Performance Targets and Peer Comparisons: Theory and Evidence from Executive Pay

Korok Ray & Adrienne Rhodes*

Mays Business School, Texas A&M University

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Abstract

Relative performance evaluation for executives increasingly takes the form of a performance target, in which the manager earns a bonus if his performance exceeds an explicit target based on a peer group. We model this contract in a general setting when the manager's peer benchmark is a random variable. We prove that the optimal bonus and target level are complements if the variance on the peer benchmark is sufficiently large, the bonus increases in the quality of the peers if the peers are strong, the bonus increases in the manager's ability if the ability of the manager is high, and the bonus increases in the variance of the manager's own performance. We test these results against executive pay data and find general support for the theoretical predictions.

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*Corresponding author, arhodes@mays.tamu.edu. We would like to acknowledge the helpful comments of Pierre Liang, Jack Stecher, and seminar participants at Carnegie Mellon University, Texas A&M University, and the O'Neil Center for Global Markets and Freedom at SMU.

1 Introduction

At large public corporations, the average CEO compensation contract is vastly complex. The compensation committees on the board of directors thus turn several dials when designing the CEO's contract. Yet, theoretical and empirical studies to date provide little guidance on how the board uses the many tools at their disposal to construct an efficient compensation contract. Prior academic literature consists of either theoretical models of linear contracts (which bear little resemblance to the actual nature of executive contracts), or empirical studies documenting associations between a single dimension of executive compensation and some external firm outcome (e.g., performance, project selection, earnings management).

Typical executive compensation contracts contain a base salary, an incentive component based on short term performance, a long term incentive component made up of equity compensation (such as stock, stock options, or restricted stock), a severance package, and possibly a pension package, among other elements. Performance-based pay can be tied to either an absolute performance target or a relative performance target in which the executive's performance is evaluated relative to a peer group.[1] For a single grant of compensation with a relative performance evaluation (RPE) component, the board chooses the level of pay, the performance construct to use as the target (e.g., stockholder return, net income, total sales, cash flow, etc.), the threshold level of performance at which the executive earns the compensation, the peer firms to include in

[1]For example in 2015, the CEO of 3M Co., Eugene Lee, received $953,750 in cash compensation comprised of short-term incentives, 70% of which was tied to an absolute EPS target and 30% tied to an absolute sales target. Additionally, Mr. Lee was awarded $2,231,443 in restricted stock with a performance-based vesting schedule over a three year period. Half of the restricted stock vests based on an absolute return on investment target. The other half are based on a RPE stock price target. The RPE peer group for this stock award is comprised of 47 firms, however, 3 M Co.'s disclosures did not include the threshold level of performance required for the stock to vest. Mr. Lee's compensation included $1,006,702 in option awards vesting over a three to four year period. Lastly, Mr. Lee received $1,610,498 of non-equity incentive pay and $338,661 of other compensation.

the RPE peer group, and the period over which performance is measured. How boards navigate the many choices involved in constructing an executive compensation contract remains largely unexplored.

The choice problem of the board is highly multi-dimensional and thus requires theory in order to understand precisely when certain contracting components are complements or substitutes. We resolve this puzzle by building a theoretical model specifically tailored to the RPE component of executive compensation and test the model with data on the ex-ante compensation contract features. We focus our model of RPE on the bonus, the target, and characteristics of the peer group and the contracting firm itself. Modeling these contracting choices matters because it can both describe how boards select these contracts (positive economics), as well as provide guidance on how they should think through future contract choices (normative economics).

We model a firm (principal) contracting with a manager (agent) to produce output through costly and unobservable effort. The firm holds the manager to a specific performance level, requiring performance to clear an explicit threshold to earn the bonus. In this contract, the firm picks both the award (bonus), as well as the threshold performance. In relative performance evaluation, the threshold takes the form of a ranking or percentile relative to a specified peer group's performance. For example, an executive receives a cash bonus if his firm's annual return over the last fiscal year exceeds the median return of a specified peer group. Our chief theoretical innovation is to model the performance of the peers as a random variable, because these peers select their own effort simultaneously. Since the manager sees the peer firms as random, his optimal contract will be a function of the moments of the distribution of the peer firms. With this simple framework, we generate some novel predictions that we then test against data.

Our first result concerns complementarity between the bonus and the threshold. The question of complementarity emerges from the literature in organizational design, in which firms employ multi-dimensional contracts to motivate their managers (Milgrom and Roberts [1990]). With such contracts, a natural question is whether the various instruments within these contracts are complements or substitutes. In other words, do they work together or against each other? Our first result shows that if the variance among a peer set is sufficiently large, then the bonus and the threshold are complements.

The intuition follows. Observe that the performance target contract is like an option, because it grants the executive a payment if he is successful, and therefore confers an upside benefit to the manager. As with option pricing theory, the value of an option increases in the variance. Hence, as the variation between the peers increases, the value of clearing the target increases. When the firm increases the threshold against that which the manager is compared, this decreases the manager's marginal return to effort because it decreases the probability of clearing the target and achieving the reward. In response, the manager reduces his effort. To compensate for this effect, the firm increases the bonus in order to induce the manager to exert higher effort.

The second prediction from our model considers the level of the bonus and the marginal productivity of the manager's effort. We simplify this notion and refer to the marginal productivity as the manager's ability. Our model predicts the bonus increases in the manager's ability when the ability of the manager is high. Our third prediction examines how the optimal bonus changes with the quality (i.e., performance) of the peer group. We show that if the quality of the peer group is sufficiently high, then increasing this quality will cause the firm to increase the bonus. To see this, observe that increasing the quality of the peers makes it harder for the manager to clear the target because his performance evaluation is relative. This decreases the marginal return to effort, and the manager exerts less effort. To compensate for this, the firm increases the bonus in order to induce more effort out of the manager. Conversely, if the manager's peer group is weak, he has little incentive to exert costly effort since he knows he will already clear the target. In this case, increasing the quality of the peer group increases the manager's marginal return to effort, inducing the manager to work more. Since this has an effort-increasing effect, the firm can afford to dial down the costly bonus payments. Taken together, increasing the quality of the peer group will *discourage* managerial effort if the peer group is strong but *encourage* managerial effort if the peer group is weak. The optimal bonus will respond to these two effects such that our second result predicts that the bonus increases in the quality of the peer group when the peer group quality is sufficiently high.[2]

Our fourth and final result shows that the manager's optimal bonus increases in the variance of his own performance. This also relies on the earlier intuition that the target has option value. As the manager's own performance becomes more variable, the value of the bonus increases just as the value of an option increases in its variance. When the variance on the manager's own performance is high, this is an increase in risk. Such an increase in risk dampens the manager's incentive to exert effort. The firm compensates by increasing the bonus in order to induce him to exert more effort. These results are in stark contrast with the standard risk-incentives trade-off, which argues that risk and incentives are inversely related. However, empirical results offer mixed results for the risk-incentives trade-off (Prendergast [2002]), and our data confirms our model's third result of an increase in bonus corresponding to an increase in risk.

To test our predictions, we rely on the ISS Incentive Lab database, which codifies the

[2]This is similar to general results for performance targets (Ray [2017]; Matějka and Ray [Semptember 2017]), where the effect of the target on effort levels depends on whether the target is high or low relative to equilibrium effort.

public company disclosures mandated by the SEC in 2006. We measure the bonus and threshold for each RPE contract from Incentive Lab. We proxy for the manager's ability using the Demerjian et al. [2012] measure which is made publicly available by the authors. We calculate the performance and variance of performance for each contracting firm and each relative performance peer group using stock return data from CRSP. Lastly, we calculate control variables for our empirical analysis from Compustat. In general, the data provides results consistent with the predictions developed from our model. Supporting our model's first empirical prediction, we find that the bonus increases in the threshold when variance within the peer group is large (above the sample median). Some empirical results are consistent with the models second implication regarding the bonus and the manager's ability. The data confirms that the bonus increases in manager ability when the manager's ability is sufficiently high. However, we fail to find corroborating empirical evidence consistent with the bonus increasing in manager ability when the peer group is weak or when the threshold is low. With respect to our model's third prediction, we find that the bonus increases in the quality of the peer group when the average quality of the peer group is high. Lastly, the data supports our model's fourth empirical prediction. We find that the bonus increases in the variance of the contracting firm's own performance.

This study combines theory and empirics to explore how firms implement RPE in executive bonus contracts. Our theoretical development extends the current literature and challenges future research to explore the many components making up a relative performance evaluation contract. Additionally, our empirical results indicate that the dynamic components within the RPE contract relate to one another in meaningful ways.

2 Background Literature

The theoretical literature in economics establishes relative performance evaluation (RPE) as an effective tool to filter out common noise. For example, Demski and Sappington [1984], Mookherjee [1984], Green and Stokey [1983], and Nalebuff and Stiglitz [1983] independently discover that if variance (or noise) is sufficiently large, then relative performance evaluation dominates individual performance evaluation (IPE). Though the precise setting of each paper is slightly different, the general direction of the results is similar.[3] Furthermore, Holmstrom [1982] on team production under moral hazard finds the optimal contract relies on individual performance evaluation if and only if the individual noise is independent. Including any common risk, the optimal contract will be a function of team output, such as RPE. Taken together, these papers provide conditions under which RPE dominates IPE. Yet, all of this analysis takes place in abstract models that do not reflect the precise nature of executive contracts that we consider here (such as performance targets and thresholds over peer sets). Thus, these models provide insight into the theoretical question of whether to employ an RPE contract at all, and not into the specific tradeoffs within a given RPE contract (as we do).

The second theoretical stream of literature derives from tournament theory. Lazear and Rosen [1981] establish the basic results that tournaments are efficient contracts under risk neutrality and can dominate piece rate contracts under risk aversion.[4] Tournament theory is a specific form of RPE, in which a team of agents competes against

[3]Green and Stokey [1983] assume additive common risk and quasi-linear utility and linear cost functions, whereas Nalebuff and Stiglitz [1983] consider multiplicative common risk and general risk aversion.

