Cash versus share payouts in relative performance plans

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Abstract:

This study examines the risk-taking properties associated with incentive plans that use relative performance evaluation, with a focus on the form of payout, whether in cash or shares. By analyzing determinants and consequences of payout form choice, I find that share-based plans offer risk-averse managers weaker incentives to pursue projects with idiosyncratic risk compared to cash plans. This occurs because share plans—unlike cash plans—expose managers to systematic performance trends, as payout values are linked to stock prices. Additionally, I document that the variation in risk-taking incentives depends on expected relative performance and the strength of the incentives. Overall, this study's findings suggest that commonly used share-based relative performance plans might not always motivate managers to pursue innovative projects with high idiosyncratic risk when projects with systematic risk are available.

JEL classification: G30, J33, J41, M12, M41

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1. Introduction

In recent years, performance-based incentives tied to firms' relative financial performance have emerged as some of the most predominant long-term incentive mechanisms for managers of large U.S. firms. Between 2006 and 2020, for instance, the use of explicit relative performance evaluation in CEO pay plans of firms in my sample increased in prevalence from roughly 20% to more than 60%.[1] Given this pronounced shift in incentive-compensation practices, this paper aims to improve our understanding of how these now ubiquitous relative performance plans affect managerial risk-taking. Since risk-taking effects cannot be understood without considering contract-design choices, on which empirical evidence is notably scarce, this paper focuses on determinants and consequences of one such contract-design choice: the payout form.

While all relative performance plans reward managers on the basis of their firms' performance relative to a peer group—creating powerful incentives to outperform these peers—not all plans compensate managers in the same way. The most common way to pay managers is through payments tied to the firm's stock price. For example, the CEO of Intel Corporation's (2019) receives 244,510 shares of Intel's stock, worth approximately $51 each at the time, if Intel outperforms all of its peers, and zero shares if all peers outperform Intel. However, a minority of plans deviate from this choice and instead pay managers with prespecified amounts of cash. An illustration of this approach is PepsiCo Inc.'s (2019) plan, where the CEO receives $9,520,000 if PepsiCo outperforms all of its peers, and $0 if all peers outperform PepsiCo. Throughout, I refer to these plans, respectively, as "share-based" and "cash-based" relative performance plans.

Motivation for studying the payout form comes from the observation that the majority of plans are share-based, which runs counter to the standard agency-theoretic argument that the

[1] Also see, for instance, Equilar (2022) and Meridian Compensation Partners LLC. (2021, 2022).

purpose of relative performance evaluation is to insulate managers from systematic performance trends beyond their control (Holmström 1982).[2] As share value depends on stock prices that are influenced by external factors, it is easy to see that awarding shares on the basis of relative performance does not shield managers from systematic trends. Even if managers do well relative to peers, they could still receive a relatively low payout if the market or industry experiences a negative shock. Thus, only cash-based plans effectively shield managers from systematic trends because payout values, conditional on the firm's relative performance, are fixed. This begs the question of why some firms choose cash-based plans and some share-based plans.

The rationale behind this decision can be inferred both from the ex ante characteristics of the firms that choose either payout form as well as from the ex post consequences of this decision, as, in principle, the "ex ante motives" should square with rational expectations of the "ex post risk-taking consequences." With respect to these risk consequences, it is important to distinguish between aggregate systematic and firm-specific idiosyncratic risk. Since cash-based plans fully shield managers from systematic trends, their expected compensation value increases only in firm-specific risk; these plans thus give managers clear incentives to pursue projects with idiosyncratic risk to beat peers. By contrast, the expected value of share-based plans also increases in systematic risk, thereby reducing managers' sensitivity to—and therefore the subjective gains from taking on—idiosyncratic risk. Since risk-averse managers favor projects characterized by systematic risk over projects with idiosyncratic risk, the central prediction in this paper is that cash-based plans are more positively correlated with future idiosyncratic risk compared to share-based plans, on average and holding all else constant.[3] In

[2] See, for instance, Bizjak, Kalpathy, Li and Young (2022) and Gong, Li and Shin (2011) for previous work that highlights the differential use of cash-based and share-based relative performance plans.

[3] Managers prefer systematic risk because this risk component allows them to better diversify their overall wealth, as they can manage exposure to systematic risk by trading the market portfolio. Managers are unable to hedge idiosyncratic risk due to de facto mandatory restrictions on trading derivative instruments linked to their

the cross-section of firms, I further predict that these differential risk-taking incentives: (1) are present primarily when managers expect to meet the threshold to qualify for compensation, as there are no benefits to shifting to systematic risk when managers expect to receive zero shares; and (2) intensify for plans that provide stronger economic incentives.

If boards have rational expectations, then the ex ante characteristics of firms that choose to use a cash-based plan should align with the prediction that these plans are used to motivate managers to pursue projects primarily characterized by idiosyncratic risk—i.e., innovation (Holmström 1989; Pástor and Veronesi 2009)—whereas the choice to use a share-based plan should be determined by other factors. To test these predictions, I estimate a multinomial logit model that assesses the joint likelihood of whether the firm uses a cash-based plan, a share-based plan, or does not use relative performance evaluation at all. Consistent with the predictions, I find that cash-based plans are common among firms facing innovation-related agency conflicts and those governed by investors who seek innovation while being tolerant of potential early-stage failures. By contrast, I find that the choice to use a share-based plan relates to various factors, including several institutional developments in recent decades (Murphy and Jensen 2018), strategic interactions in the product market (Janakiraman, Lambert, and Larcker 1992), and managerial power (Dikolli, Diser, Hofmann, and Pfeiffer 2018).

Next, I test the ex post risk-taking consequences of the payout form choice. Starting with the on-average prediction, I find descriptive evidence that suggests cash- and share-based relative performance plans provide managers with differential incentives to alter their firms' risk profile. In a within-firm comparison, the adoption of a cash-based plan, compared to the adoption of a share-based plan, is associated with increases in projects with idiosyncratic risk, as indicated by research and development intensity, and decreases in projects with systematic

own firms (Meridian Compensation Partners LLC. 2021). While these assumptions are standard in the literature (Garvey and Milbourn 2003; Jin 2002), managers still have these differential risk preferences even when prohibited from trading the market portfolio (Armstrong and Vashishtha 2012).

risk, as indicated by systematic stock-return volatility. However, since boards endogenously choose payout forms, these descriptive findings need not establish the existence of differential risk-taking effects, as the aforementioned selection effects are an apparent alternative explanation. To attempt to disentangle these effects, I perform several analyses to test whether selection is the primary factor driving the differential incentives to pursue innovative projects.

One way to address selection concerns is to find an instrument for the payout form decision. Based on anecdotal evidence, I instrument this decision with the percentage of total shares outstanding held by senior management, for which larger values appear to deter share-based payouts to avoid additional share dilution. While explicit about the source of identifying variation, a downside of this method—assuming the instrument is truly conditionally exogenous—is that the estimates might be representative only of firms whose contract-design choices are affected by the instrument. As a complement, I therefore also use a method that does not rely on the existence of a narrowly-defined instrument but instead "controls for" endogeneity, specifically stemming from innovation-related agency conflicts.[4] As a final check, I use the bounding technique put forward by Oster (2019) to assess what the impact of unobservable factors needs to be to nullify the baseline finding. All three tests produce consistent results. As each test relies on a different set of identifying assumptions, their combined findings should assuage concerns that the relation is driven primarily by selection.

In order to test the cross-sectional predictions that the differential risk-taking incentives are a function of managers' expectations of meeting the compensation threshold and the strength of incentives, respectively, I estimate the expected ranking of the firm within its peer group based on analysts' target price forecasts and measure the steepness of the pay-performance relation along with the size of the grant. When I use these measures to perform

[4] See Klein and Vella (2010) for this control function regression method, and see, for instance, Armstrong, Nicoletti and Zhou (2021) for a recent application of this method in the context of managerial risk-taking.

sample partitions, the results indicate that both factors moderate the earlier findings. First, the differential risk-taking incentives are present when managers expect to meet the threshold to qualify for compensation and absent for their counterparts not expected to qualify for compensation, consistent with there being little benefit in shifting to systematic risk when managers expect zero shares. Second, plans with stronger incentives intensify the differential risk-taking incentives, and particularly so when managers expect to qualify for compensation.

