - \bar{r}_t)^2. \tag{7}$$

Andersen and Bollerslev (1998) show that under general properties for stock returns, the estimator above converges to the conditional variance of pay in the model, i.e., $m_1^2 V_t(r_t)$, where $V_t(r_t)$ is the conditional volatility of stock returns, if we are allowed to sample returns at increasingly higher frequencies.

We expect realized variance to work well as an estimator under the null that pay evolves linearly with stock returns. Intuitively, if contract parameters are time invariant, any variation in pay is due to variation in the level of performance metrics, which can be captured by past realizations of the data. However, note that even in this simple example, there is more information in the realized volatility of pay than there is in the realized volatility of stock returns, because of the presence of the term m_1^2 that is firm specific (see, for example, Aggarwal and Samwick, 1999). More generally, realized volatility of pay and realized volatility of stock returns may not even be proportional to each other as realized variance of pay entails the variance of other performance metrics and their covariances.

The main advantage of using realized variance over the Incentive Lab simulated variance is the fact that we are able to use a significantly larger number of observations that we obtain from

ExecuComp. The main disadvantage over simulated variance is that the realized variance is potentially a less efficient way to estimate ex-ante volatility if contract parameters are time variant. The Incentive Lab simulation approach is particularly versatile along this dimension as we obtain estimates of the variance of pay that condition on firm-year-CEO actual contract parameters. While it is unclear how much of a constraint this is for the realized variance approach, we note that assuming time invariant contract parameters is the standard assumption in empirical models of CEO pay that use panel data regressions.[12] There is another disadvantage of using realized variance and TDC1 relative to using simulated variance; TDC1 uses the fair value of options and time-vested restricted shares. Two CEOs, one with \$1 million salary and no other compensation, and another with \$1 million of time-vested options and no other compensation, will display zero realized volatility over time when in fact the riskiness of their contracts is very different. This is likely to bias downwards any estimate of the elasticity of pay to variance of pay.

3.3 Conditional variance using ARCH model of variance of pay

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

$$\sigma_t^2 = \alpha + \sum_{j=1,\dots,p} \delta_j \varepsilon_{t-j}^2. \tag{8}$$

with the parameters $\alpha, \delta_j \geq 0$, and $j = 1, \dots, p$ indexes the number of ARCH terms. We estimate equations (3) and (8) jointly as an ARCH-in-mean model. The estimation uses pooled data and so the parameters α and δ_j in the volatility equation and the parameters in the mean equation (3) are assumed identical across firms. The estimation of these models is done in an unrestricted fashion and we check ex-post the non-negativity constraints on the variance-equation parameters, $\alpha, \delta_j \geq 0$.

[12] Some evidence in rigidity in contract parameters can be found in Shue and Townsend (2015).

The empirical approaches using Incentive Lab data and the ARCH model have the advantage over the realized variance approach of not requiring the assumption of time invariant contract parameters. The ARCH approach does require that the variance of pay be stationary, that is $\delta_1 + \cdots + \delta_p < 1$.

In sum, we rely on various approaches to estimate the conditional variance of pay, each having its own advantages and disadvantages. While each approach faces its own unique challenge, we show that we obtain similar results regardless of the approach used.

4. Data

We use two main datasets, Incentive Lab by Institutional Shareholder Services and ExecuComp. Incentive Lab contains detailed compensation contract information for the 750 largest U.S. firms collected from proxy statements (DEF 14A) for CEOs and other executives starting from 1998. ExecuComp contains a combination of firms from S&P 500, S&P Midcap, and S&P Smallcap 600, plus backfilling of companies who were in one of the indices at some point, starting from 1992. For both datasets, we limit our sample to CEOs serving a full year. In addition, we use financial data from Compustat, stock return data from CRSP, data on board of directors from Institutional Shareholder Services, and institutional holdings data from Thomson Reuters Institutional (13F) Holdings. The variables used are described in a table in the Appendix.

When using the Incentive Lab data, we restrict the sample period to 2006-2016 because data collection is sparse and incomplete before 2006, the year when mandatory disclosure of compensation contracts started. We restrict attention to contracts that use absolute performance metrics only (contract details for relative performance goals are generally insufficient in Incentive Lab) and to contracts with quantitative performance metrics (there is less data on qualitative performance metrics such as customer satisfaction for us to conduct a simulation exercise). We include bonus, RSU grants and options grants (we include both performance-vesting and time-vesting grants).

We identify the specific performance metrics used in each contract. In addition to providing the name of the performance metric, Incentive Lab collects data from proxy statements on whether a given performance metric is scaled (either by shares outstanding or by sales) or is expressed as a growth rate. It also collects textual information to more precisely describe the metric (e.g., when

Incentive Lab field "metric" has the value of "Cashflow", Incentive Lab clarifies whether it is operating cash flow, free cash flow or net cash flow). We use this detailed information for each compensation contract. Despite the large volume of metrics data in Incentive Lab, not all grants in ExecuComp have accompanying metrics data in Incentive Lab. To define our clean sample, we drop firms that have actual bonus, RSU, or option payments in ExecuComp but for which there is no information in Incentive Lab. The clean sample collects only firm-years for which we can simulate all known performance components. We construct an alternative sample that also includes observations for which we do not have complete contract information for the CEO for a given year (e.g., we may have bonus contract details but not restricted stock details despite observing that the CEO was paid some restricted stock, as well as bonus, in that year).[13]

From Incentive Lab, we obtain 55,076 compensation contracts at the firm-year-grant-metric level for bonus, RSU, and option grants. We are left with 20,524 compensation contracts at the metric level after excluding contracts with some missing values for the performance metrics or payouts, contracts with incomplete metric information (i.e., not all metric information is available for a given grant), and contracts where information on actual compensation is not available (i.e. salary data). The 20,524 compensation contracts at the firm-year-grant-metric level consist of 2,901 metrics for bonus contracts, 8,978 time-vested RSU contracts, 1,746 metrics for performance-vested RSU contracts, 6,868 time-vested option contracts, and 31 metrics for performance-vested option contracts. These contracts aggregate at the firm-year-grant level to yield 18,914 total grants. We refer to this sample as the "alternative" sample. The alternative sample aggregates to 6,805 firm-year observations with data available in Compustat on past performance required for the simulation.

Our goal is to simulate total compensation for a given year, which requires contract information for all grants to be available for each year. In many instances, contract information is available in Incentive Lab on one form of compensation but not on another form of compensation due to incomplete compensation disclosures on firms' proxy statements. We are able to identify the existence of incomplete compensation contract data because information on actual compensation components paid out is available in a separate file in Incentive Lab as well as in

[13] 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 of all performance grants. Therefore, our data requirements are more significant, resulting in a smaller sample size, and our simulation procedure is more complex.

ExcuComp. To obtain the clean sample, we exclude firm-years with incomplete compensation contract information from the alternative sample. After this exclusion, the sample has 939 firm-year observations with data available in Compustat on past performance required for the simulation. The Online Appendix presents detailed results of the sample selection procedure.

Table 1 presents the distribution of performance metrics used in the compensation contracts at the metric level (Panel A) and descriptive statistics for the number of performance metrics per grant/year and the number of grants per CEO/year (Panel B). For both Panels A and B, Columns 1 to 4 present results for the clean sample and Columns 5 to 8 present results for the alternative sample.

[Table 1 about here.]

Across all awarded contracts, the use of accounting-based performance metrics dominates that of stock price-based performance metrics. Excluding time-vested contracts, for the clean (alternative) sample, 99% (97%) of the performance metrics are accounting-based. Among accounting-based performance metrics, EPS, sales, operating income, and cash flow are the four most commonly used performance metrics in both the clean and alternative samples. Based on the clean sample, on average, each bonus (restricted stock and options) contract uses 1.57 (1.07 and 1) performance metrics, and each CEO receives 1.11 (1.35 and 1.24) grants per year. The maximum number of performance metrics used in bonus (restricted stock and options) contracts is 4 (3 and 2). These numbers are similar to those in the alternative sample.

Turning now to the ExecuComp sample, our main compensation variable is CEO total annual compensation flow (TDC1). Table 2 provides descriptive statistics for our sample firms. The average (median) of the logarithm of CEO total annual compensation flow (TDC1) is 7.91 (7.92) close to the average (median) logarithm of simulated CEO pay of 8.4 (8.37) in the clean sample. We use the logarithm of one plus total annual compensation in the empirical analysis to mitigate the effect of skewness in compensation. In robustness tests, we use the inside wealth variable in Coles et al. (2006) as an alternative compensation variable. Using CEO wealth is in line with Core and Guay (2010) who also develop a framework for evaluating the costs of incentive packages. In dynamic models (e.g., Albuquerque and Hopenhayn, 2004, and DeMarzo and Fishman, 2007) lifetime utility under the contract depends on wealth, the state variable of the system. Intuitively, future utility promises in the form of restricted stock or non-vested option that were granted in the past all contribute to incentivizing management currently, but are costly as they create volatility in the consumption stream. For example, we drop part-year executives to avoid, among other things, a confounding effect of large initial signing grants, but capture some of the incentives provided by these initial grants when we run our tests using CEO inside wealth.