[4]Further extensions of tournament theory show: if the agent can increase the variance on common noise, then the agent will select infinite variance and zero effort (Hvide [2002]); prizes in multiple rounds of tournaments provide incentives for contestants to continue on to the next stage (Rosen [1986]); tournaments under internal performance evaluation place a high weight on the final review (Gershkov and Perry [2009]); if a tournament allows for collusion, then the optimal collusion proof contract depends on the identity of the agent, but not on his production (Ishiguro [2004]).

each other to win a prize. Indeed, much of the discussion of tournament theory in the business press and economic textbooks describe tournaments as a form of RPE, especially for tournaments inside the firm, such as divisional managers competing for the job of a CEO. However, tournament theory, as modeled in economic theory, does not match the current contest structure of executives in public companies employing RPE compensation plans. When a given executive is benchmarked against a set of peers, each of those peers may also benchmark against a set of peers, which may or may not coincide with the peers of the original manager. Therefore, the peers are not competing against each other for the same prize; rather, each is competing against a unique peer set for a prize that only they can achieve. For this reason, we cannot directly apply the results of tournament theory as traditional tournament models assume that a team of agents compete in the same contest together for a single prize.

The empirical literature on RPE examines whether executive compensation contracts include RPE components. Much of the prior empirical research explores whether firms employ relative performance evaluation. In the search to answer this "RPE puzzle", empirical research regresses the value of executive compensation on the performance of a peer group, in which a negative regression coefficient implies the firm did indeed employ an RPE scheme (Gibbons and Murphy [1990]; Albuquerque [2009]; Janakiraman et al. [1992]). This implicit approach to identifying RPE in practice provides mixed results. However, implicit RPE tests that account for manager age and wealth constraints (Garvey and Milbourn [2003]) or outside opportunities (Rajgopal et al. [2006]) do find evidence consistent with executive compensation contracts including RPE components. Similarly, Albuquerque [2009] finds evidence of RPE when the assumed peer group is matched on industry and size.

The Securities and Exchange Commission effectively settled the debate in 2006 by mandating public companies to disclose the details of executive compensation, including the use of relative performance evaluation, in the proxy statements. With such disclosure, we now know that most firms in the S&P 500 do in fact use RPE, and research is moving from *whether* firms use RPE to *how*. The 2006 rule mandated that firms disclose the terms of executive compensation plans, including the use of relative benchmarks. Gong et al. [2011] use the explicit disclosures of RPE targets in proxy statement filings to confirm that RPE use is quite common, with about 59% of firms including RPE targets in equity compensation plans and 23% in cash compensation plans.

Recent empirical studies on RPE focus on the determinants of including RPE targets in the compensation contract (Gong et al. [2011], Lobo et al. [2018]). Gong et al. [2011] find RPE use is more prevalent in larger firms, firms with less growth opportunities, and firms sharing common risk with their peers. Additionally, Gong et al. [2011] find that more independent boards, larger boards, and compensation consultants are all positively associated with RPE use. Lobo et al. [2018] find that firms with more comparable accounting to their industry peers are more likely to benchmark accounting-based performance against a relative performance peer group in executive compensation plans. They also find that within accounting-based RPE contracts, firms are more likely to be added (dropped) from the RPE peer group when accounting comparability with the contracting firm is higher (lower).

Another stream of recent literature focuses on firm outcomes associated with the use of RPE (Gong et al. [2016]; Tice [2017]). Gong et al. [2016] find that accounting-based RPE use is associated with a later earnings announcement date for the contracting firm. They posit that observing RPE peer performance prior to releasing earnings is beneficial. Therefore, RPE firms delay earnings announcements to facilitate managers manipulating earnings as needed to beat their RPE peers. Tice [2017] documents a positive association between RPE use and investment efficiency. She argues that the risk-sharing benefits of RPE result in the CEO implementing a more efficient investment policy. Park and Vrettos [2015] find evidence consistent with RPE influencing the association between the executive's vega and the type of risk the executive undertakes. They argue that, in the presence of an RPE contract, the manager is more likely to increase total firm risk by increasing idiosyncratic risk rather than systematic risk. This implies that RPE is an effective tool for increasing the manager's risk-taking incentives such that the manager will increase idiosyncratic risk, which benefits the firm's shareholders.

This study does not follow the prior literature in documenting either determinants of RPE use or consequences of RPE use. Our paper is closest in spirit and method to a handful of studies that build simple contracting models and test them against compensation data. Most of these papers use CEO pay data because of its widespread availability. For example, Bushman et al. (2010) and Dikolli et al. (2013) both extend the standard LEN model (linear contracts, exponential utility, and normal errors) to study turnover. Like our paper, these studies build a fairly lean model and test it against standard data sets that have populated a legion of empirical compensation papers. Similar to Matějka and Ray [Semptember 2017], our study takes a different approach by considering the multidimensional nature of the RPE contract itself. Matějka and Ray [Semptember 2017] use survey data of private company CFO pay to examine target setting under a risk neutral agent and complementarity within a class of contracts. Although prior literature guides much of our understanding of how certain elements of compensation contracts are determined or how certain elements of the compensation contract influence firm outcomes, we know very little about how the dials within a contract turn with, or against, each other. We use theory and empirics to unravel how an RPE contract is constructed, and in particular, how the different elements of RPE come together to form the executive compensation contracts we see in practice. To our knowledge, this is the first study to incorporate empirical tests of the form of the RPE contract.

3 The Model

A risk neutral firm (principal) contracts with a risk neutral manager (agent).[5] The manager exerts unobservable effort e at cost $C(e) = \frac{c}{2}e^2$. The manager's performance is given by

$$q = \theta e + \varepsilon, \tag{1}$$

where ε follows the continuous density g with mean 0 and variance σ^2. Output q can be any relevant performance measure of the firm's choice, such as earnings, stock price, or some other measure. We impose the regularity condition that g is unimodal and symmetric (so $g'(x) \geq 0$ if $x < 0$ and $g'(x) \leq 0$ if $x > 0$), which fits many common probability distributions (normal, uniform, etc.). Let G be the cumulative distribution function of the density g.

The parameter θ captures the productivity of the manager's effort, which can be a characteristic of not only the manager, but also the firm. Thus, we can interpret θ as the quality of the match between the manager and the firm. In a full structural model, it may be useful to separate this single match parameter into one component specific to the manager and another specific to the firm. However, we will abstract away into a single parameter for convenience since we will not test our model structurally. We can interpret this either as the ability of the manager or as the quality of the firm because

[5]Including general risk aversion into a model of performance targets is complex, and doing so in this paper will leave no room for the empirics. See Ray [2017] for the comprehensive analysis of optimal performance targets under risk aversion. Nonetheless, **Empirical Implications 1** and **3** still continue to hold in a model of risk aversion using mean variance preferences. Full details are available from the authors on request.

better firms have more productive managers. Ultimately, it simply tracks the marginal productivity of the manager, as higher types exhibit higher marginal productivities.

This parameter is useful when taking our model to data because our model is a principal agent model between a single firm and a single manager, yet our data comes from a population of firms and managers.[6] Furthermore, we assume that θ is known to all parties. In the adverse selection literature, θ is private information to the manager. However, that entails more significant mathematical complexity because the firm must impose a distribution around that private information. Our goal is to anchor our framework into an empirical analysis. Therefore, for simplicity, we use θ to capture some of the variation in the data to better map into the model.

The (contracting) firm employs a RPE scheme, benchmarking its manager against a set of peers. Following Hemmer [2015], we treat the performance of the set of peers as a random variable, rather than modeling the effort of all managers in the set of peers for some given manager.[7] This assumption is valid if within the set of RPE contracts the RPE peer group does not resemble a tournament. We verify this assumption within the sample of firms in the Incentive Lab database using relative performance evaluation in the agent's compensation contract. On average, half of the relative performance peers named by contracting firms do not use RPE at all.

To model the RPE contract, we assume that the targets take the form ky. The benchmark y is an aggregate of the individual measures of the peers, such as a rank-ordered list of earnings performance or stock prices of a peer industry group. The variable k is the threshold, which the performance of the manager must clear to obtain

[6] We thank the editor for suggesting this path.

[7] Modeling the strategic interaction between the own firm and its peer firm becomes impractical in any setting outside of the simple, symmetric, perfect information game. Hemmer [2015] also models the peer performance measure as a random variable, ignoring the strategic interaction between the own firm and the peer firms.

the bonus. Throughout, we refer to k as the threshold, y as the benchmark, and ky as the target. Assume that y follows the density f with mean $m > 0$. For tractability, assume f is uniform over its support $[m - a, m + a]$ and 0 otherwise. This captures the notion that the performance of the peers may be to some extent unknown or unknowable to the manager during the performance horizon.[8] The parameter a tracks the variance $(a^2/3)$ of this benchmark.

The firm contracts with the manager using a performance target contract (k, s, b) where k is the threshold, s is the fixed cash salary, and b is the bonus paid on performance.[9] The target structure takes the following form:

$$Pay = \begin{cases} s + b, & \text{if } q \geq ky \\ s, & \text{if } q < ky \end{cases} \tag{2}$$

The manager always receives a fixed salary and receives the bonus only if performance exceeds the target.[10] For a given benchmark y, the probability that the manager earns the bonus is

$$P(y) = Prob(q > ky|y) = Prob(\varepsilon > ky - \theta e|y) = G(\theta e - ky), \tag{3}$$

where the last equality follows by the symmetry of g, since $G(x) = 1 - G(-x)$. Of

[8]This assumption is plausible given that the peer firms private information regarding their prospects over the performance period is likely unknown to the contracting firm's manager.