Overall, the findings in this paper suggest that the risk-taking properties of relative performance plans with share payouts may differ from those of their cash counterparts, and that these differential incentives may further depend on both expected relative performance and the strength of the incentives offered. Three limitations, however, prevent a causal interpretation of these relations. First, although these findings are consistent with theories of subjective expected utility and asset pricing, they could potentially be consistent with other theories in which, for instance, the payout form matters only as a second-order effect. These theories would then have to explain why managers favor systematic risk to idiosyncratic risk when evaluated on distinct relative performance plans other than through the payout form. Second, the theory developed here comes with limitations inherent in this literature, as various key ingredients—such as managers' risk aversion, the composition of their total wealth, and their degree of diversification—are unobservable. Because these assumptions determine the subjective evaluation of incentives (Lambert, Larcker, and Verrecchia 1991), they also influence the predictions. Third, although I use multiple distinct tests to come to these conclusions, each test relies on various assumptions and is therefore subject to identification concerns.

This paper is related to the literature on executive incentive-compensation. Similar to previous work (Do, Zhang, and Zuo 2021; Wruck and Wu 2022), this paper examines the relation between relative performance plans and firms' risk profile. However, rather than focusing on the general relation between the use of relative performance evaluation and firm risk, the focus here is on whether specific plan characteristics give managers differential incentives to alter their firms' risk profile. By examining these characteristics in depth, this paper offers new and nuanced insights into *how* relative performance plans relate to managerial risk-taking. In this respect, the paper emphasizes the relations between managerial risk-taking and the payout form, expected relative performance, and the strength of incentives.[5]

The perspective that the risk-taking properties of relative performance plans with share payouts may differ from those of their cash counterparts holds practical interest for two reasons. First, it underscores the "social" responsibility that boards play in managing firms' risk profile, thereby controlling systematic risk in capital markets—an excess of which arguably led to the financial crisis of 2007–2008 (Bair 2010; Schapiro 2010b). Second, as innovation is largely driven by idiosyncratic risk-taking (Holmström 1989; Pástor and Veronesi 2009), it suggests that relative performance plans need not unambiguously—and might not at all—encourage managers to pursue innovation. In light of growing concerns about the innovativeness of firms (Atkinson 2020; Rybnicek 2020), coupled with mounting empirical evidence supporting these concerns (Akcigit and Goldschlag 2023; Cunningham, Ederer, and Ma 2020), there may be a need to reassess whether firms and managers have effective incentives to innovate.

2. Related literature and hypothesis development

2.1. Relative performance evaluation

Holmström (1982) shows that when performance outcomes are affected by common external shocks, peer performance serves as a signal to insulate agents from these systematic performance trends—favoring relative performance evaluation to its absolute counterpart. Although the theoretical benefits from relative performance evaluation ("RPE" henceforth) are

[5] As discussed by Schapiro (2010a), it is vital to understand *how* incentive-compensation practices affect risk-taking. To the extent that expected relative performance is not directly observable from information in firms' SEC filings, a practical insight is that the Compensation Discussion and Analysis section in the Form DEF 14A ("definitive proxy statement") might paint an incomplete picture of managers' "true" risk-taking incentives.

not new (Gibbons and Murphy 1990; Lazear and Rosen 1981; Nalebuff and Stiglitz 1983), its ubiquity in recent years is. Recent evidence indicates that more than half of U.S. executive incentive-compensation contracts now contain some form of RPE (Bizjak et al. 2022). Furthermore, for firms using RPE, these plans provide economically significant incentives to managers, constituting nearly half of the total value of performance-based awards in managers' incentive-compensation contracts (De Angelis and Grinstein 2020).

Previous empirical work highlights variation in the design of RPE plans (Bizjak et al. 2022; Carter, Ittner, and Zechman 2009). From a manager's perspective, who arguably aims to maximize expected utility, the design of RPE plans is crucial for subsequent decision making. The goal of this paper is to examine variation in these plans' payout forms, whether in cash or shares. The focus on this characteristic comes from two related observations. First, evidence reveals a growing disparity between the two payout forms, with a majority of firms opting for shares (Bizjak et al. 2022; Gong et al. 2011). Second, when payouts are in shares, RPE does not insulate managers from systematic trends as payout values depend on stock prices—which are affected by external shocks. These observations raise questions about what drives firms' choices for distinct payout forms and what, if any, impact these choices have on managers' decisions. I develop hypotheses for these determinants and consequences questions below.

2.2. Hypothesis development

2.2.1. Determinants of distinct payout forms

2.2.1.1. Cash-based payouts

I hypothesize that boards' reliance on cash-based RPE comes from their aim to incentivize innovation—which is characterized primarily by idiosyncratic performance and risk (Pástor and Veronesi 2009). Motivating innovation is challenging and requires a combination of mechanisms, with two elements being essential (Holmström 1989; Manso 2011). First, it requires a commitment to a long-term plan. Second, it requires incentives, preferably with convex properties, that reward long-term success of the firm.

Cash-based RPE can assist in this context for two reasons. First, cash-based RPE filters systematic trends from performance and pay, providing clear incentives to pursue idiosyncratic risk. Second, long-term cash-based RPE plans effectively reward long-term success of the firm since a reward is always assured upon success—even in a weak market. By contrast, share-based RPE plans may not provide a guaranteed reward for success, as payout values depend on stock prices, which fluctuate with general market conditions. Thus, share-based RPE may not adequately reward managers for revolutionary innovations in bear markets.

If the above prediction is empirically descriptive, then boards' choices for cash-based RPE plans should be associated with innovation-related factors. One of these factors is the willingness to tolerate early innovation failure. Manso (2011) shows that such tolerance can be achieved if shareholders commit not to fire managers for early innovation failure—even if it is ex post efficient to do so. With this intuition in mind, I predict that firms using cash-based RPE plans are more (less) likely to governed by investors with a long-term (short-term) horizon.[6]

A second factor that underscores innovation as a determinant for cash-based RPE plans is the existence of agency problems that deter innovation. It stands to reason that if boards implement cash-based RPE to combat the lack of innovation, these plans should be more prevalent in firms where these agency conflicts are more prominent. Previous work shows that these agency conflicts are more pronounced for managers facing horizon problems, such as those nearing retirement (Dechow and Sloan 1991; Gibbons and Murphy 1992).

A final innovation-related factor is strategic flexibility. Such flexibility would enhance a firm's ability to gain a competitive advantage and innovate in turbulent markets (Eisenhardt

[6] See, for instance, Tian and Wang (2014) for empirical evidence on the relation between tolerance for failure and innovation, as well as the role long-term investors play in such failure tolerance. Conversely, other work indicates that investors with a short-term horizon are less likely to tolerate failures and pressure managers to focus on short-term results, resulting in earnings management (Bushee 2001; Matsumoto 2002), real earnings management (Bushee 1998), and systematic contract-design choices (Dikolli, Kulp, and Sedatole 2009).

and Martin 2000; Teece, Pisano, and Shuen 1997). Strategic flexibility would also be relevant in the context of RPE because, in situations with limited project choices, RPE can lead to suboptimal project selection decisions (Dye 1992).[7] Moreover, if firms and their peers compete for a handful of projects, RPE may also lead to costly sabotage or collusion (Dye 1984), rather than foster innovation. Therefore, I expect that the benefits of using cash-based RPE to motivate innovation are larger for firms with greater levels of strategic flexibility.

Collectively, the above discussion leads to the first hypothesis (stated in alternative form), which predicts that the economic determinants of cash-based RPE are threefold.

Hypothesis 1. *The probability of using RPE with cash-based payouts is increasing in:*
(a) institutional ownership that tolerates early innovation failure;
(b) the severeness of innovation-related agency costs; and
(c) strategic flexibility.

2.2.1.2. Share-based payouts

If boards use cash-based RPE to give managers incentives to pursue innovative projects with idiosyncratic risk, then the choice to use share-based RPE should be related to other factors. I hypothesize that three factors may explain reliance on share-based RPE, including several recent institutional developments (Murphy and Jensen 2018), strategic interactions in the product market (Janakiraman et al. 1992), and managerial power (Dikolli et al. 2018).