[Table 2 about here.]

The mean three-year lagged stock return (assuming dividends reinvested) is 11 percent. The logarithm of market value for the average firm is 7.45, slightly higher than the median value, consistent with our sample being skewed towards larger firms. Sample firms have 56 percent of board members hired by the CEO (coopt) on average and have 68 percent of average institutional ownership. The CEOs in our ExecuComp sample are on average of 56 years old and stay in that role for about 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 CEO pay volatility (i.e., measured with realized volatility) is 13.80 (13.89) in the ExecuComp sample, whereas the simulated log CEO pay volatility (i.e., measured by the log of the variance of simulated compensation) is 14.32 (14.40) in the clean sample of the Incentive Lab data.

[Figure 1 about here.]

Figure 1 plots the cross sectional means of actual (from ExecuComp) and simulated pay (using Incentive Lab) for the clean sample. Total compensation is reflected in the top left panel, bonus in the top right, restricted stock grants in the bottom left, and option grants in the bottom right corner. Overall, the simulation procedure does well in capturing the value of bonus, restricted stock, options, and total pay. ExecuComp bonus is the realized value of compensation 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. As with ExecuComp, we use Black-Scholes to assess the value of option grants. We differ from ExecuComp because we simulate the stock price at the end of the year, whereas ExecuComp takes the realized end-of-year price. Similar to bonus, we expect yearly deviations to wash away in a large sample. However, we find that in the later part of the sample

ExecuComp bonus and options are systematically above their simulated (expected) counterparts. One possible explanation for the gap in bonus is that firms appear to adjust performance metrics to boost executive bonus compensation (Kim and Yang, 2014). One possible explanation for the gap in options pay is that we have found that ExecuComp sometimes reports the combined value of restricted stock and options as restricted stock. Contrary to Bettis et al. (2018), we do not find that simulated fair values of restricted stock grants using Incentive Lab data differ significantly from the values reported in financial statements.

Panel A in Figure 2 plots the percentage of firms in the clean sample that offer any of the compensation grants. Options were more popular earlier in the sample, whereas bonus and restricted stock grants became more popular later in the sample. These trends in the clean sample are very similar to those displayed in the ExecuComp sample (panel B).

[Figure 2 about here.]

Figure 3 reproduces Figure 1, but now using the alternative sample. In this sample, we have firms with incomplete data in Incentive Lab on one or more compensation grants and this mostly explains the gap between simulated values and reported values. The figure indicates that this gap appears stable through the sample period.

[Figures 3 and 4 about here.]

Figure 4 plots simulated and reported values of total compensation across industries for the clean sample and the alternative sample. As in Figures 1 and 3, there is a gap between total reported pay and total simulated pay, but there are no apparent differences in this gap across industries. Overall, our simulated data appear to be largely consistent with realized pay, on average, suggesting the simulation did not entail any particular bias.

5. Results

5.1 Main results on elasticity of pay to variance of pay

Table 3, panel A, reports the results of panel regressions of the logarithm of TDC1 on the logarithm of simulated variance of pay using ordinary least squares. Columns 1 and 2 report the results using the clean sample and Columns 3 and 4 report the results using the alternative sample. In odd (even) numbered columns the regressions have no (firm and year) fixed effects. Standard errors are clustered by firm when no fixed effects are present and by firm and year when fixed effects are present.

The coefficient on the logarithm of simulated variance of pay describes the elasticity of pay to variance of pay or the average risk and reward trade off. This coefficient is positive and statistically significant at 1% level across all specifications. When fixed effects are included, the coefficient estimates are 0.072 in the clean sample and 0.033 in the alternative sample. Overall, the alternative sample produces slightly smaller estimates of the risk and reward trade off in pay, but the statistical significance increases dramatically in the alternative sample with the larger number of observations.

Columns 5 through 8 of panel A replace the logarithm of TDC1 as a dependent variable with the logarithm of simulated mean pay from Incentive Lab. The regressions result in significantly higher parameters estimates for the elasticity of pay to variance of pay. We believe these estimates are biased because of the possibility of correlated measurement error from the simulation in both the right-hand-side and left-hand-side variables. Of notice, too, is the fact that the increase in point estimates is significantly larger than the increase in t-statistics, which means that the standard errors of the estimates also increase significantly.

[Table 3 about here.]

The higher estimated coefficient in the regressions without firm fixed effects in panel A of Table 3 reveals that the trade-off between variance of pay and mean pay comes both from across firms and within firms. The cross sectional finding of a large effect across firms can also be seen in panel B of Table 3, where we report cross-sectional regressions and a Fama-MacBeth estimate of the average effect.[14] This panel shows overwhelming evidence of a positive relation between mean pay and variance of pay across firms for all cross sections for both the clean and alternative samples. The magnitude of the trade-off has some temporal dispersion between 0.07 and 0.25 in the clean sample, with a mean estimated coefficient close in magnitude to the pooled regression estimates without firm fixed effects of about 0.17. One concern in studies of CEO pay over time is that significant regulatory changes may lead to structural breaks in the model, invalidating the analysis. The evidence in panel B of Table 3 significantly dispels this concern by showing a consistent positive estimate over time of the elasticity when using only cross-sectional variation in the data.

Table 4 repeats the same exercise but using realized variance from ExecuComp data as a measure of the conditional volatility of pay. The dependent variable in Columns 1 and 2 is the logarithm of TDC1 and in Columns 3 and 4 is the logarithm of CEO wealth. Columns 1 and 3 have no fixed effects and Columns 2 and 4 have firm and year fixed effects. As in Table 3, standard errors are clustered by firm when no fixed effects are present and by firm and year when fixed effects are present. In the specifications without fixed effects, the estimated elasticity describing the risk and reward trade off in pay is positive and higher than that in the alternative sample using Incentive Lab data (0.246 versus 0.090). Introducing fixed effects as shown in Columns 2 and 4, however, lowers the magnitude of the elasticity to levels that are only slightly higher than those in Table 3 (0.046 versus 0.033). Across all specifications, the estimated coefficients using realized variance of pay are significant at 1%. In the Online Appendix, we report on cross sectional regressions using realized variance. The results are qualitatively the same as in Table 3, panel B.

[Table 4 about here.]

Table 5 presents the results with the ARCH-in-mean model. Contrary to the specifications in Tables 3 and 4, the dependent variable in Table 5 is the dollar value of pay. This is done so that the residual variance is the conditional variance of pay, to be consistent with the measures of variance used above, otherwise the residual variance would be the conditional variance of the logarithm of pay. The main independent variable remains the logarithm of the variance of pay. To

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[14] The standard error on the estimate is computed with the bias correction proposed in Pontiff (1996) that accounts for time series correlation of the residuals.

interpret the coefficient on variance of pay as an elasticity, we divide the estimated coefficient by the mean of pay. Columns 1 and 2 report the results using TDC1 and Columns 3 and 4 report the results using CEO wealth. Columns 1 and 3 have no fixed effects and Columns 2 and 4 have industry and year fixed effects. We use industry fixed effects as opposed to firm fixed effects, because the ARCH estimation in Stata cannot handle the many firm-specific indicator variables.

Using TDC1, the elasticity of mean pay to variance of pay is positive and statistically significant at 1%. In Column 2, that coefficient is 150, and dividing by the mean of TDC1 of $4,679 (the unit of TDC1 is thousands) gives an elasticity of 3.2%. This estimate is remarkably similar to the effect using realized variance (in Table 4, with firm and year fixed effects). Using CEO wealth, the estimated elasticity is negative when no fixed effects are used and insignificant with fixed effects. The ARCH coefficients across the four specifications in Table 5 are all positive as required so that variance is positive throughout.

[Table 5 about here.]

The evidence of a low elasticity presented above is especially surprising given potential contractual features linked to option grants that push the estimates upward. First, increases in firm return volatility increase average pay through the higher value of options, and increase the variance of pay through the higher variance in the value of options. Thus, options are a natural mechanism for firms to use to induce a positive relation between conditional volatility of pay and conditional mean of pay in response to changing volatility of firm stock returns. Second, Black-Scholes option values (used in TDC1 and in our simulation of option grants) overstate the value of options for under-diversified CEOs and understate their risk.

5.2 Economic significance of the estimated elasticity

We next assess the economic cost of CEO's incentive pay given the estimated elasticity. Consider a board that awards the CEO a contract that is linear with respect to incentives,

$$w_t = c_0 + c_1 x_t, \tag{9}$$

where total pay, w_t, is composed of base salary, c_0, plus a cash bonus, $c_1 x_t$. Assume c_1 is a parameter that describes the level of incentives and x_t is a random variable describing the evolution of a performance metric. Such a contract approximates many of the contracts in our sample. The variance of pay in this contract is $V_t(w_t) = c_1^2 V_t(x_t)$.