[9]We take the bonus as a fixed payment of certain value. If the bonus was granted in the form of equity, its value will fluctuate over time based on stock price. In that case, we simply represent b as the expected value of the stock, whose realization becomes certain at a later point. Moreover, the manager's own valuation of the equity grant may differ from the firm's valuation because of his risk preferences conditional on his wealth level, as discussed in Lambert et al. [1991]. However, throughout the development of the model and empirical tests of the model's predictions we refer to, and measure, b as the manager's bonus.

[10]Actual executive contracts include multiple targets, and possibly linear interpolation between some of those targets. We focus on the most elemental, single target case for tractability and to focus the analysis on elements of the RPE contract.

course, the manager does not know the realization of y when choosing his effort, since often the horizon of the manager's decision choice is contemporaneous with that of his peers (for example, the upcoming fiscal year). As such, he takes the expectation of this probability with respect to the distribution of y, so the ex-ante probability of clearing the target is

$$P = E\Big[G\left(\theta e - ky\right)\Big] = \int_{m-a}^{m+a} G\left(\theta e - ky\right) f\left(y\right) dy. \tag{4}$$

Observe that higher values of θ imply higher probabilities of success. Therefore, there is a greater likelihood the manager will clear the target and earn the bonus when the marginal productivity of the manager is higher. Thus, for a given unit of effort, higher values of θ will result in higher output and the manager will be more likely to clear the target. We will refer to θ as a more general measure of the manager's ability.

The manager earns a reservation utility $\bar{u}$ if he rejects the contract, and we impose a standard participation constraint that his expected utility must exceed these outside options. The expected utility of the manager is given by

$$EU = s + Pb - C(e). \tag{5}$$

The first order condition from this problem generates the incentive constraint:

$$bE\Big[g\left(\theta e - ky\right)\theta\Big] = C'(e). \tag{IC}$$

Because the manager is risk neutral, the participation constraint will bind in equilibrium, and the firm can implement the first best e^* given by $C'(e^*) = \theta$.[11] The profits

[11]We do not solve for the optimal second-best contract under risk-aversion and therefore remain agnostic on its precise form. Hemmer [2015] does aim to solve for the optimal RPE contract in a dynamic setting based on Holmstrom and Milgrom [1987]. The correlation between own and peer firm measure will be a feature of his optimal contract.

of the firm are $E\pi = Eq - Ew$; therefore, the firm solves the following problem:

$$\max_{(s,b,k)} E\pi \qquad \text{subject to (IC) and (PC).} \tag{6}$$

We record the solution to this in the next proposition.

Proposition 1 *The firm can implement first best effort e^* with the following class of contracts:*

$$b^* = \frac{2ak}{G(Z_2) - G(Z_1)} \; and \, s^* = \bar{u} + C(e^*) - P^* b^*, \tag{7}$$

where $Z_2 = \theta e^* - k(m-a)$, $Z_1 = \theta e^* - k(m+a)$, and $P^* = E[G(\theta e^* - ky)]$.

(All proofs are in the appendix). Note that this contract varies from the analysis of performance targets in Ray [2017], where the target is set exactly equal to first best effort. Here, that is not possible for two reasons. First, the target takes the form of a threshold over a benchmark rather than an absolute target level. Second, the benchmark itself is a random variable, which follows its own distribution. Since there are two instruments (bonus and threshold) to induce unidimensional effort, there is a continuum of contracts (k, s, b) that implements the efficient outcome. Of course, the closed form solution for the optimal contract above is possible because of the assumption of risk neutrality. Even a parameterized version of risk aversion (through mean variance preferences) does not allow for a closed form solution of the optimal contract.

The intuition behind Proposition 1 derives from expressing the bonus in terms of the expected marginal return to effort $\frac{\partial EP}{\partial e}$. This is how much a marginal change in the manager's effort changes the expected probability of receiving his bonus. Proposition 1 shows a precisely inverse relationship between the efficient contract and this expected marginal return, so $b^* = \left(\frac{\partial EP}{\partial e}\right)^{-1}$. As the manager exerts more effort, there is a higher chance of clearing the target and receiving his bonus. Therefore, this marginal increase in effort directly affects the incentives of the manager. Knowing this, the firm can optimally decrease the bonus because paying bonuses is costly. Whether the marginal return to effort is high or low will depend on many factors, such as the level of effort that the firm seeks to induce, the support of the distribution, and the average quality of the benchmark.

A key question in organizational design is whether the various instruments available to the firm are complements or substitutes. Turning to our analysis of complementarity, we employ a formal definition of complementarity[12] from economics:

Definition 1 *The bonus and threshold are complements if* $\frac{\partial^2 E\pi}{\partial b \partial k} > 0$.

Observe that the firm maximizes expected profits with respect to contract variables b and k. The formal definition of complementarity requires that the cross-partial of the expected profit function be positive with respect to any two contract variables. In other words, the marginal expected profit with respect to the bonus must increase with the threshold, and vice versa. This is the precise way in which the two contracting variables are complements, since increasing one increases the marginal profit with respect to the other. However, because the second derivative of expected profit is empirically unobservable, we instead rely on an equivalence in testing complementarity:

Lemma 1 *The bonus and threshold are complements if and only if* $\frac{\partial b}{\partial k} > 0$.

Observe that the derivative $\frac{\partial b}{\partial k}$ tracks how much a change in bonus changes with a change in the threshold. This is ultimately how one endogenous variable changes with respect to another. The lemma shows that this derivative is positive exactly when the cross-partial

[12]See, for e.g., Milgrom and Roberts [1992], p.108.

$\frac{\partial^2 E\pi}{\partial b \partial k}$ is positive. In fact, the derivative $\frac{\partial b}{\partial k}$ is the slope of the indifference curve of the profit curves $E\pi(b,k)$, for a fixed bonus and threshold. The equivalence of Lemma 1 is not guaranteed in every model of the firm. However, our setting is sufficiently well behaved such that $\frac{\partial b}{\partial k}$ is a necessary and sufficient condition for understanding and measuring complementarity. This is empirically beneficial because we observe data on both the bonus and the threshold. We can now write our empirical implication of Proposition 1 in terms of complementarity.

Empirical Implication 1: *The bonus and the threshold are complements (substitutes) if the variation in peer performance is sufficiently high (low).*

The positive association derives from the positive derivative $\frac{\partial b^*}{\partial k}$, which emerges directly from our theory.[13] Recall that the bonus b and the threshold k are endogenous variables. As such, the firm chooses both b and k jointly to optimize its profits. Recall that the firm's problem is over parameterized, with more contract parameters than variables to control. The contract is multi-dimensional, but effort is only unidimensional, so there is a continuum of contracts that implement first best effort. Nonetheless, these contracting variables still are related within this class. We seek to understand whether an increased bonus will be paired with an increased threshold. That is precisely a question of complementarity, namely, how the different contract parameters relate to one another in the firm's joint optimization over both dimensions. Empirical implication 1 gives the precise conditions for when the bonus and threshold are complements.

Figure 1 plots the optimal bonus as a function of the threshold for different parameter values of the variation in peer performance when g is standard normal ($\mu = 0, \sigma^2 = 1$).

[13]It does not matter whether we solve for $\partial b/\partial k$ or $\partial k/\partial b$, i.e. which contract parameters are taken to be exogenous versus endogenous. We choose the former because we find it more intuitive that firms first select a threshold, and then determine the optimal bonus that fits the given threshold. This is also consistent with the empirical literature that treats bonus compensation as a dependent variable. All of our theoretical results will follow through if we consider the latter derivative, since both of the contract choices b and k are optimally chosen by the firm.

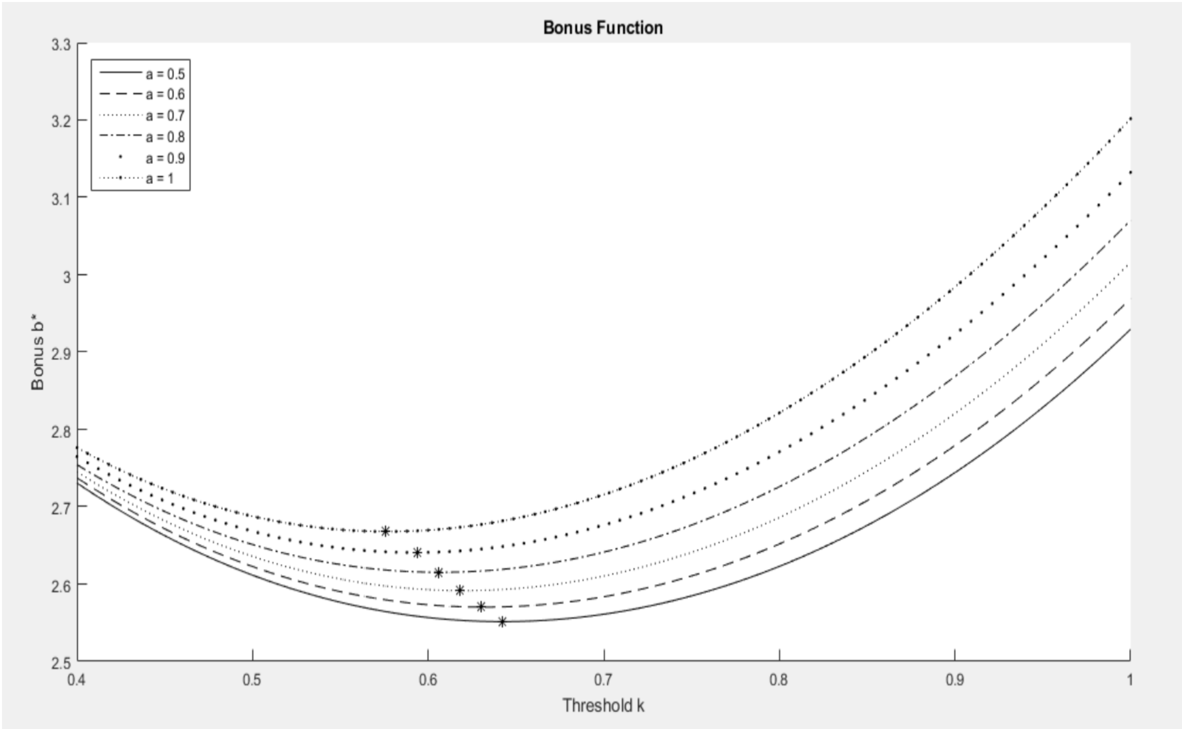

Figure 1: A plot of the optimal bonus as a function of the threshold k for different parameters of a. In this graph, we assume that $m = 1.5$, a ranges from 0.5 to 1, and g is distributed as a standard normal distribution. Furthermore, $c = 1$ so the first best effort is $e^* = 1$. With these parameter values, first best effort lies within the support of the peers.