First, reliance on share-based payouts could be attributed to several related institutional developments over the past two decades, including the passage of SFAS 123R, the rising tide phenomenon, and the encouragement of share-based RPE by proxy advisors. SFAS 123R eliminated accounting advantages associated with stock options, leveling the playing field for share-based incentive-compensation arrangements.[8] The rising tide phenomenon refers to the

[7] With RPE, managers will be inclined to choose the project where their relative performance is greatest—and not necessarily where their absolute performance is greatest. Dye (1992) shows that these projects need not coincide when there is limited discretion in project choice. In those cases, RPE incentives will motivate managers to select lines of business where the competition is "easy" as opposed to selecting those that offer the highest return on an absolute basis (Lambert 2001).

[8] Carter, Lynch and Tuna (2007) and Hayes, Lemmon and Qiu (2012) show that boards adopt share-based incentives in lieu of option-based incentives in response to SFAS 123R.

critique that rising stock market valuations increase managers' equity-based pay, even if the firm underperforms relative to peers—a situation where share-based RPE is often noted as a panacea.[9] For instance, Abowd and Kaplan (1999, 162) write:

> "*Stock options reward stock price appreciation regardless of the performance of the economy or sector. Why should CEOs be rewarded for doing nothing more than riding the wave of a strong bull market?* ***If the exercise price could be linked to measures like the S&P 500, or an index of close competitors, then executives would be rewarded for gains in stock price in excess of those explainable by broad market factors outside their control***" (emphasis added).

And, relatedly, to illustrate proxy advisors' encouragement of share-based RPE, consider, for instance, Glass Lewis & Co.'s (2022, 54) policy guidelines:

> "***[E]quity-based compensation*** *can be an effective way to attract, retain and motivate key employees. There are certain elements that Glass Lewis believes are common to most well-structured long-term incentive (LTI) plans. These include:*
> – *[…]*
> – ***At least one RPE metric*** *that compares the company's performance to a relevant peer group or index*" (emphasis added).

Firms may closely follow proxy advisors' guidelines to avoid unintended consequences from creative incentive practices and potential conflicts between managers and boards, among other things (Holmström 2006). Anecdotal evidence supports this, indicating that boards adopt share-based RPE in response to external pressures. For example, Johnson & Johnson (2012, 29–31) and American Express Company (2019, 6–7) replaced their long-term cash incentives with long-term share-based RPE plans in response to pressure coming from "say-on-pay" votes, which are largely influenced by proxy advisors' recommendations (Malenko and Shen 2016).

Second, aside from using RPE plans to improve contracting efficiency, the strategic interaction literature shows these plans can also be used to commit managers to aggressive behavior in the product market (Aggarwal and Samwick 1999; Bloomfield, Marvão, and Spagnolo 2023; Feichter, Moers, and Timmermans 2022). Specifically, in more competitive

[9] See, for instance, Edmans, Gosling and Jenter (2023) for recent field evidence on this point. Their survey findings highlight that although directors believe that CEOs should benefit from an industry upswing—since investors and stakeholders do—this viewpoint receives little support among investors.

industries, managers are incentivized to not only maximize their own firm's value but also to minimize the value of rival firms. Using RPE in this way implies that peer performance is informative about managers' actions. Consequently, it is beneficial to not completely remove the systematic component of performance from managers' pay (Janakiraman et al. 1992). Thus, in competitive environments, boards may favor share-based RPE over cash-based RPE.

Third, although the systematic component of performance imposes risk on managers, there are advantages to allowing pay to vary with this risk as it can also increase the value of managers' pay. This is especially useful when managers' outside opportunities are correlated with general market conditions (Oyer 2004). In this regard, Dikolli et al. (2018) posit that managers compare the benefits and costs of economizing on expected systematic performance. They also demonstrate that systematic risk is not eliminated in firms with powerful managers. This insight suggests that powerful managers, under the guise of adhering to high quality governance principles through RPE, influence boards to retain the benefits of systematic risk in their pay—thereby preferring share-based RPE to cash-based RPE.

Collectively, the above discussion leads to the second hypothesis (stated in alternative form), which predicts that the economic determinants of share-based RPE are threefold.

Hypothesis 2. *The probability of using RPE with share-based payouts is increasing in:*
(a) outside pressure to combat the rising tide phenomenon;
(b) the degree of product market competition; and
(c) managerial power over the board.

2.2.2. Risk consequences of distinct payout forms

This section develops hypotheses related to the consequences of distinct payout forms in RPE plans, particularly with respect to managers' risk-taking incentives. In thinking about risk-taking incentives, several studies underscore the importance of distinguishing systematic and idiosyncratic risk (Duan and Wei 2005; Henderson 2005; Tian 2004). This distinction is important because shareholders and managers have distinct preferences for these types of risk.

Shareholders want managers to undertake positive net present value projects with high idiosyncratic risk because such projects increase firm value and they can only get exposure to such projects through firms, while they can easily expose themselves to systematic risk by holding the market portfolio.[10] However, managers may opt for projects with systematic risk over those with idiosyncratic risk when such alternatives are available (Acharya and Bisin 2009; Armstrong and Vashishtha 2012; Tian 2004). This is because a substantial portion of managers' wealth is heavily exposed to the idiosyncratic value of their firms due to binding ownership guidelines put in place to reduce agency problems stemming from the separation of ownership and control (Jensen and Meckling 1976). Unlike shareholders, managers cannot reduce undesired exposure to their own firms' idiosyncratic risk, as most firms prohibit them from trading derivative instruments linked to their own firms' stock (Meridian Compensation Partners LLC. 2021). Nevertheless, like shareholders, managers can unwind undesired exposure to systematic risk by going less long in the market in their personal investments (Jin 2002).

To resolve this risk-related agency problem, boards require a mechanism that narrows the gap in idiosyncratic risk preferences—motivating managers to pursue projects characterized by high idiosyncratic risk. In theory, RPE offers this mechanism (Holmström 1982). By evaluating managers based on their firms' performance relative to peer firms', managers are neither rewarded nor penalized for systematic performance trends. Instead, they must increase their firms' idiosyncratic performance to outperform peers. Thus, evaluating managers based on their firms' relative performance should incentivize them to increase idiosyncratic rather than systematic risk. However, if managers are subsequently compensated

[10] Although modern portfolio theory proposes that investors hold the market portfolio in equilibrium, empirical evidence reveals that investors do not hold perfectly diversified portfolios (Goetzmann and Kumar 2008; Kumar 2009; Mitton and Vorkink 2007). Instead, investors tend to invest in firms that, through their innovative projects, generate abnormal returns beyond those of the market portfolio. Intuitively, abnormal returns are attainable only by exposure to firms' idiosyncratic risk, as abnormal event-related returns are determined by the volatility of individual stock returns relative to systematic factors (Campbell, Lettau, Malkiel, and Xu 2001).

with shares of their firms' stock, the value of their payouts becomes inherently linked to their firms' stock price—which are affected by systematic trends. As risk-averse managers prefer systematic risk, share-based payouts reduce managers' sensitivity to, and therefore the subjective gains from taking on, idiosyncratic risk compared to cash-based payouts. This intuition suggests that cash- and share-based RPE plans provide managers with differential risk-taking incentives.

To formalize this intuition and provide a basis for the empirical analysis, I follow prior literature and use a model of risk-taking incentives based on first principles from subjective expected utility theory, specifically, the certainty equivalent framework.[11] This framework starts from the principle that an agent's response to incentives depends on the value the agent places on those incentives. It also stipulates that the value of uncertain incentive-compensation equals the immediate cash payment that yields the same expected utility as the uncertain incentives would. Thus, an agent's subjective value of an incentive-compensation arrangement (referred to as the "certainty equivalent") can be thought of as the guaranteed sum of pay the agent would accept now instead of taking a chance on potentially greater, but uncertain, compensation. Intuitively, the agent prefers the arrangement with the greatest subjective value.

The goal of the model is to generate exact testable predictions for the effects of key characteristics of RPE plans on a risk-averse agent's incentives to alter idiosyncratic and systematic risk. To conserve space, Appendix B details the model. Although the primary focus is on the payout form of RPE plans, I also consider two additional plan characteristics that likely trigger first-order interaction effects: expected relative performance and RPE incentive strength. Figure 1 illustrates these characteristics by depicting the RPE plans of Chevron Corporation (2019) and The Coca-Cola Company (2019). Expected relative performance

[11] See, for instance, Armstrong and Vashishtha (2012), Duan and Wei (2005), Henderson (2005), Park and Vrettos (2015), and Tian (2004) for similar models. Also see, for instance, Conyon, Core and Guay (2011), Gormley, Matsa and Milbourn (2013), Hall and Murphy (2000, 2002), Kahl, Liu and Longstaff (2003), Lambert et al. (1991), and Lewellen (2006) for variants of this model without explicit risk substitution.

varies with characteristics of the peer group, which differ widely between these firms. With regard to incentive strength, Chevron Corporation's plan provides larger payouts and exhibits a higher level of payout convexity compared to The Coca-Cola Company's plan.