Suppose the board would like to increase incentives, c_1, while keeping all else constant. Since increasing incentives increases the variance of pay, how much should total pay increase given the estimated elasticity? Assuming for simplicity that the mean and variance of the performance metric, x_t, do not change with the change in incentives, then (see the Appendix for calculation details)

$$\%\Delta V_t(w_t) = 2 \times \%\Delta c_1,$$

where the notation %Δy refers to a percentage change in the variable y.

Increasing incentives by say 20%, i.e., $\%\Delta c_1 = 20\%$, implies that the percentage change in variance of pay equals $\%\Delta V_t(w_t) = 40\%$. Given that the elasticity of pay to variance of pay is $\varepsilon = \%\Delta E_t(w_t)/\%\Delta V_t(w_t)$, an elasticity of $\varepsilon = 0.05$ leads to a percentage change in mean pay of $\%\Delta E_t(w_t) = 2\%$. That is, it costs the firm an additional 2% in total pay to increase incentives in CEO pay by 20%.

How can firms implement an increase in pay of only 2% when incentive pay is increasing by 20%? To answer this question, we return to the contract in Equation (9). Noting that in our sample the average ratio of pay at risk in total pay, $c_1 E(x_t)/E(w_t) = 0.75$, the increase in incentives contributes to $0.75 \times 20\%$=15% increase in total pay. Since total pay needs to increase by only 2%, it must be the case that salary decreases. Salary needs to decrease by 52% to keep the increase in total pay at only 2%.

These calculations suggest that firms would seem to be able to substitute salary for incentive pay, thus using incentives to decrease the burden of fixed compensation in their cost structure. Alternatively, the rate of increase in incentive pay is significantly greater than for fixed pay. This evidence offers a quantification of the discussion in Murphy and Jensen (2018) regarding how the growth in pay at risk in the last two decades is unrelated to provision of economic incentives and risk and reward arguments.

We offer another way to assess the economic magnitude of the elasticity of pay to variance of pay. The estimated elasticity of pay to variance of pay can be transformed into an estimate of the risk aversion coefficient. Estimating the model using the logarithms of pay and variance of pay is useful to reduce the skewness in these variables and to facilitate interpretation of the estimates as elasticities. However, to our knowledge, this empirical specification is not a direct representation of any preference specification, which constrains our ability to report on an implied estimate of risk aversion. The closest we can get to an estimate of risk aversion is to assume that CEOs have constant relative risk aversion preferences and that pay is log normally distributed. In that case, 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 risk aversion. Estimates of the elasticity of pay to variance of pay in the regressions above with fixed effects are about 0.05, yielding estimates of risk aversion at 1.1. Put into perspective, asset pricing studies typically assume the coefficient of relative risk aversion is around 10. It is possible though that CEOs have lower risk aversion than the marginal investor. In fact, Taylor (2013) estimates CEO risk aversion to be 2.8. Still, Taylor's estimate is substantially higher than our estimate of risk aversion; it corresponds to an elasticity of pay to variance of pay of 0.9 (i.e., (2.8-1)/2=0.9). Because the additional compensation associated with variance in pay is determined by risk aversion, low estimates of risk aversion suggests that CEO's incentives are not too costly for firms.

5.3 Alternative hypotheses

This section considers several extensions of the basic Grossman and Hart model that could explain the finding of a low elasticity of mean pay to variance of pay.

Following Oyer (2004), Laffont and Martimort (2002) and Nickerson (2017), CEO's outside opportunities may be type dependent, correlating positively with CEO pay. If the CEO's outside opportunities happen to covary negatively with the variance in pay, then mean and variance of pay may be negatively related causing a downward bias in the elasticity due to an omitted variable problem. Following Himmelberg and Hubbard (2000), and Oyer (2004), we use lagged values of stock performance of the firm's industry, and lagged own stock performance, respectively, to describe outside opportunities.[15]

An entrenched CEO may be able to guarantee an expected utility under the optimal contract that is above her reservation utility, generating slack in the participation constraint that depends on the level of CEO entrenchment. If greater slack comes with high volatility of pay, and this effect is strong enough, then mean and variance of pay would be positively related in ways that do not reflect the risk and reward trade off that we investigate. For entrenchment proxies, we use Coles et al. (2014) co-opted board measure, as well as the percentage ownership by institutional investors.

If the utility function is nonseparable in consumption and effort, then incentives may be provided by reducing the marginal cost of effort. For example, higher CEO pay creates status enjoyed by the CEO that reduces the cost of effort for the CEO. In such cases, the participation constraint is not binding and the risk and reward trade-off in pay may not be directly implied by the participation constraint (see Laffont and Martimort, 2002). For cost of effort proxies, we use CEO age and log of CEO tenure, the volatility of stock returns, an indicator variable for when the CEO is the founder, and the lagged value of the firm's market capitalization.

We include in the regressions simulated skewness. Hemmer, Kim and Verrecchia (2000), Ross (2004), and Chaigneau (2015) using a more general utility specification than mean-variance utility predict a preference for positive skewness, besides a disutility to volatility associated with risk aversion. A prudent CEO has a preference for positive skewness in pay if the CEO dislikes downside risk, i.e., the third partial derivative of utility with respect to pay is positive (Chaigneau, 2015). A prudent CEO requires less mean pay if awarded a contract with positively skewed payouts, say through option grants. In addition, if skewness in pay is positively related to the variance of pay, then a strong enough effect of volatility of pay on skewness can introduce a downward bias in the relation between mean and volatility of pay due to an omitted variable. The effect of skewness of pay on mean pay is not unambiguous. Agren (2006) shows that loss averse investors prefer negative skewness, which predicts that skewness should instead have a positive association with mean pay.[16]

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[15] In untabulated results, we control outside opportunities using industry times year fixed effects and find similar results to those shown above.

[16] Interestingly, Dittmann et al (2010) show that options are still optimal with loss averse agents.

We control for CEO overconfidence. There is evidence that CEOs overestimate the performance of their investments while underestimating the risks (e.g., Dittrich et al., 2005, Huang and Kisgen, 2013, Kolasinski and Li, 2013, and Malmendier and Tate, 2005 and 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, Heaton and Odean, 2011). We use the Humphery et al. (2016) overconfidence indicator that is based on whether the CEO keeps deep-in-the money options that have vested.

[Table 6 about here.]

Laffont and Martimort (2002) show that in moral hazard models if the agent is risk neutral and there is a limited liability constraint that sets a lower bound to pay, then this new constraint together with the incentive compatibility constraint imply the participation constraint. That is, if the limited liability constraint is binding, then the principal is constrained in her ability to induce effort and the participation constraint may be slack. In this case, the risk-return trade-off breaks down. This explanation is less realistic unless one wants to dismiss the long -standing assumption of risk averse CEOs. Accordingly, we do not explore it further.

Table 6 presents the results of estimating the elasticity of pay to variance of pay, controlling for these various alternative hypotheses, using OLS on the Incentive Lab alternative sample.[17] The main result to note from the table is that the inclusion of the various controls does not significantly change the small economic magnitude of the sensitivity of mean pay to variance of pay. Focusing on Column 7, high skewness in pay is associated with higher pay consistent with loss aversion utility (Agren, 2006). A positive coefficient associated with skewness is also consistent with the view that firms use stock options to provide excess pay to CEOs (Bebchuk and Fried, 2004, made this argument when options were not expensed). CEO outside opportunities have an effect on mean pay through the firm's own lagged 3-year stock return, entrenchment has an effect via institutional ownership, and CEO tenure, firm size, and non-founder all lead to higher pay.

[17] In addition to the control variables shown in the paper, we have also used IPO activity, average industry ROA, and median of peer pay as proxies for outside opportunities. We also have included a concentration index of institutional holdings to proxy for governance, and a concentration index for business segments and book-to-market value to proxy for job complexity. These variables are not significant and are dropped from the estimation. The Online Appendix reports results with CEO wealth.

Table 7 repeats the analysis using the ExecuComp sample. We use OLS and realized volatility as the main right-hand side variable in Columns 1 to 3 and ARCH in-mean in Columns 4 and 5. The full ExecuComp sample is used in Columns 1, 2, and 4, and the ExecuComp/Incentive Lab matched sample is used in Columns 3 and 5 (for comparison with Column 7 in Table 6). The main result is the robustness of a low estimated value of the elasticity of pay to variance of pay. The effect of skewness on total pay is sample and method dependent as is the case also for lag own 3-year stock return. Founder CEOs earn less and larger firms pay more as in Table 6.

6. Robustness analysis

Because the theoretical motivation for the elasticity of pay to variance of pay ties its value to risk aversion, we consider several proxies of risk aversion and modify our estimation by allowing the sensitivity of pay to variance of pay to depend on these proxies. 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 suggests that the low elasticity may be driven by the presence of a few low risk averse CEOs.

To proxy for risk aversion, we consider CEOs' early-life exposure to fatal disasters (Bernile et al., 2017), whether the CEO possesses a private pilot license (Cain and McKeon, 2016), whether the CEO is a depression baby (Malmendier and Nagel, 2011), CEO gender (Borghans et al., 2009), and CEO marital status (Roussanov and Savor, 2014). We do not find any significance of these proxies using any of our variance of pay proxies. The results are available upon request.