First, observe that for any fixed peer performance variance, the bonus decreases to a minimum and then increases. Let $\kappa^*(a)$ be the minimal point on the U-shaped graph. For all thresholds $k > \kappa^*(a)$, the derivative $\frac{\partial b}{\partial k}$ is positive and, therefore, the bonus and threshold are complements. For all thresholds $k < \kappa^*(a)$, the derivative $\frac{\partial b}{\partial k}$ is negative and the bonus and threshold are substitutes.[14]

More importantly, as the variation of peer performance increases, this causes the U-shaped curves to shift upward and to the left. This is important because the minimal point on the graph moves leftward. Said differently, the function $\kappa^*(a)$ is decreasing in

[14]Empirically, from Table 2 the average threshold in the sample is 0.8. Therefore, it is more likely that $k > \kappa^*(a)$. This leads us to expect complementarity between the bonus and threshold (on average).

a. Observe that figure 1 and our first empirical implication operate in both directions: when the peer variance is low, the bonus and threshold are more likely to be substitutes than complements. This is clear from the smaller levels of peer variance, illustrated in the lower curves in figure 1. As the peer variance a decreases (moving from the topmost curve to the bottommost curve), the region over which the bonus function is decreasing (i.e., where the bonus and threshold are substitutes) grows. Our empirical tests discussed later show strong support for the bidirectional nature of our first empirical implication: complements when variation in peers is high and substitutes when variation in peers is low.

Next, we consider how the optimal bonus relates to variation in managerial ability, θ. We record these results in our next proposition.

Proposition 2 *The optimal bonus increases in managerial ability if and only if* $\theta^2 > ckm$.

The relationship between the bonus and ability is non-monotonic and depends on the parameters of the firm and manager. The joint condition is $\theta^2 > ckm$, which can be interpreted as either a sufficiently high managerial type, a sufficiently low cost of effort, a sufficiently low threshold, or sufficiently low peer group quality. Intuitively, for the bonus to increase in ability we must adhere to the joint conditions that the manager is high quality, the threshold is easy, and the average peer set is weak. If such conditions hold, then were the firm to recruit a more talented manager to work, it would need to offer a larger bonus to motivate this manager. If the conditions fail and the manager was a low-type with a high threshold, cost of effort, or average peer quality, then increasing the bonus would discourage the manager and the firm would decrease the bonus instead. High-type managers are encouraged by higher bonuses, while low-type managers are discouraged. For our empirical analysis, we test this proposition with respect to the average peer quality, leading to our next empirical implication.

Empirical Implication 2: *There is a positive association between the bonus and managerial ability if the ability of the manager is sufficiently high.*

We now turn to the relations between the bonus and the quality of the peers, represented by the variable m, the mean of the peer distribution.

Proposition 3 $\frac{\partial b}{\partial m} > 0$ *if and only if* $\theta^2 < ckm$.

Recall that the variable m is the mean of the random variable y, and therefore is the average quality of the benchmark. When m is high, the peer group is strong, making the target difficult to achieve. Proposition 3 provides conditions on the comparative static $\partial b / \partial m$. Observe that the joint condition for the sign of this comparative static is identical to the prior proposition. Ultimately, the same forces are at play. Intuitively, the differential effect on effort incentives depends on whether the manager is likely to achieve his target. This leads us to our next empirical implication.

Empirical Implication 3: *The optimal bonus increases in the quality of the peers if and only if the quality of the peers is sufficiently high.*

If the peer group is strong (and the benchmark is high) then increasing the benchmark will only discourage the manager, causing him to reduce effort. To compensate for this reduction, the firm increases the bonus to elicit effort from the manager. Conversely, when the average quality of the peer group is weak (m is low), increasing the average benchmark makes it more likely that the manager will clear the target and receive his bonus. This increases his expected compensation. As such, the firm can afford to reduce the size of the prize. Remember, bonuses are costly for the firm, so the firm does not care to pay them out unless it needs to.

The next proposition shows that we can achieve more precise comparative statics if we make an additional assumption on the noise term on the firm's own performance.

Proposition 4 *When g is uniform over $[-\alpha, \alpha]$, then the optimal contract is given by:*

$$b^* = 2\alpha, \tag{8}$$

$$s^* = \bar{u} + \frac{\theta^2}{2c} - P^*, \tag{9}$$

where $P^* = \frac{\alpha + \theta e^* - mk}{2\alpha}$.

For a uniform random variable with support of $[-\alpha, \alpha]$, the variance is $\alpha^2/3$, so α tracks the variance on the firm's own performance. The optimal bonus $b^* = 2\alpha$ increases in this variance. If we interpret variance as risk (as common in the finance literature), then Proposition 4 says that there is a positive relationship between risk and incentives ($\frac{\partial b}{\partial \alpha} > 0$). As risk increases, the firm will optimally increase the bonus, even though the manager is risk neutral.

Empirical Implication 4: *The manager's optimal bonus increases in the variance in his own performance.*

This occurs primarily because the target creates option value. Just as the value of an option increases in the variance, the proof of Proposition 4 shows that the probability of clearing the target decreases in the variance on noise (risk). As risk increases, the firm's performance is more likely to rest in the tails of the distribution, and the manager has less control over his output, thereby decreasing the probability of success. This decrease in the probability of success leads the manager to rationally reduce effort. To compensate for this effect, the firm increases the bonus in order to induce effort from the manager.[15]

[15] It is noteworthy that this effect occurs even without explicit risk aversion. In the canonical agency

The proposition also provides comparative statics on the probability of clearing the target across a variety of exogenous parameters:

Corollary 1 *The manager's equilibrium probability of clearing the target decreases in the threshold, his cost of effort, and the average performance of his peers. If $cmk < 1$, this probability decreases in the variance of his own performance.*

These comparative statics are straightforward. As the cost of effort rises, the efficient effort falls. It is more costly for the manager to exert effort, and this reduces his probability of clearing the target. As the threshold rises, the target naturally becomes harder to achieve, so the probability of success falls. As with the average performance of the manager's peer group, as risk (measured by the variance of the firm's own performance) increases, this reduces the connection between the manager's own effort and his performance.

3.1 Discussion of Assumptions of the Model

Any model with closed-form solutions must necessarily make compromises to simplify the contract into a model that can both be solved and generate precise insights and intuitions. At the same time, the model needs to fit the core features of the environment in question, which in this case is RPE in executive contracts. This necessarily requires hard choices on modeling: what can be abstracted away versus what cannot. Nonetheless, we believe this attempt is worthwhile as it generates empirical implications that are unavailable through verbal reasoning alone. Nonetheless, it is important to remember that (broadly speaking) our results derive from our particular combination of assump-

model, an increase in risk leads the principal to decrease incentives because of the manager's risk aversion. However, empirical tests of the risk-incentives trade-off provide mixed results, documented in Prendergast [2002].

tions of risk neutrality, unimodal error distribution, and representing the performance of peer firms as a single, aggregate measure.

We assume the manager is risk neutral. Solving for the optimal contract in a general target framework under risk aversion is complex and would not deliver the comparative statics that we need to test the model against data. Moreover, risk aversion does not directionally change the implications of our model, since complementarity between the different contract parameters still holds locally even when that manager faces a concave utility function.[16]

We model the peer firms as random variables rather than as strategic choices by rational agents. This is apparent from our benchmark measure y, which is the aggregate performance of the peer firms. An alternative is to include the behavior of these peer managers inside the model itself. In that sense, the true RPE game is not between simply one manager and an aggregate statistic, but rather between $n + 1$ executives: the executive in question and his set of n peers. This approach is problematic because each of those n peers benchmarks against a set of m peers. Some of these m peers may overlap with the original set of n peers, but others will not. Continuing in this fashion, each of those m peers also benchmarks against a set of $l \neq m$ peers. As such, modeling the full game is intractable, since at some point the researcher must close the model in order to generate results. This is why RPE is not a strict application of tournament theory. In tournament models, all players compete in the same contest against each other for a single prize. But in the context of modern executives today, each executive is playing against a different set of peers and with concomitant different prizes. To date,

[16]Risk aversion under mean variance preferences provides comparative statics which can map into our empirical predictions even though closed form solutions for the optimal contract are not possible. However, tools like the envelope theorem are still helpful. It is still possible to identify the shape of the expected profit function to generate **Empirical Implications 1** and **3**. Details are available from the authors upon request.

no one has fully solved this equilibrium of the RPE market. Therefore, we rely on the statistical characterization to drive empirical predictions.

Finally, our model does not allow for interpolation in our performance target contract. Interpolation occurs when the manager achieves a performance level in between two targets and the firm awards him a payoff that is the linear combination of the payoffs at those two targets. Murphy [2000] first produced the famous picture of interpolation as the "incentive zone," based on proprietary compensation data from compensation consultants. Yet, the Incentive Lab data shows that from 1998 to 2015, of the 2427 unique executives subject to relative performance evaluation, 1188 (or 45%) face a discrete target without interpolation. Therefore, we do not feel it necessary to model the more complex interpolation contract, and rather focus analysis on the basic binary performance target, which is present in many of the contracts in our sample.