To examine the effects of payout forms, expected relative performance, and incentive strength on an agent's risk-taking incentives, I solve for the agent's certainty equivalent across different RPE plans with different payout forms, different levels of expected relative performance, and different levels of incentive strength, while holding the agent's total wealth constant. Since a closed-form solution is not available for certainty equivalent value, I estimate these values numerically by simulating the price processes for the market portfolio and the firm's stock. I perform these simulations for a baseline scenario as well as for two scenarios in which I exogenously alter the idiosyncratic and systematic volatility of the firm's stock returns, respectively. A comparison of the latter scenarios to the baseline scenario sheds light on what would be the expected change in the agent's expected utility if the agent endogenously alters the firm's idiosyncratic or systematic risk profile. Results of these simulations are in Figure 2.

Figure 2 Panel A depicts a risk-averse agent's incentives to increase idiosyncratic and systematic risk in response to RPE plans with distinct payout forms and different levels of expected relative performance, while holding RPE incentive strength constant. This panel paints a picture that aligns with the economic intuition described earlier. Specifically, for cash-based RPE, it shows that these plans unambiguously incentivize idiosyncratic risk, while systematic risk-taking incentives are absent because both performance and payouts are insensitive to systematic performance trends in this plan type. For share-based RPE, it shows that the nature of the risk-taking incentive provided depends on whether the agent has met the threshold to qualify for compensation. If the agent qualifies for compensation, the systematic risk-taking incentive dominates. However, if the agent has not met the first threshold in the incentive plan, the idiosyncratic risk-taking incentive dominates since there are no benefits to increasing systematic risk when the agent receives zero shares. Jointly, these patterns suggest that if the agent had to choose only one project, either with pure systematic or idiosyncratic risk, the agent would opt for the systematic project once some shares are secured.[12]

Figure 2 Panel B is analogous to Figure 2 Panel A, except that it depicts the risk-averse agent's risk-taking incentives for different levels of RPE incentive strength, while holding expected relative performance constant at a level that exceeds the threshold (which implies that some shares are secured in share-based plans). Two key patterns emerge from this panel. First, with regard to cash-based RPE, the idiosyncratic risk-taking incentive increases as RPE incentives become stronger. This effect is due to the "convexity effect" of incentives—the potential for additional cash makes risky bets more desirable, which, in turn, induces further risk-taking (Ross 2004).[13] Second, with regard to share-based RPE, both the systematic and idiosyncratic risk-taking incentive increase with small increases in RPE incentive strength, but sharply decrease when RPE incentives become exceptionally strong. This decreasing effect is due to the "magnification effect" of incentives: the agent becomes overly exposed to the firm's risk profile as larger share-based payouts increase the portion of the agent's wealth that is tied to the value of the firm ("delta") (Ross 2004). When delta becomes sufficiently large and not all of this risk can be hedged with private wealth, the agent dynamically adjusts (i.e., reduces) volatility stemming from the firm as the agent targets a fixed level of volatility for the overall portfolio of shares and outside wealth.[14] Notably, the idiosyncratic risk-taking incentives

[12] While the idiosyncratic risk-taking incentive weakens, it remains in effect as the agent has incentives to increase the firm's relative performance by taking on idiosyncratic risk in order to earn more shares. The model thus predicts that the agent undertakes such projects if there are no alternative projects with systematic risk available.

[13] Stronger RPE incentives need not always lead to stronger idiosyncratic risk-taking incentives in plans with cash-based payouts. For instance, when a single exceptionally large reward is offered for extraordinary performance, the incentive plan moves the agent into a more risk-averse portion of the domain of the utility function. This "translation effect" of incentives can be sufficiently powerful to offset the induced incentives that come from the convexity effect—reducing the incentive to take risk (Ross 2004). However, while theoretically possible, empirical evidence indicates that RPE plans typically provide a large range of incentives (Do et al. 2021), suggesting that the translation effect likely enhances rather than offsets the convexity effect.

[14] This prediction is not in conflict with previous work that indicates that stock options will always give

decrease more rapidly than their systematic counterpart because the agent is particularly averse to idiosyncratic risk, which cannot be hedged (Carpenter 2000).

Collectively, the simulations in Figure 2 delineate three testable predictions regarding the idiosyncratic risk-taking incentives stemming from RPE plans with distinct payout forms, whether in cash or shares. First, on average and holding all else constant, cash-based RPE is more positively correlated with future idiosyncratic risk compared to share-based RPE. I summarize this prediction in the third hypothesis (stated in alternative form).

Hypothesis 3. *RPE plans with cash-based payouts are more positively associated with future idiosyncratic risk than RPE plans with share-based RPE payouts.*

Second, the differential idiosyncratic risk-taking incentives are present primarily when managers expect to meet the threshold to qualify for compensation. Third, the differential idiosyncratic risk-taking incentives increase in the strength of RPE incentives. These cross-sectional predictions lead to the fourth hypothesis (stated in alternative form).

Hypothesis 4. *The differential idiosyncratic risk-taking incentives of RPE plans with cash- and share-based payouts are positively moderated by:*
(a) expected relative performance; and
(b) RPE incentive strength.

The simulations in Figure 2 also suggest that RPE plans with distinct payout forms, whether in cash or shares, can provide risk-averse managers with a differential incentive to alter their firms' systematic risk profile. In particular, the simulations suggest that a manager with share-based RPE incentives opts for systematic risk once some shares are secured. While I also test this prediction in the empirical section of the paper, I must note that this prediction is less robust than the ones regarding firms' idiosyncratic risk because it depends on parameter

stronger incentives to increase systematic risk. This is because the effect of stock options is modeled through the agent's vega—while holding the agent's delta constant. Here, larger share-based payouts increase the agent's delta, reducing the incentive to take risks due to the magnification effect of incentives. As Armstrong and Vashishtha (2012) note: "unlike the effect of vega, the effect of delta on [systematic and idiosyncratic risk] is theoretically ambiguous […] delta gives managers an incentive to reduce total risk and its components by magnifying the concavity of their utility functions."

values of firm risk, the agent's risk aversion, and composition of the agent's total wealth (Carpenter 2000; Lambert et al. 1991; Ross 2004). As shown in Figure 2 Panel B, the prediction can flip sign if share-based pay overly exposes the agent to the firm's risk profile. Unfortunately, the managers' risk aversion and composition of their total wealth are inherently unobservable.

I must also note that while the simulations presented here form a basis for the predictions, there could be reasons why these predictions are not empirically descriptive. For instance, managers may not view the payout form as a primary factor shaping their decisions. It could be that other elements of RPE plans, such as the perceived challenge of outperforming the peer group (defining expected relative performance) and the specific payout terms (defining RPE incentive strength), might have a more significant impact in practice, making the payout form a secondary consideration. It could also be that boards adjust the RPE threshold, the point at which managers qualify for compensation, to differentially modify the risk-taking properties of RPE plans with cash- and share-based payouts. While empirical evidence suggests limited cross-sectional variation in these thresholds (Do et al. 2021), any such variation could mean that the incentive effects kick in at different points along managers' utility function, potentially offsetting all incentive effects due to the translation effect of incentives (Ross 2004). Thus, whether the payout form provides risk-averse managers with differential incentives to alter their firms' risk profile remains an empirical question.