The Online Appendix includes a proxy for risk of turnover to the regressions. We find that the prospect of forced turnover is associated with less pay to the CEO, contrasting with evidence in Peters and Wagner (2014). We also find that the estimated elasticity of pay to variance of pay is virtually unchanged. The reason for the similarity in results with regards to the elasticity is the small unconditional probability of CEO forced turnover in the US (Peters and Wagner, 2014, show that it is just under 3%).

We also report in the Online Appendix the results from simulating mean pay and the variance of pay using concurrent (i.e. measured in time *t*) variables as the mean in the conditional distribution of the performance metrics. This specification presumes that the board has perfect foresight when designing the contracts, which is unrealistic but constitutes an upper bound on the board's information set. The analyses reported in Section 5 constitute a lower bound on the board's information as it assumes the board relies solely on past information. Overall, the results on the elasticity of pay to variance of pay are largely unchanged.

In summary, although we cannot fully rule out the possibility that the low compensation for risk in the cross section of U.S. CEOs is not subject to an omitted variable bias, we are comforted by the result that our conclusion does not change after inclusion of a long list of controls in the regressions and of several robustness tests.

7. Conclusion

We examine the cost of incentive provision using a theoretically motivated measure, the elasticity of pay to variance of pay. The mainstream agency model of Grossman and Hart (1983) has a fundamental prediction imbedded in the model's participation constraint that mean pay and the volatility of pay are positively related. Using a variety of methods to test this prediction and a variety of datasets for U.S. CEOs, including simulations using Incentive Lab CEO-contract data, we find a positive association between mean pay and variance of pay. However, the compensation for risk in pay appears too small to be fully consistent with model. Using a back-of-the-envelope calculation, we find that firms appear to be able to substitute salary for incentives implying that incentives are not too costly to offer to CEOs.

There are model departures from Grossman and Hart (1983) that are worth studying in future research within the context of optimal contracting models. One is to introduce dynamic considerations. For example, models of career concerns (Axelson and Baliga, 2009, Gibbons and Murphy, 1992, or Noe and Rebello, 2012) will have an implicit trade-off between mean and volatility of consumption streams as opposed to current pay. Another is agent heterogeneity. Models with adverse selection in agent type or models of assortative matching (e.g., Tervio, 2008, and Edmans, Gabaix and Landier, 2009) generally predict that the participation constraint holds only for one agent. If CEO compensation data come from a cross section where the participation constraint holds only for a few of the CEOs, then there is a downward bias in the risk and reward trade off.

While this paper assesses the costs of incentive provision, it is only half of the larger question of what is the optimal level of incentives. Future research should concentrate on developing tools directed at identifying the benefits of incentive provision.

Appendix

This appendix further details on the simulation exercise using Incentive Lab data. It also contains details of the back-of-the envelope calculation in the main text, and a table with the definitions of variables used in the paper.

Simulation using the Incentive Lab data

We use information available at the beginning of the year to simulate expected pay and variance of pay for the current year.

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

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

RSU/options into dollar values. We provide details of the two-step simulation exercise for performance-vested incentive pay below.

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

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

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

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

We implement the contract estimations in four steps. In the first step, we construct a sample of compensation contracts that meets the following three criteria: (i) using absolute performance metrics only, (ii) including cash and equity compensation contracts only, and (iii) including contracts for CEOs only. In particular, we start with the Absolute Performance Goals Data (referred to as "GpbaAbs" by Incentive Lab) to get all compensation contracts using absolute performance metrics. We drop firms that use relative performance metrics in addition to absolute performance metrics, (i.e., the variable "numRelative" has a positive value). We then limit the sample to cash and equity compensation contracts by merging the Grants of Plan-Based Awards Table (referred to as "GpbaGrant"): we keep contracts where the "AwardType" variable in GpbaGrant has the value of "cashShort", "cashLong", "Option", or "rsu". Next, we limit the sample to include contracts for CEOs only by merging the Participant Data by Fiscal Year (referred to as "ParticipantFY"): we keep contracts where the "currentCEO" variable in ParticipantFY has the value of one.

In the second step, we classify each firm-year-CEO into one of seven groups: (i) firm-years with bonus contracts only, (ii) firm-years with RSU contracts only, (iii) firm-years with option contracts only, (iv) firm-years with bonus and RSU contracts only; (v) firm-years with bonus and option contracts only; (vi) firm-years with RSU and option contracts only, and (vii) firm-years with bonus, RSU, and option contracts. We separately examine the seven groups because we need to ensure contract details are available for simultaneously simulating all performance metrics for a given firm-year-CEO. Some firms may have an actual compensation component without disclosing the contract details. For example, a firm may have reported values of RSU grants in

ExecuComp, but lack contract details on Incentive Lab (either not listed in GpbaAbs or showing missing values of the contract details in GpbaAbs); these firms are dropped in our clean sample, but kept in our alternative sample. In constructing our sample, we first use Incentive Lab contract information to classify the seven groups of firms described above; the seven groups combined is our alternative sample. We then merge the alternative sample with actual compensation from ExecuComp to construct the clean sample. We provide detailed description of the difference between the alternative sample and the clean sample for each of the seven groups in footnote X.[18] The online appendix tabulates the sample selection process.

In the third step, we pinpoint the specific performance metrics used in each contract. In particular, "GpbaAbs" has five relevant variables for this task: (i) the variable "metric" lists the name of the performance metric, (ii) the indicator variable "metricIsPerShare" describes whether the performance metric is scaled by the number of common stocks; (iii) the indicator variable "metricIsMargin" describes whether the performance metric is scaled by sales; (iv) the indicator variable "metricIsGrowth" describes whether the performance metric is measured as the growth rate; and (v) the variable "metricOther" provides additional textual information about the

[18] We use the following procedures to construct our sample consisting of seven groups of firms described before. (i) The “bonus only” group in the *alternative* sample consists of firms that only have bonus contract information in Incentive Lab (i.e., no RSU or option contract information available). To get from the “bonus only” group in the *alternative* sample to the “bonus only” group in the *clean* sample, we exclude firms having actual RSU payment or actual option payment or both as indicated in ExecuComp. (ii) The “RSU only” group in the *alternative* sample consists of firms that only have RSU contract information in Incentive Lab (i.e., no bonus or option contract information available). To get from the “RSU only” group in the *alternative* sample to the “RSU only” group in the *clean* sample, we exclude firms having actual bonus payment or actual option payment or both as indicated in ExecuComp. (iii) The “options only” group in the *alternative* sample consists of firms that only have option contract information in Incentive Lab (i.e., no bonus or RSU contract information available). To get from the “options only” group in the *alternative* sample to the “options only” group in the *clean* sample, we exclude firms having actual bonus payment or actual RSU payment or both as indicated in ExecuComp. (iv) The “bonus and RSU only” group in the *alternative* sample consists of firms that only have bonus and RSU contract information in Incentive Lab (i.e., no option contract information available). To get from the “bonus and RSU only” group in the *alternative* sample to the “bonus and RSU only” group in the *clean* sample, we exclude firms having actual option payment as indicated in ExecuComp. (v) The “bonus and options only” group in the *alternative* sample consists of firms that only have bonus and option contract information in Incentive Lab (i.e., no RSU contract information available). To get from the “bonus and options only” group in the *alternative* sample to the “bonus and options only” group in the *clean* sample, we exclude firms having actual RSU payment as indicated in ExecuComp. (vi) The “RSU and options only” group in the *alternative* sample consists of firms that only have RSU and option contract information in Incentive Lab (i.e., no bonus contract information available). To get from the “RSU and option only” group in the *alternative* sample to the “RSU and option only” group in the *clean* sample, we exclude firms having actual bonus payment as indicated in ExecuComp. (vii) The “bonus, RSU, and options” group in the *alternative* sample consists of firms that have bonus, RSU, and option contract information in Incentive Lab. The sample composition for this group is the same for both the *alternative* sample and the *clean* sample.

performance metric. For example, when "metric" has the value of "Cashflow", several possibilities exist: if all three indicator variables equal zero, it means the performance metric used in the contract is the dollar amount of cash flow; if "metricIsPerShare" equals one, "metricIsMargin" equals zero, and "metricIsGrowth" equals one, it means the performance metric used in the contract is the growth rate of cash flow per share. In addition, the textual description in "metricOther" may indicate it is operating cash flow or free cash flow rather than net cash flow. We consider all possible combinations of the indicator variables as well as the additional information in the textual description from "metricOther" to pinpoint the performance metric used in each compensation contract.

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

Performance Simulation. We simulate current year performance using actual performance in the past five years from Compustat. The Incentive Lab contract information is presented at the firm-year-grant-metric level. It is possible for firms to use more than one performance metric for a given grant (contract). It is also possible for firms to set up several grants (contracts) for the same CEO in a given year. We consider all metrics used for a given firm-year-CEO and simultaneously simulate all metrics for that year. In particular, for each CEO and year, we assume a multivariate normal distribution for all performance metrics used for a given CEO across all contracts; we set the mean of the joint normal distribution equal to the actual values in the previous year (i.e., year $t-1$),[19] and set the covariance matrix for the joint normal distribution equal to the covariance

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

matrix calculated from the actual values of the performance metrics in the past five years (i.e., years $t-5$ to $t-1$). Using these assumptions, we run 10,000 simulations for each firm-year-grant-metric, which provides simulated performance for estimating simulated compensation.