4 Data and Design

Sample selection begins with compensation grants in the ISS Incentive Lab that uses relative performance targets over the period 2006 to 2015.[17] The ISS Incentive Lab covers firms that fall into the 750 largest companies with respect to market capitalization and reports details of the executive compensation contracts disclosed in the firm's proxy statements. To coincide with our model of RPE use in executive bonus compensation we restrict our empirical analysis to cash compensation tied to RPE. We identify 1,654 cash compensation grants using a market-based relative performance target. We focus on market-based RPE instead of accounting-based RPE to test our model's implications for several reasons. First, market-based RPE is more common than accounting-based

[17]We restrict the sample to only include years after the SEC mandated disclosures of RPE use in executive compensation plans.

RPE in cash compensation grants reported by Incentive Lab from 2006 to 2015. Within the cash grants tied to a relative performance target, 55% use a market-based measure of performance while 52% use an accounting based measure of performance. Second, there is significant variation in the accounting-based measures used in RPE contracts, making it difficult to capture a construct for performance which is comparable across contracts.[18] Third, the empirical tests of our model's predictions rely on measuring the variance of the performance measure used in the RPE contract. Accounting-based performance is only observable for accounting reporting periods, thus limiting our ability to capture a reliable variance measure. On the other hand, stock returns are observable on a nearly continuous basis.

To test the first empirical implication of our model, regarding complementarity between the bonus and threshold when variance in the peer group's performance is high, we require data on the RPE threshold. We measure b as the natural logarithm of the dollar value of the cash bonus tied to a market-based relative performance target. When the data is available, we capture the threshold, k, specified in the bonus contract as the percentile that the contracting firm must fall within for the executive to earn the bonus.[19] Our model's predictions are with regards to the ex ante compensation contract terms. Importantly for research regarding the ex ante contract form, Incentive Lab reports the ex ante compensation contract terms such that both b and k measure the ex ante compensation contract. After requiring data for b and k, the sample comprises 1,260 RPE cash compensation grants. We merge the sample from Incentive Lab to CRSP and

[18]Amongst cash grants using accounting-based RPE, 12.91% use a ROE threshold, 12.02% a ROIC threshold, 11.40% an EPS threshold, 9.75% a sales threshold and 17.36% a threshold specified as "Other." On the contrary, 75.91% of cash grants using market-based RPE specify a threshold in terms of total stockholder return, 18.07% in terms of stock or share price performance, and 6.02% in terms of price-to-book ratio.

[19]Many firms do not disclose the threshold (Incentive Lab terms the threshold as *percentile*) for the RPE contract. The SEC allows for non-disclosure of the threshold provided the disclosure would include proprietary information that may adversely affect the firm's competitive stance.

Compustat, resulting in 1,179 bonus contracts.

Our model indicates the complementarity of b and k is conditional on the variation in the RPE peer group's performance, a. To calculate a we identify the peer group and the performance of each peer. For each contract specifying a custom peer group for relative evaluation, the contracting firm discloses the names of the firms comprising this RPE peer group.[20] For the 1,179 bonus contracts with the contracting firm's financial, stock price, and compensation data, we collect the RPE peer firms. Each peer firm is matched to Compustat and CRSP by hand.[21] We calculate the variance in the peer group's performance, a, by first calculating the average monthly return of the peer group. We then calculate the variance of the average monthly peer group returns over the prior fiscal year. We calculate a lagged by one year because at the time the compensation contract is negotiated the variance of the peer group over the current fiscal year is unknown. If the variance of the peer group's performance is relevant for contracting, as our model suggests, the measure of peer variance would be considered retrospectively. Detailed variable definitions are contained in Table 1. The data availability to measure a further reduces the sample to 556 bonus contracts. We dichotomize a to capture the peer groups with high peer variance by setting the variable $High\_a$ equal to one when a is in the top quartile of the sample and zero otherwise. Our first empirical implication is tested with the following model estimated with OLS:

$$\begin{aligned} b_{i,t} =& \beta_1(k_{i,t}) + \beta_2(High\_a_{i,t-1}) + \beta_3(k_{i,t} \times High\_a_{i,t-1}) \\ &+ \sum_{n=4}^{10} \beta_n(Controls_{n,j,t}) + \epsilon_{i,t}, \end{aligned} \tag{10}$$

[20]Several grants are tied to an index as the relative performance measure.

[21]Incentive Lab provides a list of RPE peer names and CIK numbers. However, a non-trivial number of CIKs are missing and peer names are misspecified. Therefore, we hand match RPE peers to Compustat and CRSP using the peer names provided in Incentive Labs to preserve the number of RPE peers in the sample.

where i, j, and t represent manager, firm, and year, respectively. The vector of control variables $Controls$ is measured at the firm-year level and includes controls for size, leverage, return on assets, free cash flow, market-to-book, an indicator for managers serving as the current chief executive officer and the stock return. Consistent with prior literature we measure size as the natural logarithm of market value of equity and expect size to be positively associated with b [Gabaix and Landier, 2008]. We control for capital structure with leverage and expect more leveraged firms to pay more in cash compensation. We control for accounting performance with return on assets. Cash constrained firms may compensate managers with non-cash compensation, to control for this possibility we include a control variable for free cash flow. Growth firms are more likely to pay executives with long term equity incentives than cash compensation, therefore we control for market-to-book and expect this variable to be negatively associated with b [Lambert and Larcker, 1987]. Lastly, we expect the bonus compensation of managers serving as the CEO to be higher, therefore we include an indicator variable for CEOs. We winsorize all continuous variables at the 1st and 99th percentiles. Here and throughout our empirical tests we include industry and year-fixed effects and cluster standard errors by manager.

Consistent with our model's first empirical implication, we expect the sum of β_1 and β_3 to be positive and significant. The interaction term, $k \times High\_a$, captures the incremental association between the executives bonus and the RPE threshold when the variance of the peer group's performance is high. Additionally, we expect the coefficient on the interaction term, β_3, to be positive, consistent with the first empirical implication of our model, that the bonus and threshold are complements when the variance of the peer group is high.

From Figure 1, we can see that the relation between the bonus and threshold is not linear. In fact, the figure indicates a quadratic functional form between the bonus and threshold (i.e., a U-shaped relation). We use an alternative model to assess whether the data suggests a similar pattern:

$$b_{i,t} = \beta_1(k_{i,t}) + \beta_2(k_{i,t}^2) + \sum_{n=3}^{9} \beta_n(Controls_{n,j,t}) + \epsilon_{i,t}, \tag{11}$$

where i, j, and t represent manager, firm, and year, respectively. Consistent with Figure 1, we expect the coefficient on k to be negative and the coefficient on the squared term, k^2, to be positive. The vector of control variables, $Controls$, includes the same control variables described previously.

We test our second empirical implication that the bonus increases in manager ability when manager ability is sufficiently high, the peer group is sufficiently weak or the threshold is sufficiently low by measuring θ with the Demerjian et al. [2012] measure of managerial ability. We allow the coefficient estimate on θ to vary between firms with high and low ability managers by setting the variable $High\_\theta$ equal to θ when θ is above the sample median and zero otherwise. Similarly, Low_θ is equal to θ when θ is below the median and zero otherwise. The quality of the peer group, m, is measured by first calculating the cumulative monthly return of each peer over the twelve month period preceding the contracting firm's fiscal year. We then construct m as the average of the cumulative monthly returns across the peer firms. Similar to our measure of peer variance (a), we measure peer group quality, m, over the year preceding the year the bonus contract is struck between the manager and the shareholders. We then capture sufficiently low peer quality with an indicator variable, $IndicateLow\_m$, equal to one when the peer group's average performance, m, is less than that of the contracting firm in the prior year and zero otherwise. To capture a sufficiently low threshold we create an indicator variable, Low_k, set equal one when the threshold, k, is less than the sample median and zero otherwise. Our second empirical implication is tested with the following models estimated with OLS:

$$\begin{aligned} b_{i,t} =& \beta_1(\theta_{i,t}) + \beta_2(IndicateLow\_m_{i,t-1}) + \beta_3(\theta_{i,t} \times IndicateLow\_m_{i,t-1}) \\ &+ \sum_{n=4}^{12} \beta_n(Controls_{n,j,t}) + \epsilon_{i,t}, \end{aligned} \tag{12}$$

$$b_{i,t} = \beta_1(\theta_{i,t}) + \beta_2(Low\_k_{i,t-1}) + \beta_3(\theta_{i,t} \times Low\_k_{i,t-1}) + \sum_{n=4}^{12} \beta_n(Controls_{n,j,t}) + \epsilon_{i,t}, \tag{13}$$

$$b_{i,t} = \beta_1(High\_\theta_{i,t}) + \beta_2(Low\_\theta_{i,t-1}) + \sum_{n=3}^{11} \beta_n(Controls_{n,j,t}) + \epsilon_{i,t}, \tag{14}$$

where i, j, and t represent manager, firm, and year, respectively and the vector $Controls$ includes the control variables specified above. We include as additional control variables the threshold and the threshold squared.[22]

We next test the third empirical implication of our model, that bonus increases in the quality of the RPE peer group if and only if the quality of RPE peer group, m, is sufficiently high. To test whether the bonus increases in m, when m is sufficiently large, we allow the coefficient on m to vary between peer groups of high and low quality. To capture the association between the bonus and m when the peer group's quality is high, we set the variable $High\_m$ equal to m when m is greater than the contracting firm's performance (i.e., the contracting firm's cumulative monthly return over the same 12 month window) and zero otherwise. The variable Low_m equals m when the peer group's performance in the prior year is less than that of the contracting firm and zero

[22]Our results remain qualitatively similar when we exclude k from the specification.

otherwise. We test our third empirical prediction with the following model estimated with OLS:

$$b_{i,t} = \beta_1(High\_m_{i,t-1}) + \beta_2(Low\_m_{i,t-1}) + \sum_{n=3}^{11} \beta_n(Controls_{n,j,t}) + \epsilon_{i,t}, \tag{15}$$

where i, j, and t represent manager, firm, and year, respectively. Consistent with our model's prediction, we expect a positive coefficient estimate for peer group quality amongst high quality peer groups, $High\_m$. Conversely, we expect the coefficient estimate for peer group quality amongst low quality peer groups, Low_m, to be non-positive.