3. Data and summary statistics

3.1. Data sources

Data to create the sample I use in this study are drawn from ten sources. First, data on RPE plans come from ISS Incentive Lab. This database contains detailed executive incentive-compensation data from SEC Form DEF 14A and Form 10-K filings, and covers all firms in the S&P 500, a large portion of the S&P 400, and firms that fall into the top 750 of market capitalization in any year and across all industries (Institutional Shareholder Services Inc. 2022a). Second, data on equity portfolio holdings come from Standard and Poors' ExecuComp, which I use to compute the sensitivity of CEOs' portfolio of stock and stock options to price ("delta") and volatility ("vega"). Third, data on firm fundamentals, including firms' idiosyncratic investments, come from Compustat. Fourth and fifth, data on stock returns and systematic stock-return factors come from CRSP and Fama-French Portfolios and Factors, respectively, which I use to estimate firms' systematic risk profile. Sixth, governance data come from BoardEx. Seventh, data on analyst forecasts come from I/B/E/S, which I use to estimate firms' expected performance rank in their peer group. Eighth, data on firms' product market rivals come from the Hoberg-Phillips Data Library. Ninth, data on investor types come from Brian Bushee's Institutional Investor Classification Data. Tenth, data on firms' segments come from Compustat Segments.

3.2. Relative performance plans

3.2.1. Cash- and share-based payouts

I determine RPE types using grant-level compensation data from ISS Incentive Lab. Grants are coded as cash-based if the value in the *nonequitytarget* field is positive, and as share-based if the value in the *equitytarget* field is positive. This data is then aggregated at the firm-year level, creating RPE^{cash} and RPE^{share}. These variables take the value of one if the firm evaluates at least one senior executive based on relative firm performance, with corresponding payouts in cash and shares, zero otherwise.[15] Appendix A provides examples of each plan type.

3.2.2. Expected relative performance

In order to test the prediction that expected relative performance moderates the differential risk-taking incentives of cash- and share-based RPE plans, I create *RPE Expected*

[15] In rare cases where a firm-year uses both cash- and share-based RPE, the observation is coded as RPE^{cash} == 0, as the overall RPE plan does not insulate managers from systematic performance trends.

Performance. This variable measures the expected ranking of the firm within its peer group. To determine this ranking, I first compute expected stock returns for the focal firm and all of its peers based on twelve-month analyst price forecasts (Gong et al. 2011). I then rank all firms according to these expected stock returns and compute the focal firm's expected performance percentile. The resulting variable ranges between 0 and 100, with higher values indicating a superior performance rank. I rely on analyst forecasts for price movements because prior research shows these forecasts are informative about the idiosyncratic component of returns (Givoly and Lakonishok 1979; Lys and Sohn 1990). This idiosyncratic component aligns closely with the relative component of performance that is necessary to beat peers.[16]

3.2.3. RPE incentive strength

In order to test the prediction that RPE incentive strength moderates the differential risk-taking incentives of cash- and share-based RPE plans, I create two measures for the strength of RPE incentives. First, *RPE Convexity* quantifies the strength of RPE incentives through the plan's payout convexity, i.e., the RPE payout-performance relation. I estimate an RPE plan's payout convexity with a plan-year-specific regression of payouts on percentiles and percentiles squared: $Payout_{jt} = \alpha_{0jt} + \beta_{1jt} Percentile_{jt} + \beta_{2jt} Percentile_{jt}^2 + \varepsilon_{jt}$. In this equation, plan *j*'s payout convexity in year *t* is the estimated regression coefficient on the squared term, $\hat{\beta}_{2jt}$.[17] Figure 3 assesses the sensitivity of *RPE Convexity* to changes in four

[16] In order to precisely estimate the expected ranking of the firm within its peer group, I restrict the computation of this variable to firms that employ self-selected peer groups. This restriction results in a slight reduction in the sample size for some of the empirical tests.

[17] Estimating this equation presents two practical challenges. First, there is cross-sectional variation in payout structures as firms are free to choose the number of hurdles and whether to specify them as percentiles (i.e., 100, …, 1) or ranks (i.e., 1, …, *N*). This variation complicates the comparability of a payout convexity measure between firms. To address this issue to the best of my ability, I standardize all incentive plans in "percentages." In this approach, irrespective of the payout structure, any percentile or rank falls on a continuum between 0 percent and 100 percent. Second, when estimating this equation, OLS estimates the least squares line passing through the combination of data points. This implies that I must explicitly specify payouts for "imaginary" percentiles (e.g., percentiles 41 through 59 when a plan specifies payouts for percentiles 40 and 60). Failing to do so would result in interpolation of payouts between percentiles, effectively rendering the incentive plan linear. (Some incentive plans interpolate between percentiles, and I carefully determine the payouts for imaginary percentiles using the actual interpolation rules of each firm-year's plan.) To handle these challenges, I transform each incentive plan into a 2-by-100 matrix representing payouts and percentiles, which is used as input for estimating the equation.

features of the payout structure that are of the first order and depicts that it takes a higher value if the RPE plan has, *ceteris paribus*: (1) larger payouts for extraordinary performance; (2) lower hurdles for ordinary performance; (3) fewer hurdles for the same payouts; and (4) no interpolation.

Second, *RPE Grant Size* quantifies the strength of RPE incentives through the size of the grant. The value of an RPE grant with equity awards equals the target number of shares multiplied by the firm's current stock price. The value of an RPE grant with cash awards simply equals the target cash payout. I scale these values by prior cash compensation, so the resulting variable is more comparable in the cross-section.

3.3. Determinants of distinct payout forms

3.3.1. Cash-based payouts

In order to test the predictions about the determinants of cash-based RPE plans, I create three sets of variables. First, to test the tolerance for early failure prediction, I create *Long-Term Investors* and *Short-Term Investors*, which capture the fraction of institutional investors that is, respectively, long-term oriented (i.e., "dedicated" and "quasi-index" investors) and short-term oriented (i.e., "transient" investors) (Bushee 2001; Bushee and Noe 2000). Jointly, these variables capture the degree to which investors are likely to commit to long-term success of the firm—and hence to not fire managers for early innovation failure. Second, to test the innovation-related agency conflicts prediction, I create *Horizon Problem*, which equals one if the CEO's age is in the top quartile of the sample, zero otherwise. This variable measures the degree of innovation-related agency conflicts that come from managers being close to retirement (Dechow and Sloan 1991). Third, to test the project choice prediction, I create *Segments* and *Segments HHI* as proxies for the firm's strategic flexibility. *Segments* is the number of two-digit SIC segments the firm operates in. *Segments HHI* is the asset-weighted Herfindahl-Hirschman index of the firm's segments and inversely proxies for strategic flexibility.

3.3.2. Share-based payouts

In order to test the predictions about the determinants of share-based RPE plans, I create three sets of variables. First, to test the rising tide prediction, I create *Options-Luck Sensitivity* and *SOP Votes*. *Options-Luck Sensitivity* is the sensitivity of realized options-based pay to realized industry returns over the preceding five years, reflecting the extent to which options-based pay moves with systematic performance trends. *SOP Votes* is the percentage of favorable say-on-pay votes for the CEO's incentive-compensation contract, providing insights into shareholder feedback regarding executive compensation (Ertimur, Ferri, and Oesch 2013).[18] Second, to test the strategic interaction prediction, I create *Number of Rivals*. This variable is the natural logarithm of one plus the number of product market rivals, as identified by Hoberg and Phillips (2010, 2016), and measures the degree of competition in the firm's product market. Third, to test the managerial power prediction, I create several measures of CEO power. Appropriate measures in my setting are ones that capture the power a CEO holds over the board, as such power allows the CEO to influence board dynamics and potentially impact the design of his/her own incentive-compensation package. Previous work argues such power arises when the CEO co-opts a greater fraction of the board (Coles, Daniel, and Naveen 2014) or holds the board chairperson position (Jensen 1993). Following this work, I create *Co-Option* and *CEO Duality* to capture these power dimensions, respectively. Conversely, and following Coles et al. (2014), I also compute *Non-Co-Opted Independence*—the fraction of directors who are independent and were appointed before the CEO—as a proxy for board monitoring effectiveness. I use this variable to test whether boards with more power are more likely incorporate cash-based RPE plans compared to share-based RPE plans.

[18] Since say-on-pay voting became mandatory only starting from fiscal year 2011 and need not occur every year, a number of firm-year observations have missing values. In the empirical analysis, I address this issue by estimating a separate model in which I impute missing values by setting them to the two-digit SIC-year median.