In our main test, we convert the performance metrics stated in dollar amount into scaled variables to make the covariance matrix comparable with other scaled metrics (i.e., metrics expressed as a rate or ratio such as growth rate, margin, per share value, ROA, etc.). In particular, when the performance metric is the dollar amount of sales, we simulate the firm's sales growth rate, and then get the dollar amount of simulated sales as $simulated\ sales_t = sales_{t-1} \times (1 + simulated\ sales\ growth\ rate_t)$; when the performance metric is operating income, profits before tax, net income, cash flow, etc., which can have negative values in the past five years, we simulate the corresponding performance scaled by lagged total assets, and get the dollar amount of the simulated performance as $simulated\ performance_t = total\ assets_{t-1} \times simulated\ scaled\ performance_t$.[20]

While bonus contracts are written on the dollar value of cash payment, equity grants are written on the number of shares granted. Thus we need a price estimate to convert the simulated number of shares granted to the dollar value. Because price is related to accounting performance, we avoid simulating price directly; instead, we simulate the price to lagged sales ratio to get simulated price. In particular, $simulated\ price_t = sales_{t-1} \times simulated\ price\ to\ lagged\ sales\ ratio_t$. Because of the price estimates, for all CEOs with restricted stock grants or option grants, the covariance matrix for the joint normal distribution includes the price to lagged sales ratio as an additional input variable in addition to the actual performance metrics used in the compensation contracts.

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

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

grant level compensation based on information in the variable "performanceGrouping", which describes the relationship between the various performance metrics.

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

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

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

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

Calculations of effect of change in incentives on salary

Consider the compensation package given in Equation (9). The variance of pay in this contract is $V_t(w_t) = c_1^2 V_t(x_t)$. The percentage change in the variance of pay equals

$$\%\Delta V_t(w_t) = 2 \times \%\Delta c_1 + \%\Delta V_t(x_t),$$

which equals the expression in the text under the assumption that the variance of the performance metric x_t is unchanged with the change in incentives; an assumption made in most contract theory papers. The percentage change in pay equals

$$\%\Delta E_t(w_t) = \frac{c_0}{E_t(w_t)} \%\Delta c_0 + \frac{c_1 E_t(x_t)}{E_t(w_t)} [\%\Delta c_1 + \%\Delta E_t(x_t)].$$

Recall that an elasticity of pay to variance of pay of 0.05 implies

$$\%\Delta E_t(w_t) = 0.05 \times \%\Delta V_t(w_t),$$

so that an increase in incentives of 20% leads to an increase in pay of 2% ($\%\Delta E_t(w_t) = 0.05 \times 2 \times 20\%$).

Using as we did in the main text the value of $\frac{c_1 E_t(x_t)}{E_t(w_t)} = 0.75$ from our sample, we have

$$2\% = 0.25\%\Delta c_0 + 0.75[20\% + \%\Delta E_t(x_t)].$$

Thus

$$\%\Delta c_0 = 8\% - [60\% + 3\%\Delta E_t(x_t)].$$

The calculations in the text assume $\%\Delta E_t(x_t) = 0$. Under this assumption, salary must decrease by 52%. If, however, higher incentives increase $\%\Delta E_t(x_t)$, then salary would have to decrease even further.

Variable definitions

Total Compensation (TDC1)	=	Total annual compensation flow is calculated as the sum of salary, bonus, other annual compensation (e.g., gross-ups for tax liabilities, perquisites, preferential discounts on stock purchases), long-term incentive payouts, restricted stocks granted during the year (determined as market value of the date of the grant), the value of stock options granted (estimated using the Black-Scholes formula or total grant-date present value of options awarded when Black-Scholes is not available), and all other compensation (e.g., payouts for cancellation of stock options, 401K contributions, signing bonuses, tax reimbursements) before 2006. After 2006, annual compensation flow is calculated as the sum of salary, bonus, non-equity incentive plan compensation, the grant-date fair value of option awards, the grant-date fair value of stock awards, and other compensation.
Log of TDC1	=	The natural logarithm of total compensation (TDC1).
CEO Inside Wealth	=	Value of the CEO's stock and option portfolio (in $000s) from Coles, et al. (2006) plus salary, bonus, and other annual compensation (othcomp) before 2006; or value of the CEO's stock and option portfolio plus salary, bonus, non-equity incentive plan compensation, and other compensation after 2006.
Simulated Mean Pay	=	Simulated total annual compensation, calculated as the sum of (i) salary, (ii) the mean value of the sum of simulated bonus, simulated restricted stock, and simulated stock options from 10,000 simulations for each firm-year-CEO; (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 total annual compensation.
3-Year Stock Return	=	The 3-year total return to shareholders, including the monthly reinvestment of dividends.
Firm Volatility	=	The standard deviation of monthly stock returns calculated over months $t-37$ to $t-1$.
Average Industry Return	=	Average of all the firms' annual stock return that are in the same industry, defined as firms in the same 4-digit Global Industry Classification System (GICS).
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.

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% of the option strike price, zero otherwise.
Co-Opted Board (Coopt)	=	Indicator variable equal to one if the number of directors hired after the CEO took office is above the sample mean, zero otherwise.
CEO Age (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.
CEO is Founder (Founder)	=	Indicator variable equal to one if the CEO is also the founder of the firm, zero otherwise.
Institutional Holdings Percent	=	Percentage of the firm's shares outstanding that are owned by all institutional investors. This is obtained by Thomson Reuters Institutional (13f) Holdings – Stock Ownership (variable "instown_perc").
Realized Variance of CEO Pay	=	The natural logarithm of the variance of CEO total pay flow (TDC1) calculated over the last 5 years ($t-5$ to $t-1$).
Realized Variance of CEO Wealth		The natural logarithm of the variance of CEO inside wealth calculated over the last 5 years ($t-5$ to $t-1$).
Simulated Variance of CEO Pay	=	The natural logarithm of the variance of the sum of simulated bonus, simulated restricted stock, and simulated stock options from the 10,000 simulations for each firm-year-CEO.
Realized Skewness of CEO Pay	=	Skewness of CEO total pay flow (TDC1) calculated over the last 5 years ($t-5$ to $t-1$).
Realized Skewness of CEO Wealth	=	Skewness of CEO inside wealth calculated over the last 5 years ($t-5$ to $t-1$).
Simulated Skewness of CEO Pay	=	Skewness of the sum of simulated bonus, simulated restricted stock, and simulated stock option from the 10,000 simulations for each firm-year-CEO.

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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. For both Panel A and Panel B, Columns 1 to 4 (5 to 8) present results for the clean (alternative) sample.

Panel A. Metric Level Information

	Clean Sample				Alternative Sample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Bonus	Restricted Stock	Options	Combined	Bonus	Restricted Stock	Options	Combined
Book Value	0	2	0	2	0	2	0	2
Cashflow	87	23	0	110	189	78	3	270
EBIT	31	7	0	38	53	12	0	65
EBITDA	62	13	0	75	141	75	5	221
EBT	37	13	0	50	82	27	0	109
EPS	194	56	4	254	372	269	6	647
Earnings	60	19	0	79	127	44	0	171
FFO	8	1	0	9	17	5	0	22
Operating Income	76	20	0	96	210	86	3	299
Profit Margin	14	3	0	17	38	22	0	60
ROA	18	4	0	22	29	22	0	51
ROE	41	22	1	64	76	83	1	160
ROI	4	1	0	5	6	3	0	9
ROIC	47	38	0	85	86	125	0	211
Sales	130	26	1	157	274	173	7	454
Stock Price	2	3	1	6	10	72	2	84
Time	0	880	821	1,701	0	5,318	5,022	10,340
Total (metric level)	**811**	**1,131**	**828**	**2,770**	**1,710**	**6,416**	**5,049**	**13,175**

Table 1. Panel B. Grant Level and CEO Level Information

	Clean Sample				Alternative Sample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Bonus	Restricted Stock	Options	Combined	Bonus	Restricted Stock	Options	Combined
Number of performance metrics per grant/year								
Min	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Mean	1.57	1.07	1.00	1.15	1.53	1.05	1.00	1.07
Std. Dev.	0.71	0.27	0.03	0.43	0.70	0.24	0.06	0.31
Skewness	1.18	3.98	28.71	3.24	1.27	6.00	31.01	5.05
Max	4.00	3.00	2.00	4.00	5.00	4.00	3.00	5.00
Number of grants per CEO/year								
Min	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Mean	1.11	1.35	1.24	2.57	1.08	1.29	1.15	1.81
Std. Dev.	0.38	1.00	1.23	1.61	0.33	0.80	0.74	1.15
Skewness	4.52	6.81	7.67	3.00	5.04	6.67	9.90	3.75
Max	4.00	13.00	12.00	13.00	4.00	15.00	12.00	15.00

Table 2. Descriptive Statistics

N is the number of observations, and *Px* is the percentile *x* value of the sample distribution, with *x*=1, 25, 50 (median), 75, and 99. The appendix gives detailed definitions of each variable, data source and time availability.