Lastly, we test the fourth empirical implication of our model that the bonus is increasing in the variance (or risk) of the contracting firm's own performance. To capture the variance of the contracting firm's performance, α, we calculate the variance of the twelve monthly returns for the prior year. Again, we use a lagged measure of α because at the time the terms of the bonus contract are negotiated the variance over the current year is unknown and unknowable to the contracting parties. Our fourth prediction does not involve constructs related to the peer group's performance (variance or quality). Therefore, the sample to test our fourth prediction is slightly larger with 1,127 observations. We formally test the third empirical implication with the following model estimated with OLS:

$$b_{i,t} = \beta_1(\alpha_{j,t-1}) + \sum_{n=2}^{9} \beta_n(Controls_{n,j,t}) + \epsilon_{i,t}, \tag{16}$$

where i, j, and t represent manager, firm, and year, respectively. We expect the coefficient estimate for α to be positive, consistent with our model's prediction.

Descriptive statistics are reported in panel A of table 2. Our sample is comprised of large firms due to the ISS Incentive Lab database being limited to the 750 largest firms with respect to market cap.[23] On average, the value of the bonus is $408,000 and the average firm market value is roughly $5.4 billion. Although simple correlations cannot decisively test all of our empirical implications, in particular the conditional predictions, we report correlations in panel B of table 2.

4.1 Empirical Results

Our first empirical implication is formally tested in column one of table 3. We find that b is increasing in k when the variance of the peer group performance is above the sample median. The coefficient estimate on the interaction between k and the indicator variable $High\_a$ is positive and significant at the 10% level (t-statistic of 1.652). The main effect of the threshold, k, is positive and significant at the 1% level (t-statistic of 3.073). The sum of β_1 and β_3 is positive and significant at the 1% level (F-statistic of 19.72), consistent with our theoretical prediction. This result provides strong support for our first empirical implication.

Next, we test whether the functional form of the relation between b and k reflects the quadratic form derived from our model and represented in figure 1. In column two of table 3, the coefficient estimates on k and k^2 are negative and positive, respectively. Both coefficients are significantly different from zero, suggesting that the data reflects the functional form obtained from our model. Therefore, the empirical results are consistent with the U-shaped pattern as shown in Figure 1. Taken together, the results reported in the first four columns of table 3 support our model's first empirical prediction. Additionally, the results suggest that the data follows the pattern displayed in Figure 1 generated from our model.

[23]Incentive Lab back fills and forward fills observations for firms that fall within the top 750 market capitalization in any year. Therefore, the coverage is roughly the firms comprising the S&P 1500.

Tests of our second empirical implication are reported in table 4. In the first column of table 4, we report a baseline specification to gauge the association between the bonus and the manager's ability. This specification indicates that on average the manager's bonus and ability are positively associated with a coefficient estimate of 0.817, significant at the 10% level (t-statistic of 1.971). In column two, we test the model's prediction that the bonus increases in the manager's ability when the peer group is sufficiently weak by interacting θ with the indicator variable for a weak peer group. The main effect for the manager's ability remains positive and significant, however, the interaction between ability and a weak RPE peer group is not significantly related to the level of the bonus (coefficient estimate of -0.012 and t-statistic of -0.066). In column three, we test the model's prediction that the bonus increases in the manager's ability when the threshold is sufficiently low by interacting θ with the indicator variable for a low threshold. Again, the main effect for the manager's ability remains positive and significant, however, the interaction between ability and low threshold is not significantly related to the level of the bonus (coefficient estimate of 0.030 and t-statistic of 0.166). Lastly, we test whether the bonus increases in the manager's ability when ability is sufficiently high. We find that the coefficient estimate of 0.622 for ability when ability is above the sample median is positive and significant at the 1% level (t-statistic of 2.692). Conversely, the coefficient estimate of 0.046 for ability when ability is below the sample median is positive and insignificant (t-statistic of 0.246). Therefore, we fail to find evidence consistent with the model's second empirical implication with respect to the association between θ and b when the peer group is weak or the threshold is low. However, we do find evidence consistent with b increasing in θ when θ is sufficiently high.

Our third empirical implication is tested in table 5. Consistent with our prediction, the results indicate that the bonus is increasing in the quality of the peer group when the quality of the peer group is sufficiently high (when the peer group outperforms the contracting firm in the prior fiscal year). The coefficient estimate on $High\_m$ of 0.717 is positive and significant at the 5% level (t-statistic of 2.327). The coefficient estimate on Low_m of -0.051 is insignificantly different from zero (t-statistic of -0.323). This is consistent with our model's prediction that b increases in the quality of the peer group if and only if the quality of the peer group is sufficiently high.

For our final empirical implication we test whether the bonus increases in the variance of the contracting firm's performance. The results are reported in table 6. We find that b is increasing in the variance of the contracting firm's performance, α. The coefficient estimate on α of 1.253 is positive and significant at the 5% level (t-statistic of 2.450). This is consistent with our model's prediction and the intuition that as the variance of the manager's performance increases then the likelihood that manager will miss the target increases, therefore, to induce the manager to exert effet the firm pays a higher bonus.

In general, our empirical results provide support for the empirical implications of our theoretical model. Additionally, these empirical consistencies provide a first step toward understanding how RPE contracts are constructed. In particular, we demonstrate the dynamic nature of the components of a RPE contract. Our model's predictions hold within a sample of bonus contracts tied to a market-based relative performance target. Although our model does not rely on a specific type of performance target, market-based or accounting-based, it is important to note that our empirical findings may not generalize to bonus contracts using *accounting-based* relative performance targets. Similarly, our empirical analysis is limited to a sample of large corporations, as covered by the ISS Incentive Lab database, and may not generalize to smaller firms.

5 Conclusion

Public companies now routinely reveal not just that they use RPE, but its precise form (i.e., the size and composition of the benchmark set of peers against which the executive is compared, the threshold level of performance above which the executive must clear in order to earn a bonus, the size of the bonus itself, the ratio of fixed to variable pay across the compensation package as a whole, and the number of different performance measures on which the executive earns his pay). This detailed structure calls for a model to guide analysis and generate predictions that can be tested against data. We do so with a principal agent model, tailored to the RPE context, and test predictions of our model with data from the proxy filings.

New databases, like the ISS Incentive Lab database, codify these disclosures into machine readable form. This provides researchers the opportunity to examine these contracts in detail. The additional disclosure detail naturally calls for more structured approaches, such as formal economic models to guide analysis on the costs and benefits of the components of the contract. We adopt a fairly lean model in order to take the first steps towards combining theory and empirics in a context that naturally calls for their combination. We are pleased to report that our empirical tests broadly confirm our theory. This shows reasonable empirical support for issues raised within the theory community for generations, such as complementarity in contract parameters.

Our contribution is both substantive and methodological. On the substantive side, we show that firms do in fact make real choices in their contract design, and there are conditions under which various contract parameters are complements and others when they are substitutes. Moreover, the optimal bonus structure can depend on the specific environment of relative performance, such as the average quality of the peer set.

On a methodological level, we derive predictions that we do not believe were available without the assistance of a formal, albeit simple, economic model. We admit that the model cannot capture all features of our empirical reality and that from a pure theory perspective it is necessarily incomplete. Yet, at the same time, we see this as a strength and not a limitation of the paper; even a basic model can provide insights that qualitative, verbal reasoning alone never could.

We imagine future research proceeding in three distinct ways. First, we hope to inspire more work that ties together a simple model with a simple test, which can be useful in the early stages of exploring a new data set. The goal is to deliver testable predictions primarily through comparative statics on the equilibrium contract. In order to deliver such comparative statics, such a model necessarily requires simplifying assumptions that ease analysis and provide several dials to turn.

A second approach is to adopt a more structural model, which even more faithfully represents the actual contract that executives face. There is a natural tradeoff between realism and tractability, as these more realistic models become less analytically tractable, leading to fewer closed-form solutions and more likely requiring extensive computer simulations. A structural model can generate specific quantitative estimates and policy counterfactuals that no reduced form model ever could, and it is the gold standard for actually estimating the model itself rather than merely the predictions of the model. We did not walk down that path on this paper not because of a lack of desire, but rather because of our belief that initial work in this area of combining theory and empirics should begin with a reduced form model.

Finally, a third approach is to conduct an ever more sophisticated empirical analysis of executive contracts motivated by issues arising in theory. For example, the disclosed contracts from proxy statements of public filings are ex ante executive contracts. Even though we cannot observe the actual ex post contract, we can observe final payoffs (i.e., executive's total compensation in the following year). Carefully calculating this difference may allow researchers to determine the level of renegotiation in the executive's contract, which could provide insight into the theory of renegotiation from contract theory. Another example is to model the compensation peers of a CEO as a kind of social network, and then to bring the tools of network theory to bear on this data set. For example, defining when some companies are "close" to one another in their social network of RPE peers, and whether this leads to greater firm performance. This analysis has already been conducted on boards of directors, so it would be a fairly easy application to RPE. Any three of these directions themselves are worth exploring, and we hope RPE continues to provide a fruitful playground for combining theory and empirical work.