3.4. Risk measures

My proxy for idiosyncratic risk is the firm's research and development intensity. Specifically, *R&D* is the firm's expenditures on research and development, scaled by the book value of total assets at the beginning of the year (Armstrong, Glaeser, Huang, and Taylor 2019; Coles, Daniel, and Naveen 2006). The choice for this proxy is twofold. First, existing evidence shows that inputs of projects that generate idiosyncratic (i.e., abnormal) risk and returns are expenditures on research and development (Chan, Lakonishok, and Sougiannis 2001; Eberhart, Maxwell, and Siddique 2004). Second, as Armstrong et al. (2019, 2) discuss, a key benefit of these investments is that they are "directly controllable by senior managers and are not mechanically related to trading activity in capital markets, disclosure, or taxes on shareholders"—which is a critique of measures of risk computed based on realized volatility of stock returns (Armstrong and Vashishtha 2012).

To examine whether different RPE plans provide managers with differential systematic risk-taking incentives, I create several measures of firm risk computed based on realized volatility of stock returns as well as with modified versions of them designed specifically to address some of their downsides. One benefit of these measures is that they capture actual movement in firms' stock price and likely more directly measure changes in managers' actual wealth. First, I follow Armstrong and Vashishtha (2012) and impute firms' stock returns based on the allocation of assets across segments. I then compute firms' risk profile by regressing imputed returns on various risk factors (e.g., *MKTRF*, *HML*, *SMB*, and *UMD*) using past data (i.e., the information available to managers), i.e., I compute firms' risk profile using three- and four-factor models over 36 months periods (i.e., a typical RPE performance period). Second, I follow Campbell et al. (2001) and compute firms' risk profile by regressing stock returns on a market and an industry factor, i.e., I compute firms' risk profile using two-digit and four-digit industry factors over 36 months periods. Third, I follow Fama and French (1992) and Carhart

(1997), respectively, and compute firms' risk profile by regressing stock returns on the typical three factors (i.e., *MKTRF*, *HML*, and *SMB*) and the typical three factors plus a momentum factor (i.e., *UMD*) over 36 months periods. To streamline subsequent analyses, I also combine the variation in individual proxies into a comprehensive systematic risk index (*Systematic Risk*), computed as the first principal component of all measures. This variable accounts for ~67% of the variance in all seven measures, with its first eigenvalue exceeding one at $0.668 \times 7 \approx 4.676$.

3.5. Other controls

To reduce the influence of confounders on the parameter estimates of interest, I include in all specifications an array of "manager-year," "firm-year," and "governance-year" time-varying controls for which there exists economic theory or empirical evidence to support a relation with the key constructs. Manager-level controls are alternative incentives at the CEO-level, including the CEO's equity portfolio incentives (*Delta* and *Vega*), the number of share- and cash-based non-RPE metrics in the CEO's incentive-compensation contract (*Share-based Non-RPE* and *Cash-based Non-RPE*), and his/her tenure (*Tenure*) (Core and Guay 1999; Guay 1999). Firm-level controls are included to replicate a representative set of controls used in prior literature examining the relation between incentives and firm risk (Armstrong and Vashishtha 2012; Coles et al. 2006). This set of controls includes the firm's mean similarity to its product market peers (*Rival Similarity*), annual revenue (*Sales*), book-to-market ratio (*Book-to-Market*), leverage (*Leverage*), sales growth (*Sales Growth*), and property, plant, and equipment intensity (*PP&E*). Governance-level controls are the number of board members (*Board Size*) and the fraction of board members that sits on at least three boards (*Board Experience*) (Field, Lowry, and Mkrtchyan 2013; Linck, Netter, and Yang 2008).

3.6. Sample and summary statistics

The sample begins in fiscal year 2006, following the SEC's (2006) mandate for firms to disclose information about their incentive-compensation contracts, and ends in fiscal year 2021. In order to study the determinants of boards' choices for RPE plans, I use leading data on RPE payout forms. The resulting sample contains 10,906 firm-year observations. In order to study the consequences of RPE plans, I use leading data on firms' risk profile and narrow the sample to firms using RPE plans, which reduces it to 3,198 firm-year observations.

Table 1 contains some summary statistics on the use of cash- and share-based RPE plans by year and industry. Summary statistics on all other variables for the whole sample and split by treatment status are in Table 2. All variables are as defined in Appendix C. The use of RPE is most common in the "Oil, Gas, and Coal Extraction" and "Utilities" industries. Across all years and industries, roughly 45% of firm-year observations use an RPE plan. This average, however, hides a sharp increase in the use of RPE over the past decade and the popularity of share-based RPE. For instance, the use of share-based RPE has quadrupled from 15% to 60% of firms between 2006 and 2020. By contrast, the use of cash-based RPE has decreased from 8% to 3% of firms in this period.

4. Main results

4.1. What determines boards' choices for distinct payout forms?

I test Hypotheses 1 and 2 by estimating a multinomial logit model that assesses the joint likelihood of three outcomes: (1) not using RPE; (2) using RPE with share-based payouts; and (3) using RPE with cash-based payouts. The multinomial logit model offers two key advantages over the binary logit model (Wooldridge 2010). First, it allows for outcomes with more than two categories, allowing me to disentangle boards' choices for cash- and share-based RPE, vis-à-vis not using RPE.[19] Second, it estimates a vector of coefficients for each outcome

[19] Excluding a category, such as the non-RPE category, could lead to erroneous conclusions. For instance, one of my predictions is that powerful managers prefer share-based RPE. If, in reality, powerful managers strongly prefer not using RPE at all, but slightly prefer share-based RPE over cash-based RPE when forced to choose between these RPE alternatives, then a simple probit model of share- versus cash-based RPE might inaccurately attribute powerful managers' preference to share-based RPE.

category, allowing me to falsify that determinants of share-based RPE do not relate to cash-based RPE, and vice versa. The multinomial logit model assumes that the logarithm of each outcome's odds relative to the baseline outcome ("logit") follows a linear model. Given that "not using RPE" serves as the baseline outcome, each coefficient measures the odds ratio of using a share- or cash-based RPE plan relative to not using RPE for a unit change in a respective independent variable, *ceteris paribus*.[20] Specifically, I estimate:

$$\Pr(RPE\ Choice_{ijt+1} = k) = \frac{e^{\mathbf{B}_k \cdot Factors_{ijt} + \mathbf{\Phi}_k \cdot X_{ijt} + \varphi_k + \mathbf{\Psi}_k \cdot \xi_j + \mathbf{\Omega}_k \cdot v_t + \varepsilon_{kijt+1}}}{1 + \sum_{m=1}^{K\text{-}1} e^{\mathbf{B}_m \cdot Factors_{ijt} + \mathbf{\Phi}_m \cdot X_{ijt} + \varphi_m + \mathbf{\Psi}_m \cdot \xi_j + \mathbf{\Omega}_m \cdot v_t + \varepsilon_{mijt+1}}}, \tag{1}$$

where the indices i, j, and t correspond to firm, industry, and time, respectively, and k refers to one of the K choices for RPE (i.e., RPE^{share} or RPE^{cash}). *Factors* and X, respectively, are vectors of economic determinants and controls, which are all measured prior to the dependent variable to capture the most recent factors contemporaneous with boards' choices for RPE.

The theoretical arguments underlying Hypotheses 1 and 2 predict that variation in economic factors among firms relates to boards' choices for RPE. Therefore, this test consists of an analysis that relies on a comparison between firms. To alleviate concerns that inferences are attributable to omitted industry characteristics (e.g., business models across sectors) or time trends (e.g., macroeconomic shocks), equation (1) includes industry fixed effects ξ_j based on the 48 industry groups identified by Fama and French (1997) and year fixed effects v_t. To correct for arbitrary correlation in the error term ε_{ijt+1}, standard errors are clustered at the level of treatment (i.e., firm) to conform to Abadie, Athey, Imbens and Wooldridge (2023).