VARIABLES	N	Mean	Std. Dev.	P1	P25	P50	P75	P99
ln of simulated CEO total pay (clean sample)	939	8.4	0.88	5.75	7.84	8.37	8.94	11.12
ln of total compensation (TDC1)	37,322	7.91	1.07	5.30	7.16	7.92	8.68	10.34
ln of CEO wealth	29,567	9.90	1.44	6.73	8.93	9.83	10.79	13.97
3-year shareholder return	34,963	0.11	0.25	-0.53	-0.03	0.10	0.23	1.02
Firm return volatility	35,936	0.11	0.06	0.04	0.07	0.10	0.14	0.34
Average industry return	37,319	0.16	0.24	-0.41	0.01	0.15	0.30	0.85
ln of market value	32,836	7.45	1.64	3.63	6.35	7.35	8.47	11.67
Overconfidence indicator	37,320	0.34	0.47	0.00	0.00	0.00	1.00	1.00
Co-opted board (coopt)	20,905	0.56	0.32	0.00	0.29	0.55	0.88	1.00
CEO age (age)	36,495	55.82	7.38	39.00	51.00	56.00	60.00	76.00
CEO tenure	34,731	8.23	7.39	0.92	2.92	5.92	10.92	35.92
Founder indicator (founder)	37,322	0.11	0.32	0.00	0.00	0.00	0.00	1.00
Percent of institutional ownership	29,852	0.68	0.22	0.07	0.54	0.70	0.83	1.13
Simulated variance of CEO pay (ln of variance(simulated pay)) (clean sample)	939	14.32	2.6	6.33	12.83	14.4	15.98	21.47
Realized variance of CEO pay (ln of variance(TDC1))	24,813	13.80	2.53	6.75	12.34	13.89	15.45	18.66
Realized variance of CEO wealth (ln of variance(wealth))	17,147	18.04	3.20	10.69	16.15	18.02	19.90	25.52
Simulated skewness of CEO pay (skewness(simulated pay)) (clean sample)	939	0.77	0.85	-1.01	0.1	0.64	1.19	4.00
Realized skewness of CEO pay (skewness(TDC1))	24,794	0.29	0.70	-1.33	-0.21	0.31	0.84	1.49

Table 3. Panel A. The Risk and Reward trade off in Pay Using Simulated Conditional Volatility

This table presents results from regressions of the natural log of TDC1 (Columns 1—4) and the natural log simulated mean pay (Columns 5—8) on the natural log of simulated conditional variance of pay using Incentive Lab data and compensation contract information available at the beginning of each year. Columns 1, 2, 5, and 6 (3, 4, 7, and 8) report results using the clean sample (alternative sample). Columns 1, 3, 5, and 7 (2, 4, 6, and 8) report results without (with) firm and year fixed effects included. Robust t-statistics are reported in parentheses, clustered by firm (firm and year) in Columns 1, 3, 5, and 7 (2, 4, 6, and 8). Significance at 1%, 5%, and 10% is indicated by ***, **, and *, respectively.

	log of TDC1				log of Simulated Mean Pay			
	Clean Sample		Alternative Sample		Clean Sample		Alternative Sample	
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log Simulated Variance of Pay	0.179***	0.072***	0.090***	0.033***	0.275***	0.217***	0.204***	0.175***
	(10.65)	(4.60)	(14.71)	(8.37)	(22.80)	(17.81)	(33.10)	(21.60)
Constant	5.954***		7.561***		4.463***		5.431***	
	(23.35)		(86.66)		(24.69)		(63.82)	
Observations	939	769	6,805	6,718	939	769	6,805	6,718
Adj. R-squared	0.322	0.805	0.135	0.772	0.658	0.841	0.545	0.740
Firm + Year FE	NO	YES	NO	YES	NO	YES	NO	YES
Cluster s.e.	Firm	Firm/Year	Firm	Firm/Year	Firm	Firm/Year	Firm	Firm/Year

Table 3. Panel B. Fama-MacBeth Regressions

VARIABLES (RHS variance)	(1) Log of TDC1 Clean Sample	(2) Log of TDC1 Alternative Sample
CROSS SECTION		
2006	0.160	0.110
2007	0.155	0.119
2008	0.177	0.112
2009	0.185	0.100
2010	0.178	0.086
2011	0.253	0.116
2012	0.210	0.082
2013	0.073	0.060
2014	0.147	0.086
2015	0.253	0.101
2016	0.130	0.076
Average slope	0.17***	0.10***
T-stat (corrected)	9.64	5.94
Observations	939	6,805
Number of groups	11	11

Table 4. The Risk and Reward trade off in Pay Using Realized Conditional Volatility

This table presents results from regressions of the natural log of TDC1 (Columns 1 and 2) and the natural log of CEO wealth (Columns 3 and 4). The measures of conditional variance of pay are lagged to reflect the information known at the beginning of the period and are based on TDC1 (Columns 1 and 2) or CEO wealth (Columns 3 and 4). Panel A reports robust *t*-statistics in parentheses. Panel B reports Fama-Macbeth regressions with standard errors on the average slope corrected according to Pontiff (1996). Significance at 1%, 5%, and 10% is indicated by ***, **, and *, respectively.

VARIABLES	(1) log of TDC1	(2) log of TDC1	(3) log of CEO wealth	(4) log of CEO wealth
Lag log realized var(TDC1)	0.246***	0.046***		
	(38.92)	(6.29)		
Lag log realized var(CEO Wealth)			0.260***	0.099***
			(9.20)	(5.32)
Constant	4.789***		5.526***	
	(54.75)		(10.43)	
Observations	16,769	16,522	11,971	11,744
Adjusted R-squared	0.405	0.760	0.366	0.811
Firm and Year FE	NO	YES	NO	YES
Cluster s.e.	Firm	Firm/Year	Firm	Firm/Year

Table 5. The Risk and Reward trade off in Pay Using ARCH Conditional Volatility

The table presents estimates of ARCH-in-mean models on TDC1 and CEO wealth (TDC1 in columns 1 and 2, and CEO wealth in columns 3 and 4). The estimations assume an ARCH(p) 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) CEO wealth	(4) CEO wealth
Lag log var(TDC1)	128.0***	150.0***		
	(12.02)	(12.41)		
Lag log var(CEO Wealth)			-96.9***	-27.6
			(-5.48)	(-1.46)
Constant	-87.0	-2242.4***	10843***	44033***
	(-0.52)	(-3.39)	(26.49)	(18.42)
Industry and Year FE	NO	YES	NO	YES
ARCH(1) coefficient	2.16***	2.42***	1.68***	1.72***
	(22.33)	(20.10)	(34.55)	(34.20)
ARCH(2) coefficient			0.00005	0.00001
			(0.62)	(0.36)
ARCH(3) coefficient			0.0002**	0.00006
			(2.40)	(1.55)
ARCH constant	2.57***	2.37***	36.5***	28.5***
(in millions)	(18.67)	(16.26)	(15.41)	(13.76)
Observations	37,322	37,322	29,567	29,567

Table 6. Alternative Hypotheses Using Simulated Conditional Volatility

The table evaluates several alternative hypotheses using panel regressions and simulated conditional variance of pay. The dependent variable is the natural log of TDC1. The measures of conditional volatility of pay and skewness of pay are obtained from the simulation exercise, using compensation contract information available at the beginning of the year from Incentive Lab. 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.

	Dependent variable is log TDC1						
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log simulated variance	0.033***	0.035***	0.034***	0.030***	0.031***	0.032***	0.032***
	(8.37)	(7.92)	(8.54)	(6.60)	(8.00)	(8.11)	(5.80)
Simulated skewness		0.009*					0.011**
		(1.86)					(2.79)
Lag 3-year stock return			0.279***				0.132*
			(6.45)				(2.19)
Lag avg industry return			0.072				0.083
			(1.33)				(1.40)
Coopt				0.180***			0.025
				(4.98)			(0.43)
Institutional holding %				-0.225***			-0.139*
				(-3.39)			(-1.97)
Firm return volatility					-0.262		-0.713**
					(-0.95)		(-2.37)
Founder					-0.080*		-0.133**
					(-2.03)		(-3.03)
Age					0.004		0.004
					(1.37)		(1.36)
Log CEO tenure					0.074***		0.067**
					(3.46)		(2.54)
Log lag market value					0.179***		0.144***
					(8.67)		(5.62)
Overconfidence						0.115***	-0.018
						(5.90)	(-0.62)
Observations	6,718	6,718	6,576	5,147	6,334	6,718	4,948
Adjusted R-squared	0.772	0.772	0.780	0.796	0.788	0.774	0.802

Table 7. Alternative Hypotheses Using ExecuComp Sample

This table evaluates several alternative hypotheses. Columns 1—3 report results from panel regressions for log TDC1. Columns 4—5 report results from ARCH estimation for TDC1. Realized volatility of pay is used in Columns 1 and 3; simulated volatility of pay is used in Column 2; ARCH volatility of pay is used in Columns 4 and 5. The full ExecuComp sample is used in Columns 1, 2, and 4; ExecuComp / Incentive Lab matched sample is used in Columns 3 and 5. The measure of realized volatility of pay is computed as the lagged sample variance of last five year pay and is based on TDC1. The measure of simulated volatility of pay is obtained from the simulation exercise, using compensation contract information available at the beginning of the year from Incentive Lab. 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.