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6 Appendix: Proofs

Proof of Proposition 1: Suppose the firm offers a contract (k, s, b). Given this contract, the manager maximizes his expected utility, generating (IC):

$$b\theta\, Eg(\theta e - ky) = C'(e). \tag{IC}$$

Since f is uniform over $[m-a, m+a]$ we can write the expectation as

$$\begin{aligned} \frac{\partial P}{\partial e} = \theta E g(\theta e - ky) = \frac{\theta}{2a}\int_{m-a}^{m+a} g(\theta e - ky)dy &= \frac{\theta}{2ak}\int_{\theta e - k(m+a)}^{\theta e - k(m-a)} g(z)dz \\ &= \frac{\theta}{2ak}\Big(G\big(\theta e - k(m-a)\big) - G\big(\theta e - k(m+a)\big)\Big), \end{aligned} \tag{A1}$$

where we have done a change of variables, $z = \theta e - ky$. To implement first best, impose $C'(e^*) = \theta$ on (IC), and continue with the equation above to solve for the optimal bonus:

$$b^* = \frac{1}{Eg(\theta e^* - ky)} = \frac{2ak}{[G(Z_2) - G(Z_1)]} > 0, \tag{A2}$$

where $Z_2 = \theta e^* - k(m-a)$ and $Z_1 = \theta e^* - k(m+a)$, so $Z_1 < Z_2$. The incentive constraint is not a function of s, so the firm can lower the salary without affecting incentives. So the participation constraint will bind. Therefore, we can write the ex-ante probability of clearing the target as:

$$P^* = E\left(G\left(\theta e^* - ky\right)\right) = \int_{m-a}^{m+a} G\left(\theta e^* - ky\right) f(y)dy > 0. \tag{A3}$$

Combining this with the binding participation constraint and solving for the optimal salary generates:

$$s^* = \bar{u} + C(e^*) - P^* b^*. \tag{A4}$$

Now,

$$\frac{\partial b^*}{\partial \theta} = -\frac{2ak}{\left[G(Z_2) - G(Z_1)\right]^2}\left[g(Z_2)e^* - g(Z_1)e^*\right]. \tag{A5}$$

■

Proof of Lemma 1: The expected utility of a manager facing contract (s, b, k) is

$$EU = s + bP - C(e). \tag{A6}$$

Differentiating with respect to effort generates the incentive constraint

$$e = \frac{b}{c} E\Big[g(\theta e - ky)\theta\Big]. \tag{IC}$$

To save notation, write e for e^*. The second order sufficient condition is

$$bE\Big[g'(\theta e - ky)\theta^2\Big] < c, \tag{SOSC}$$

which we assume. Differentiating (IC) with respect to bonus gives

$$\frac{\partial e}{\partial b} = \frac{\frac{1}{c} E\Big[g(\theta e - ky)\Big]}{1 - \frac{b}{c} E\Big[g'(\theta e - ky)\theta^2\Big]} > 0, \tag{A7}$$

because of the second order sufficient condition. Differentiating (IC) with respect to threshold gives

$$\frac{\partial e}{\partial k} = \frac{b}{c} E\left[g'(\theta e - ky)\theta\left(\theta \frac{\partial e}{\partial k} - y\right)\right]. \tag{A8}$$

So,

$$\frac{\partial e}{\partial k} = \frac{-\frac{b}{c} E\Big[g'(\theta e - ky)\theta y\Big]}{1 - \frac{b}{c} E\Big[g'(\theta e - ky)\theta^2\Big]} > 0 \quad \text{iff} \;\; E\Big[g'(\theta e - ky)\theta y\Big] < 0, \tag{A9}$$

where the denominator is positive from (SOSC). At first-best $C'(e) = \theta$, so the optimal bonus solves

$$b = \frac{1}{E\Big[g(\theta e - ky)\Big]}, \tag{A10}$$

so

$$\frac{\partial b}{\partial k} = -\frac{E\Big[g'(\theta e - ky)\Big(\theta \frac{\partial e}{\partial k} - y\Big)\Big]}{E\Big[g(\theta e - ky)\Big]^2} = -\frac{c}{b}\frac{\partial e}{\partial k} E\Big[g(\theta e - ky)\Big]^{-2}. \tag{A11}$$

Combine this with (A9), so

$$\frac{\partial b}{\partial k} > 0 \text{ iff } \frac{\partial e}{\partial k} < 0 \text{ iff } E\Big[g'(\theta e - ky)\theta y\Big] > 0. \tag{A12}$$

Firm profits are $E\pi = e - Ew$, so after substituting in the binding (PC), the firm solves

$$\max_{(b,k)} e - C(e) \quad \text{s.t. (IC).} \tag{A13}$$

From economics, the threshold and bonus are complements iff $\frac{\partial^2 E\pi}{\partial b \partial k} > 0$. Differentiating with respect to bonus is

$$\frac{\partial E\pi}{\partial b} = \Big[1 - C'(e)\Big]\frac{\partial e}{\partial b}. \tag{A14}$$

And again with respect to threshold gives

$$\frac{\partial^2 E\pi}{\partial b \partial k} = -C''(e)\frac{\partial e}{\partial k}\frac{\partial e}{\partial b} + \frac{\partial^2 e}{\partial b \partial k}\Big[1 - C'(e)\Big], \tag{A15}$$

where the last term is zero since $C'(e) = 1$. Combining with (A7), (A9), and (A12) we have

$$\frac{\partial^2 E\pi}{\partial b \partial k} > 0 \Leftrightarrow \frac{\partial e}{\partial k} < 0 \Leftrightarrow E\Big[g'(\theta e - ky)\theta y\Big] > 0 \Leftrightarrow \frac{\partial b}{\partial k} > 0. \tag{A16}$$

■

Proof of Proposition 2: Recall that the optimal bonus is given by

$$b^* = \frac{2ak}{G(Z_2) - G(Z_1)} \tag{A17}$$

where $Z_2 = \frac{\theta^2}{c} - km + ka$ and $Z_1 = \frac{\theta^2}{c} - km - ka$, substituting in first best effort $e^* = \frac{\theta}{c}$. Observe that

$$\frac{\partial Z_i}{\partial \theta} = \frac{2\theta}{c} \tag{A18}$$

Differentiating the bonus with respect to ability gives

$$\frac{\partial b^*}{\partial \theta} = -\frac{2ak}{\left(G\left(Z_2\right) - G\left(Z_1\right)\right)^2}\left(g\left(Z_2\right) - g\left(Z_1\right)\right)\frac{2\theta}{c} \tag{A19}$$

Recall that g is symmetric around a mean of 0. So if $\theta e^* - km = \frac{\theta^2}{c} - km = 0$ then Z_1 and Z_2 are equidistant from the mean, and by symmetry $g\left(Z_1\right) = g\left(Z_2\right)$. If $\frac{\theta^2}{c} - km > 0$, the mean of g lies below $\frac{\theta^2}{c} - km$, so $g\left(Z_1\right) > g\left(Z_2\right)$ and $\frac{\partial b^*}{\partial \theta} > 0$. Conversely, if $\frac{\theta^2}{c} - km < 0$, then the mean of g lies above $\frac{\theta^2}{c} - km > 0$, so $g\left(Z_1\right) < g\left(Z_2\right)$ and so $\frac{\partial b*}{\partial \theta} < 0$. Thus $\frac{\partial b^*}{\partial \theta} > 0$ if and only if $\theta^2 > ckm$. ■

Proof of Proposition 3: Write e for e^*. Let Z_1, Z_2 as before. Differentiate Z_1 and Z_2 with respect to m, to generate

$$\frac{\partial Z_1}{\partial m} = -k = \frac{\partial Z_2}{\partial m}. \tag{A20}$$

Now differentiate (IC) with respect to m to give:

$$X = \frac{\partial b}{\partial m} = \frac{2ak^2}{D^2}\big(g(Z_2) - g(Z_1)\big), \tag{A21}$$

where $D = G(Z_2) - G(Z_1)$. There are 3 cases.

Case 1. $Z_1 < Z_2 < 0$. In this case g is increasing over this domain, and therefore $g(Z_1) < g(Z_2)$, so $X > 0$.

Case 2. $0 < Z_1 < Z_2$. Here g is decreasing over its positive domain, so $g(Z_1) > g(Z_2)$. So $X < 0$.

Case 3. $Z_1 < 0 < Z_2$. Therefore, this implies that $e - km - ka < 0 < e - km + ka$. Define the variable $Z_3 = e - km$ to be the midpoint between Z_1 and Z_2. Suppose $Z_3 = 0$. Let $Z_i^* \equiv Z_i$ be the benchmark points for $Z_3 = 0$. Then $g\left(Z_1^*\right) = g\left(Z_2^*\right)$ and $X = 0$.

Suppose $Z_3 > 0$. Then $Z_i^* < Z_i$. Because g is increasing from (Z_1^*, Z_1) and decreasing from (Z_2^*, Z_2),

$X < 0$ since

$$g(Z_2) < g\left(Z_2^*\right) = g\left(Z_1^*\right) < g(Z_1). \tag{A22}$$

Suppose $Z_3 < 0$. By a similar argument as above (but in reverse), this means $g(Z_1) < g(Z_2)$, so $X > 0$. In Case 1, $Z_3 < 0$ and $X > 0$. In Case 2, $Z_3 > 0$ and $X < 0$. So the sign of Z_3 sufficient to determine the sign of X. Thus $X < 0$ iff $Z_3 > 0$ iff $\theta e^* > km$. Since $e^* = \frac{\theta}{c}$, this requires $\theta^2 > ckm$.

■

Proof of Proposition 4: Suppose the noise term g on the firm's own performance is distributed uniformly around zero over the interval $[-\alpha, \alpha]$. Then, G is

$$G(z) = \frac{1}{2} + \frac{z}{2\alpha}. \tag{A23}$$

Recall the definition of Z_1 and Z_2 from (A2). Plugging into G gives

$$G(Z_1) = \frac{1}{2} + \frac{\theta e^* - k(m+a)}{2\alpha}, \tag{A24}$$

$$G(Z_2) = \frac{1}{2} + \frac{\theta e^* - k(m-a)}{2\alpha}. \tag{A25}$$

Inserting these values to (IC) gives the optimal bonus $b^* = 2\alpha$.