Table 3 presents results of estimating equation (1). With regard to the hypothesis tests, Column (1) in Panel A shows that the coefficients on *Long-Term Investors*, *Horizon Problem*,

[20] Further note that while the contract-design decision of deciding whether to use RPE and then choosing the payout structure may seem sequential, I do not estimate a nested logit model. Nested logit models are estimated by combining a multinomial logit model and a conditional logit model. A conditional logit model, however, requires that the values on the explanatory variables within an observation vary for each outcome category (Wooldridge 2010). Because the variables used in this analysis are specific to the firm-year observation—and not to the different outcome categories—estimating a nested logit model is not feasible.

and *Segments* are positive and both statistically and economically significant when the outcome category is *RPE*^{cash}, whereas the coefficient on *Short-Term Investors* is negative. In economic terms, the coefficient estimates indicate that a one standard deviation increase (or a one-unit increase for indicator variables) in the value of these variables is associated with a 0.149 (for *Long-Term Investors*), 0.566 (for *Horizon Problem*), and 0.186 (for *Segments*) increase in the probability that the board chooses to use a cash-based RPE plan relative to not using RPE.[21] For *Short-Term Investors*, the estimate suggests an analogous 0.097 decrease in the probability using cash-based RPE. Notably, except for *Long-Term Investors*, these factors are negatively related or statistically unrelated to the likelihood of using a share-based RPE plan.[22]

Column (2) in Table 3 Panel A shows that the coefficients on *Options-Luck Sensitivity*, *Number of Rivals*, *Co-Option*, and *CEO Duality* are positive and both statistically and economically significant when the outcome category is *RPE*^{share}. In economic terms, the estimates indicate that a one standard deviation increase (or a one-unit increase for indicator variables) in these variables is associated with a 0.059 (for *Options-Luck Sensitivity*), 0.816 (for *Number of Rivals*), 0.209 (for *Co-Option*), and 0.542 (for *CEO Duality*) increase in the probability that the board chooses to use a share-based RPE plan relative to not using RPE. Importantly, these factors are statistically unrelated to the likelihood of using a cash-based RPE plan. It is also noteworthy that *Non-Co-Opted Independence*—which measures board monitoring effectiveness—is associated with an increased probability that the board chooses to use an RPE plan, particularly a cash-based one. Overall, the evidence related to the governance variables thus suggests that effective boards with more power are more likely incorporate cash-based RPE plans compared to share-based RPE plans, which are favored by

[21] To obtain these estimates, I first convert the logits to probabilities using: probability = $e^{\text{logit}} / (1 + e^{\text{logit}})$.

[22] The connection between long-term institutional ownership and general RPE usage is consistent with the idea that RPE is viewed favorably by investors and proxy advisors as indicators of good governance practices (Glass Lewis & Co. 2022; Institutional Shareholder Services Inc. 2022b).

CEOs with greater power—supporting the predictions of the managerial power hypothesis.[23]

Table 3 Panel B presents results after including *SOP Votes* and shows that this variable exhibits a positive and both statistically and economically significant relation with RPE^{share}. In economic terms, the coefficient estimate indicates that a one standard deviation increase in the value of this variable is associated with a 0.135 increase in the probability that the board chooses to use a share-based RPE plan relative to not using RPE. Notably, *SOP Votes* exhibits a negative association of roughly similar magnitude with the choice to use cash-based RPE.

Results further suggest there exist complementarity relations between RPE-based and non-RPE-based performance metrics. For instance, the choice for share-based RPE appears to be related to the number of share-based non-RPE performance metrics in the compensation contract. Similarly, the choice for cash-based RPE, and to a lesser extent the choice for share-based RPE, relates to the number of cash-based non-RPE performance metrics in the compensation contract. Finally, it is worth noting that several determinants of firms' reliance on RPE found in prior literature (e.g., firm size and sales growth) (Albuquerque 2014; Gong et al. 2011) are common determinants of cash- and share-based RPE.

Collectively, these findings support most of the predictions underlying Hypotheses 1 and 2 and provide several insights into boards' payout form choices.[24] For instance, regarding cash-based RPE, the evidence supports its use in motivating innovation, as this plan type is common among firms suffering from innovation-related agency conflicts and firms governed

[23] One concern regarding the inferences related to *Non-Co-Opted Independence*, *Co-Option*, and *CEO Duality* could be the correlation they have with the other corporate governance factors—*Board Size* and *Board Experience*. However, these correlations are notably weak, which should help mitigate concerns about multicollinearity. Specifically, Pearson correlation coefficients between *Board Size* and the mentioned factors, respectively, are 0.132, –0.004, and 0.102. For *Board Experience*, these coefficients equal 0.030, –0.010, and 0.083, respectively. To further address multicollinearity concerns, I repeat the analysis and exclude the two corporate governance factors. Untabulated results indicate that the inferences regarding *Non-Co-Opted Independence*, *Co-Option*, and *CEO Duality* are unaffected.

[24] In untabulated analyses, I assess the robustness of the results to using only subsets of the explanatory variables—including only the cash-based RPE factors, only the share-based RPE factors, and only both RPE factors—as well as to using alternative fixed effects structures—year fixed effects and no fixed effects. These alternative specifications generally lead to similar conclusions.

by investors who tolerate early innovation failure. Furthermore, the results reveal three determinants underlying the choice to use a share-based RPE plan, including external pressure to address the rising tide phenomenon, a commitment tool for product market aggression, and alignment to keep powerful managers' pay fluctuating with outside opportunities. However, I find no support for the strategic flexibility prediction in Hypothesis 1(c).[25]

4.2. What are the risk consequences of distinct payout forms?

I test Hypothesis 3 by estimating an empirical model of firm risk that is a generalization of that used throughout the empirical risk-taking literature (Armstrong and Vashishtha 2012; Coles et al. 2006; Guay 1999):

$$R\&D_{it+1} = \beta \cdot RPE_{it}^{cash} + \mathbf{\Phi} \cdot X_{it} + \varphi + \mathbf{T} \cdot \tau_i + \mathbf{\Omega} \cdot \nu_t + \varepsilon_{it+1}, \tag{2}$$

where X contains all control variables of equation (1), including the cash- and share-based factors. I estimate equation (2) for the subsample of firms using RPE and achieve covariate balance between firms using cash-based RPE and firms using share-based RPE by reweighting the subsamples by entropy balancing the first moment of all control variables (Hainmueller 2017). The simulations in Figure 2 provide the testable prediction that *on average* and *within* a given firm, time-series variation in cash-based RPE is more closely related to time-series variation in idiosyncratic risk-taking than it is to time-series variation in share-based RPE. This prediction delineates that β in equation (2) should be positive and calls for a comparison within firms, implying the inclusion of firm fixed effects τ_i. This design has the added benefit of helping to reduce concerns that omitted time-invariant firm-specific factors drive the results.

[25] In untabulated analyses, I assess whether the coefficients on the cash- and share-based RPE factors are statistically significantly different from each other. Such differences would indicate that the odds of choosing one payout form type (e.g., cash-based RPE) over the reference group of not using RPE differ from the odds of choosing the other payout form type (e.g., share-based RPE) over the reference group of not using RPE. I find that the coefficients on *Short-Term Investors*, *Horizon Problem*, *Non-Co-Opted Independence*, *Number of Rivals*, *Co-Option*, and *SOP Votes* are statistically significantly different from each other, whereas the coefficients on *Long-Term Investors, Segments, Options-Luck Sensitivity*, *CEO Duality* are not. With respect to the hypothesis tests, this thus implies that I find support for all sub-predictions of Hypotheses 1 and 2, except for the strategic flexibility prediction in Hypothesis 1(c).

Standard errors clustering is similar to the tests of equation (1).

Table 4 Panel A presents results of estimating equation (2), with the separate columns presenting specifications without and with controls and entropy balancing, as well as, following Breuer and deHaan (2023), after restricting the sample to firms with variation in the dependent and treatment variables. Across all specifications, the coefficient on RPE^{cash} is positive and both statistically and economically significant. Consistent with Hypothesis 3, this pattern indicates that within firms the adoption of cash-based RPE is associated with an increase in idiosyncratic investments relative to the adoption of share-based RPE.[26] Following Breuer and deHaan (2023), when expressed as a percentage of the "within-fixed-effects (FE)" standard deviation of the dependent variable, these estimates suggest that the adoption of a cash-based RPE plan is associated with a 0.232 to 0.689 within-FE standard deviation increase in *R&D*, corresponding to the estimates in Columns (4) and (7), respectively (with the average across all columns being 0.443). Notably, within-firm changes in research and development intensity are also sensitive to changes in firms' growth opportunities.