	OLS Panel Regression			ARCH Estimation	
	(1)	(2)	(3)	(4)	(5)
VARIABLES	Log of TDC1	Log of TDC1	Log of TDC1	TDC1	TDC1
Log variance of pay	0.024***	0.032***	0.005	143.4***	253***
	(3.24)	(5.80)	(0.96)	7.33	4.95
Skewness of pay	-0.042***	0.011**	-0.006	-73.43*	11.84
	(-3.15)	(2.79)	(-0.50)	(-1.76)	0.12
Lag 3-year stock	0.213***	0.132*	0.130*	-1214***	-987***
return	(3.39)	(2.19)	(1.85)	(-9.15)	(-2.75)
Lag avg industry	0.123***	0.083	0.088	92.77	238.5
return	(3.79)	(1.40)	(1.69)	0.79	0.75
Coopt	0.153**	0.025	0.072	727.1***	766.8**
	(2.54)	(0.43)	(0.82)	6.02	2.27
Institutional	0.147	-0.139*	-0.116	649.5***	803**
holding %	(1.39)	(-1.97)	(-0.90)	4.11	2.10
Firm return volatility	-0.260	-0.713**	-0.770*	5397***	9198***
	(-0.93)	(-2.37)	(-1.94)	9.05	3.86
Founder	-0.092**	-0.133**	-0.080*	-458.5***	-705.2***
	(-2.43)	(-3.03)	(-2.09)	(-5.87)	(-2.92)
Age	-0.007**	0.004	0.003	7.94*	35.17***
	(-2.17)	(1.36)	(0.45)	1.74	2.72
Log CEO tenure	0.004	0.067**	0.018	-240.3***	182
	(0.13)	(2.54)	(0.40)	(-3.51)	0.91
Log lag market value	0.166***	0.144***	0.158***	1785***	2540***
	(6.38)	(5.62)	(3.88)	35.87	32.71

Overconfidence	0.072**	-0.018	0.014	20.93	-207.7
	(2.78)	(-0.62)	(0.49)	0.34	-1.58
ARCH(1) coefficient				1.58***	1.24***
				13.79	10.41
ARCH constant				2.62***	3.44***
(in millions)				13.07	8.45
Observations	10,346	4,948	3,178	10,530	3,285
Adjusted R-squared	0.783	0.802	0.816		