Now, we have the ex-ante probability as

$$P^* = E\Big[G\left(\theta e^* - ky\right)\Big] = G\Big(E\Big[\theta e^* - ky\Big]\Big) \tag{A26}$$

$$= G\left(\theta e^* - km\right) = \frac{1}{2} + \frac{\theta e^* - km}{2\alpha}, \tag{A27}$$

since G is linear. This probability is interior ($0 < P^* < 1$) if $mk + \alpha > \theta e^* > mk - \alpha$. So assume the parameters are such that $P^* \in [0, 1]$. Now, consider the optimal salary. At the efficient effort e^* we have $C(e^*) = \frac{\theta^2}{2c}$, so

$$s^* = \bar{u} + \frac{\theta^2}{2c} - P^*. \tag{A28}$$

■

Proof of Corollary 1: Using the development in the proof of Proposition 4, the equilibrium probability of clearing the target is given by:

$$P^* = \frac{\alpha + \frac{1}{c} - mk}{2\alpha}, \tag{A29}$$

since $e^* = 1/c$. Observe that this probability falls in k, c, m. And P^* falls in α if $mk < \frac{1}{c}$.

■

Table 1: Variable Definitions

Contracting Variables

b	equals the natural logarithm of dollar value of the cash compensation specified in the ex ante contract that is tied to a relative performance target.
k	equals the threshold performance, above which the manager earns the bonus, expressed as a percentile of the peer group.
Low_k	equals one when k is below the sample median and zero otherwise.
a	equals the variance in the relative performance peer groups cumulative monthly returns over the twelve month period comprising the contracting firm's fiscal year.
$High\_a$	equals one if the variance of the peer group's returns is in the top quartile of peer variance for the sample and zero otherwise.
θ	equals the measure of managerial ability from Demerjian et al. [2012].
$High\_\theta$	equals θ if θ is above the sample median and zero otherwise.
Low_θ	equals θ if θ is below the sample median and zero otherwise.
m	equals the average cumulative return of the peer group over the twelve month period comprising the contracting firm's fiscal year.
$IndicateLow\_m$	equals one if the average stock price performance of the peer group is below that of the contracting firm over the prior fiscal year and zero otherwise.
$High\_m$	equals m if the average stock price performance of the peer group is above that of the contracting firm over the prior fiscal year and zero otherwise.
Low_m	equals m if m if the average stock price performance of the peer group is below that of the contracting firm over the prior fiscal year and zero otherwise.
α	equals the variance of monthly returns of the contracting firm over the fiscal year.
$Return$	equals the contracting firm's cumulative monthly return for the fiscal year.

Firm Controls

$Size$	equals the natural logarithm of the market value of equity.
$Leverage$	equals the sum of short-term and long-term debt, all over total book assets.
ROA	equals income before extraordinary items divided by average total book assets.
CF	equals operating cash flow minus cash dividends all divided by total assets.
MTB	equals end-of-year share price times shares outstanding, all over total book assets.
CEO	equals one if the executive holds the position of CEO during the fiscal year and zero otherwise.

Table 2 Descriptive Statistics and Correlations

Panel A: Descriptive Statistics

	N	Mean	σ	Q1	Median	Q3
b	1179	12.919	0.975	12.255	12.899	13.528
k	1179	0.808	0.104	0.750	0.760	0.900
k^2	1179	0.664	0.163	0.563	0.578	0.810
θ	827	0.551	0.305	0.300	0.600	0.800
α	1168	0.012	0.035	0.002	0.004	0.011
a	556	0.005	0.005	0.001	0.002	0.006
m	556	0.157	0.259	0.043	0.156	0.263
Size	1179	8.593	1.162	7.806	8.498	9.208
Leverage	1179	0.302	0.164	0.192	0.293	0.406
ROA	1179	0.046	0.051	0.020	0.044	0.078
CF	1179	0.068	0.050	0.034	0.066	0.098
MTB	1179	1.725	0.739	1.236	1.558	2.020
CEO	1179	0.198	0.398	0.000	0.000	0.000
Return	1179	0.149	0.373	-0.015	0.162	0.320

Panel B: Correlations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) b	1						
(2) k	-0.019	1					
(3) k^2	-0.015	0.977 ***	1				
(4) θ	0.001	0.005	0.017	1			
(5) α	0.000	-0.077 **	-0.085 **	-0.069 *	1		
(6) a	-0.003	-0.299 ***	-0.286 ***	0.026	0.696 ***	1	
(7) m	0.035	0.076	0.079	-0.100	0.264 ***	0.120 **	1
(8) *Size*	0.359 ***	0.027	0.028	0.150 ***	-0.244 ***	-0.259 ***	-0.074
(9) *Leverage*	0.012	0.015	0.003	-0.158 ***	0.030	-0.020	0.035
(10) *ROA*	-0.047	0.063 *	0.056	0.252 ***	-0.118 ***	-0.091 *	0.044
(11) *CF*	0.005	0.086 **	0.065 *	0.275 ***	0.022	-0.014	0.051
(12) *MTB*	-0.002	0.074 *	0.066 *	0.265 ***	-0.089 **	-0.193 ***	0.088 *
(13) *CEO*	0.534 ***	-0.001	0.001	0.009	-0.025	-0.017	-0.025
(14) *Return*	0.058 *	-0.077 **	-0.071 *	0.012	0.241 ***	0.363 ***	-0.079
(15) $Return_{t-1}$	-0.016	-0.021	-0.022	-0.011	0.522 ***	0.282 ***	0.680 ***

	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(9) *Leverage*	-0.132 ***	1					
(10) *ROA*	0.418 ***	-0.203 ***	1				
(11) *CF*	0.280 ***	-0.211 ***	0.545 ***	1			
(12) *MTB*	0.460 ***	-0.004	0.551 ***	0.428 ***	1		
(13) *CEO*	0.011	-0.009	-0.000	0.005	-0.021	1	
(14) *Return*	0.104 ***	0.067 *	0.075 *	0.200 ***	0.242 ***	0.007	1
(15) $Return_{t-1}$	0.017	0.019	0.157 ***	0.108 ***	0.137 ***	-0.012	-0.035

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: Complementarity of the Bonus and Threshold (Empirical Implication 1)

k	1.386 ***	-2.428 **
	(3.073)	(-2.093)
k^2		1.605 **
		(2.248)
$High\_a$	-0.625	
	(-1.118)	
$k \times High\_a$	1.088 *	
	(1.652)	
Controls		
Size	0.342 ***	0.396 ***
	(9.348)	(16.013)
Leverage	0.463 *	0.311
	(1.846)	(1.610)
ROA	-1.786 **	-2.081 ***
	(-2.474)	(-3.493)
CF	0.604	0.380
	(0.737)	(0.630)
MTB	-0.275 ***	-0.366 ***
	(-3.129)	(-6.749)
CEO	1.300 ***	1.314 ***
	(15.409)	(21.541)
Return	-0.072	0.092
	(-0.644)	(1.430)
Year & Industry Fixed Effects	Yes	Yes
R-Square	0.664	0.672
Observations	556	1,138

t statistics in parentheses

Standard errors are clustered by manager.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Bonus and Manager Ability (Empirical Implication 2)

θ	0.817 *	0.416 **	0.240 *	
	(1.971)	(2.537)	(1.710)	
$IndicateLow\_m$		-0.124		
		(-1.273)		
$\theta \times IndicateLow\_m$		-0.012		
		(-0.066)		
Low_k			0.021	
			(0.153)	
$\theta \times Low\_k$			0.030	
			(0.166)	
$High\_\theta$				0.622 ***
				(2.692)
Low_θ				0.046
				(0.246)
Controls				
k	3.294	1.299		7.893 **
	(0.689)	(0.303)		(2.173)
k^2	-1.091	0.637	0.766 ***	-3.971 *
	(-0.371)	(0.250)	(2.745)	(-1.809)
$Size$	0.362 ***	0.351 ***	0.386 ***	0.391 ***
	(4.137)	(6.153)	(12.650)	(13.142)
$Leverage$	0.512	1.350 ***	0.634 ***	0.720 ***
	(1.164)	(4.789)	(3.189)	(3.525)
ROA	-2.723 **	-0.032	-1.354 **	-1.385 **
	(-2.497)	(-0.042)	(-2.231)	(-2.272)
CF	-0.714	1.698	-0.569	-0.598
	(-0.488)	(1.390)	(-0.841)	(-0.846)
MTB	-0.387 ***	-0.398 ***	-0.399 ***	-0.407 ***
	(-5.651)	(-4.312)	(-7.369)	(-7.477)
CEO	1.356 ***	1.393 ***	1.395 ***	1.394 ***
	(18.047)	(15.848)	(21.367)	(21.303)
$Return$	0.019	-0.061	0.090	0.102
	(0.097)	(-0.464)	(1.278)	(1.453)
Year & Industry Fixed Effects	Yes	Yes	Yes	Yes
R-Square	0.772	0.774	0.734	0.737
Observations	349	347	827	827

t statistics in parentheses

Standard errors are clustered by manager.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Bonus and Peer Group Quality (Empirical Implication 3)

$High\_m$	0.717**
	(2.327)
Low_m	-0.051
	(-0.323)
Controls	
k	0.475
	(0.117)
k^2	0.652
	(0.270)
$Size$	0.363***
	(9.328)
$Leverage$	0.477*
	(1.857)
ROA	-1.309*
	(-1.728)
CF	0.218
	(0.252)
MTB	-0.257***
	(-2.967)
CEO	1.299***
	(15.352)
$Return$	-0.035
	(-0.318)
Year & Industry Fixed Effects	Yes
R-Square	0.666
Observations	550

t statistics in parentheses

Standard errors are clustered by manager.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Bonus and the Variance of Firm Performance (Empirical Implication 4)

α	1.253**
	(2.450)
Controls	
k	-2.452**
	(-2.090)
k^2	1.654**
	(2.274)
Size	0.410***
	(16.722)
Leverage	0.295
	(1.528)
ROA	-2.005***
	(-3.362)
CF	0.228
	(0.378)
MTB	-0.369***
	(-6.764)
CEO	1.315***
	(21.468)
Return	0.075
	(1.184)
Year & Industry Fixed Effects	Yes
R-Square	0.674
Observations	1,127

t statistics in parentheses

Standard errors are clustered by manager.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$