Figure 1. Clean Sample Simulated Pay Versus Actual Pay

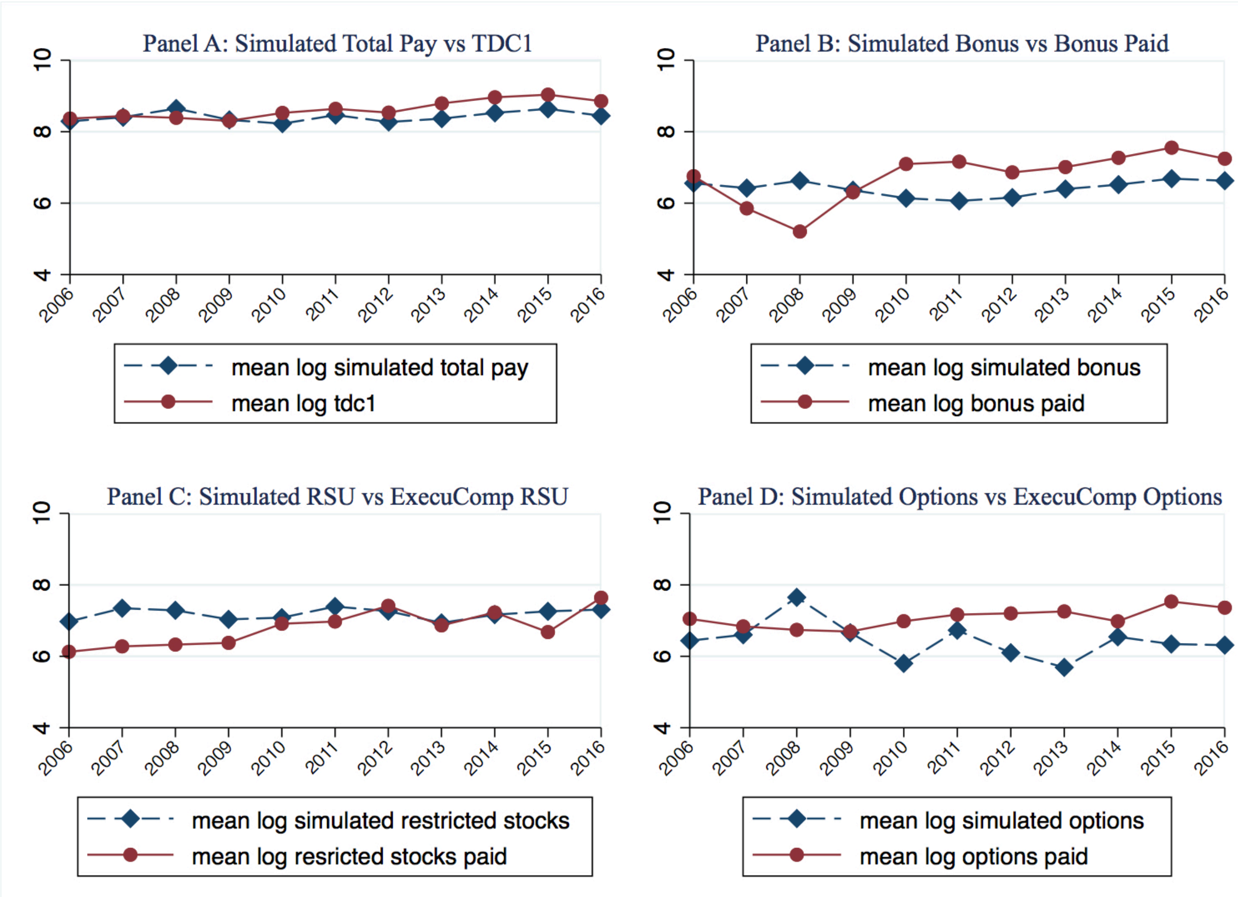


Figure 2. Clean Sample Grant Frequency Incentive Lab Versus ExecuComp

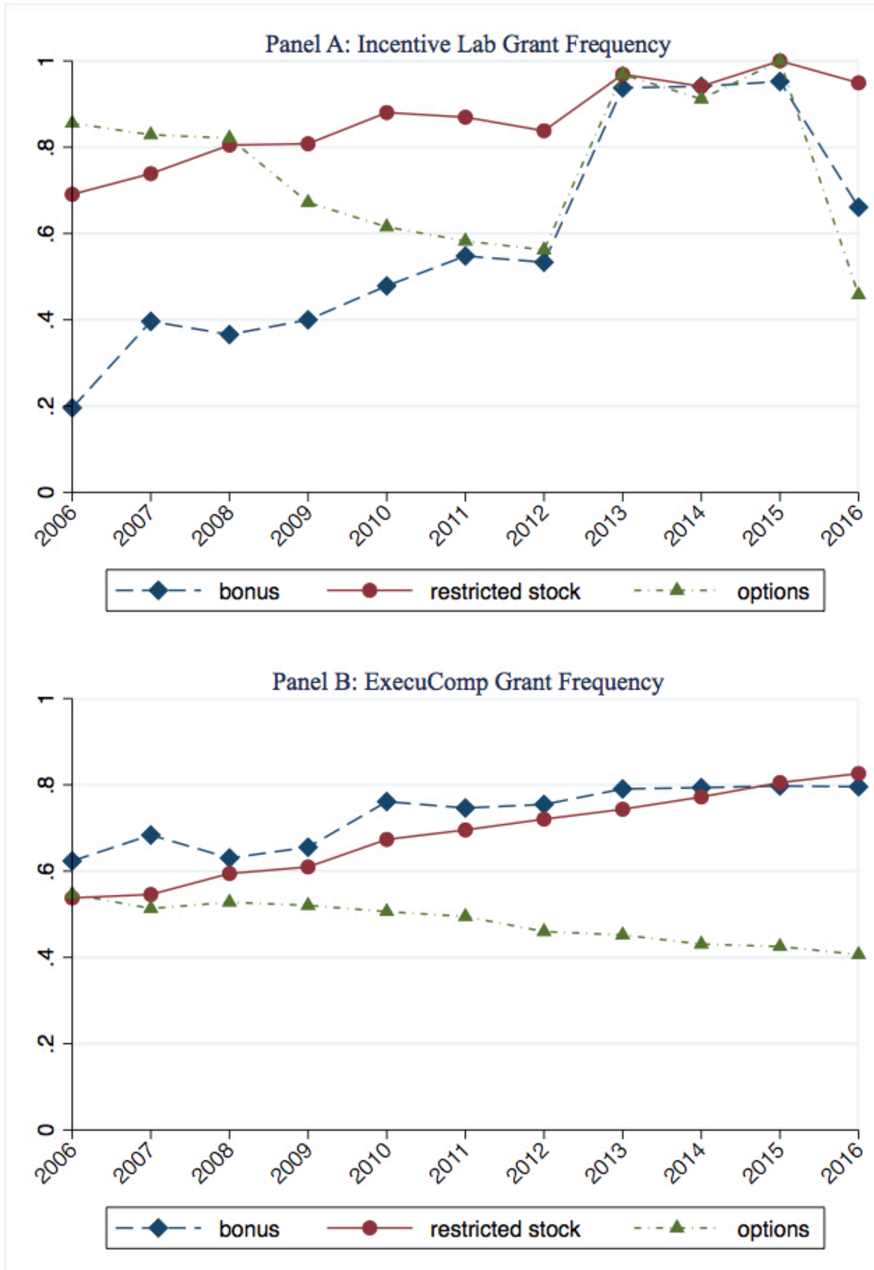


Figure 3. Alternative Sample Simulated Pay Versus Actual Pay

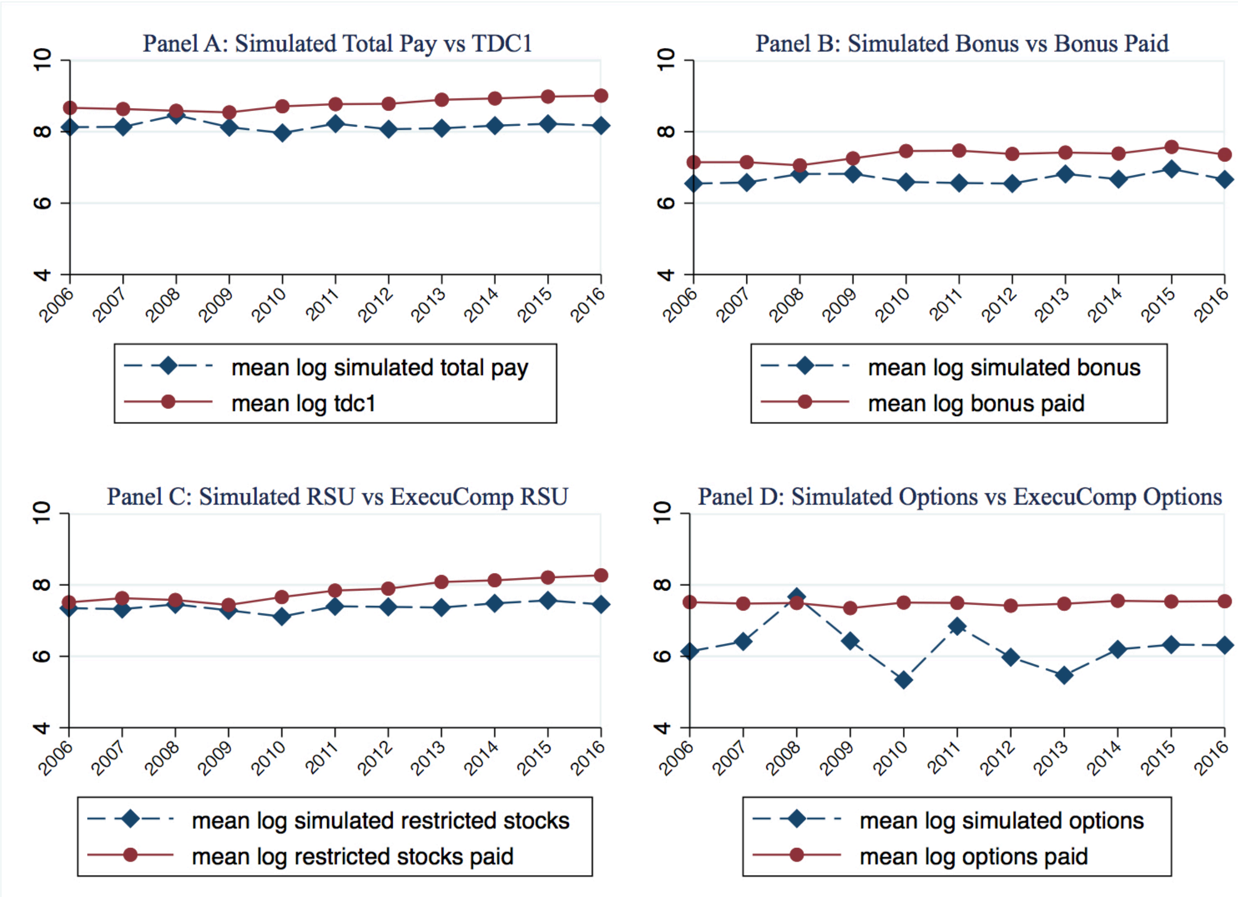
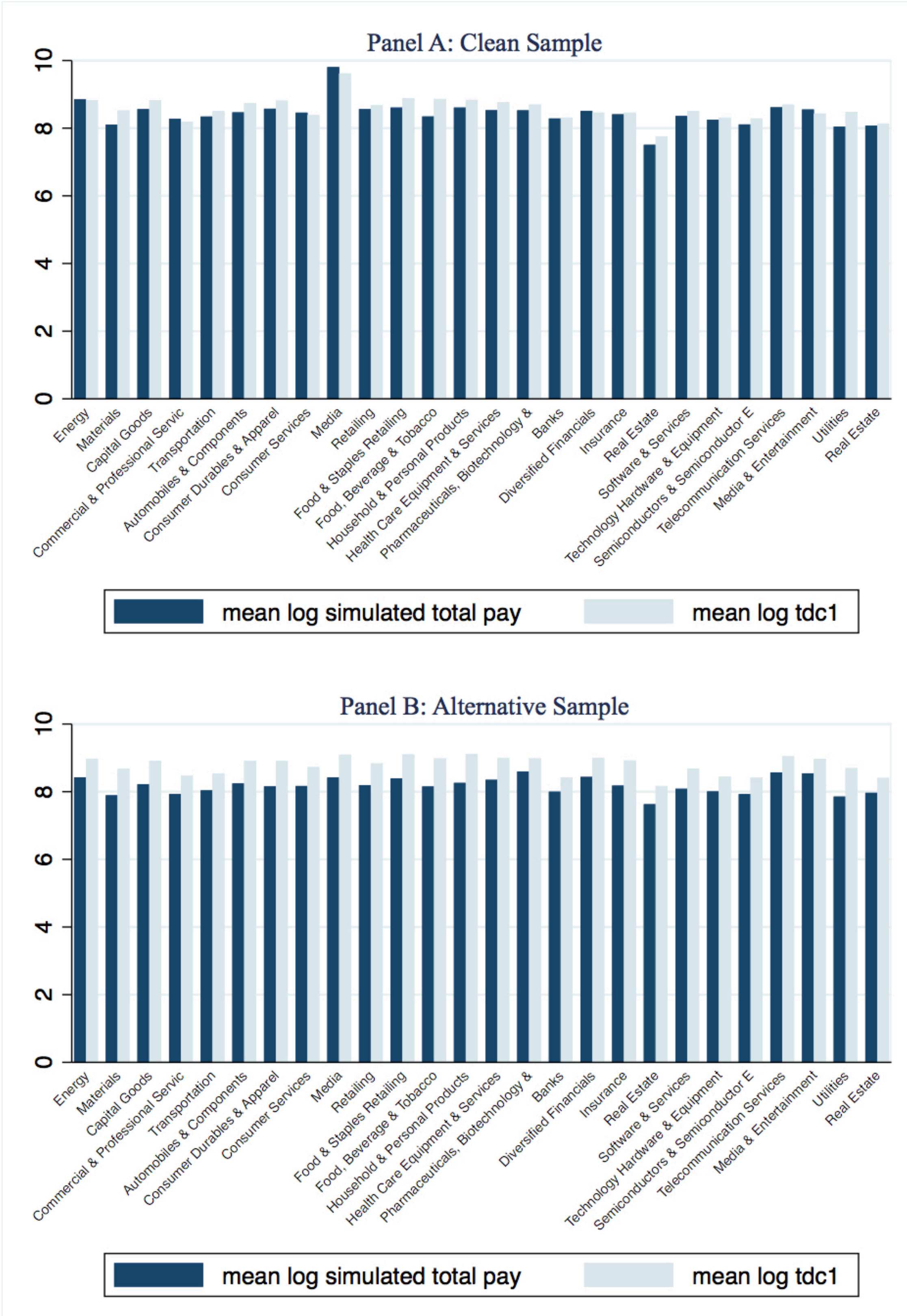


Figure 4. Simulated Pay Versus Actual Pay by GICS 4-digit Industry



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