To test whether the systematic risk-taking properties of cash-based RPE plans also differ from those provided by share-based RPE plans, which is a weaker prediction from the model, I re-estimate equation (2) and replace the dependent variable with measures of firms' systematic risk profile estimated using realized stock return volatility. Results in Table 4 Panel B show that the coefficient on RPE^{cash} is negative and both statistically and economically significant. This pattern indicates that within firms the adoption of cash-based (share-based) RPE is associated with a decrease (increase) in the firm's systematic risk profile relative to

[26] Similar results are observed with an unscaled *R&D* measure, suggesting that this pattern is not driven by changes in the denominator. Results are also robust to using all other balancing methods accessible through the WeightIt package in R, including propensity score weighting using generalized linear models ("glm"), propensity score weighting using generalized boosted modeling ("gbm"), covariate balancing propensity score weighting ("cbps"), non-parametric covariate balancing propensity score weighting ("npcbps"), optimization-based weighting ("optweight"), propensity score weighting using SuperLearner with random forests ("super"), propensity score weighting using Bayesian additive regression trees ("bart"), and energy balancing ("energy").

adoption of share-based (cash-based) RPE. In economic terms, these estimates suggest that the adoption of an RPE plan with share-based payouts is associated with a ~0.369 within-FE standard deviation increase in the firm's systematic risk profile (averaged across all columns).

5. Robustness and cross-sectional tests

The results so far lend themselves to two possible interpretations. First, cash-based RPE provides managers with stronger incentives to pursue idiosyncratic risk than does share-based RPE, on average. Second, because firms choose RPE plans endogenously, it is plausible that idiosyncratic risk and the choice between cash- and share-based RPE plans are jointly determined by some unobservable omitted factor. While both channels are important, distinguishing between them provides greater insights into the relation between RPE and managerial risk-taking. I therefore perform three robustness tests, each relying on distinct identifying assumptions, to triangulate the earlier inferences as effectively as possible and to reduce selection concerns: (1) two-stage least squares; (2) modified control function; (3) and coefficient stability. If the primary finding is driven by an unobserved omitted factor, I expect these alternative research methods to not yield the same results.

5.1. Two-stage least squares

As a first robustness check, I examine the impact of cash-based RPE on idiosyncratic risk using a two-stage least squares approach. This method requires an instrumental variable that must satisfy the testable relevance and untestable exclusion conditions (Roberts and Whited 2013). I instrument for the RPE payout decision using the percentage of the firm's total shares outstanding held by senior management prior to the adoption of the RPE plan.

In terms of relevance, managerial ownership (*% Ownership*) is a plausible instrument for payout form choice as anecdotal evidence suggests some boards choose cash-based RPE to avoid share dilution that comes with share-based RPE.[27] In terms of exclusion, managerial ownership is unlikely to be directly correlated with firms' risk profile, conditional on the covariates in equation (2). While prior literature indicates that managerial ownership affects risk-taking incentives (Coles et al. 2006; Ross 2004) and could impact firms' risk profile due to agency costs (Jensen and Meckling 1976), I argue these channels are largely blocked by controlling for *Delta* and the time-varying firm and governance factors. Thus, any remaining direct effect of *% Ownership* should be plausibly near zero (Conley, Hansen, and Rossi 2012).

Table 5 Panel A presents results of estimating equation (2) using two-stage least squares. In Column (1), the first-stage results show a positive association between *% Ownership* and RPE^{cash}, indicating that managerial ownership is relevant to the adoption of RPE plans with cash-based payouts. The weak instrument test statistics further suggest this instrument is relevant from an empirical perspective (Cragg and Donald 1993; Olea and Pflueger 2013). Column (2) presents the second-stage results, which identify a local average treatment effect for firms that use cash-based RPE due to high managerial ownership. This result is consistent with those in Table 4 Panel A, supporting the hypothesis that the payout form plays a role in determining the risk-taking properties of RPE plans.

5.2. Modified control function

One key advantage of two-stage least squares is that it is explicit about the source of variation used to assess the impact of cash-based RPE on idiosyncratic risk, but a downside is that the estimate might only be representative of firms whose RPE decisions are affected by the instrument (Imbens and Angrist 1994). In the second robustness check, I use a modified

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[27] For example, Centene Corporation (2013, 22) describes: "*Beginning in 2013, with the 2013-2015 Cash LTIP cycle, executives will be awarded cash […] total shareholder return (TSR) objectives relative to our healthcare industry peer group. […] the Compensation Committee adopted this type of long term cash plan to, among other things, […]* ***assist in managing annual dilution****, [...]*" (emphasis added). Similarly, Dominion Resources Inc. (2007, 17) describes: "*The reasons for shifting a portion of the program to cash were (i)* ***the significant ownership of Dominion stock by executives and the high rate of compliance with our share ownership requirements***" (emphasis added).

control function approach that does not rely on the existence of a narrowly-defined instrument, but instead "controls for" endogeneity in RPE choices (Klein and Vella 2010). I closely follow the approach in Armstrong et al. (2021), which comprises three steps: (1) making assumptions about the source of the endogeneity; (2) estimating the endogeneity by exploiting heteroskedasticity in errors; and (3) controlling for the endogeneity in the main equation.[28]

This method decomposes the error term of equation (2), ε_{it+1}, into two components:

$$\varepsilon_{it+1} = \rho \frac{\sigma_\varepsilon}{\sigma_\xi} \xi_{it} + \omega_{it+1}. \tag{3}$$

Here, ξ_{it} is the error term of a probit model of RPE^{cash} that includes all variables of equation (1). This "endogenous" component, ξ_{it}, captures the extent to which unobservable factors drive both RPE^{cash} and $R\&D$. If this is the case, $\rho \neq 0$. The component ω_{it+1} is the "exogenous" error term, which, by design, is uncorrelated with RPE^{cash}. Substituting equation (3) into a regression of $R\&D$ on RPE^{cash} demonstrates how this approach controls for endogeneity:

$$R\&D_{it+1} = \beta \cdot RPE_{it}^{cash} + \rho \frac{\sigma_\varepsilon}{\sigma_\xi} \xi_{it} + \omega_{it+1}. \tag{4}$$

To identify ρ in equation (4), the first step is to estimate the decomposition in equation (3). This can be done by regressing ε_{it+1} on ξ_{it} and exploiting variation in the standard deviation ratio (i.e., $\frac{\sigma_\varepsilon}{\sigma_\xi}$). Variation in this ratio comes from heteroskedasticity in the first-stage error term across firms, time, or both (i.e., σ_ξ). As this decomposition highlights, the identification of ρ—and consequently the control variable for endogeneity—relies on unobservable factors that drive the endogenous relation between cash-based RPE on idiosyncratic risk. Based on the theoretical arguments and empirical evidence related to Hypothesis 1(b), I assume that innovation-related agency conflicts constitute a significant source of this endogeneity, as supported by the clear differential coefficients on *Horizon Problem* in Table 3. I therefore

[28] I thank Chris Armstrong, Allison Nicoletti, and Frank Zhou for sharing their code to perform the modified control function test.

estimate $\frac{\sigma_\varepsilon}{\sigma_\xi}$ across time and groups of managers in distinct age quintiles and include this variable in equation (4) to control for endogeneity stemming from innovation-related agency conflicts.[29]

Table 5 Panel B presents results of estimating equation (4) using the modified control function approach, with the two columns presenting specifications without and with the inclusion of the first-stage controls in the second-stage equation. To address the concern that statistical significance may be an artifact of influential observations, I follow Armstrong et al. (2021) and estimate bootstrapped standard errors, based on 1,000 bootstrapped samples. I find that the coefficient on ρ (i.e., the endogeneity variable) is negative and statistically significant, suggesting that boards' RPE choices are indeed endogenously determined with respect to firm risk. More importantly, the results for RPE^{cash} align with those from the main analysis and the two-stage least squares analysis, further supporting the hypothesis that the payout form plays a role in determining the risk-taking properties of RPE plans.

5.3. Coefficient stability

As a final robustness check, I formally assess the impact of unobservable factors on my main finding using the bounding technique put forward by Oster (2019). This partial identification technique allows me to estimate a reasonable range in which the "true" β in equation (2) lies, based on estimated coefficients, R^2 values, and assumptions regarding omitted variable bias. These assumptions pertain to the impact of unobservable factors on the relation between cash-based RPE and idiosyncratic risk, relative to all observables factors (denoted as "δ"). Following Altonji, Elder and Taber (2005) and Oster (2019), I consider $R^2_{max} = min(1.3\tilde{R}^2, 1)$ and assume $\delta = 1$ or $\delta = -1$. This implies that I assume equation (2) is misspecified by 30%, and that the impact of unobservable factors is similar to the impact of observable factors and goes in either the same or the opposite direction. Coefficient stability results in Table 5 Panel

[29] Armstrong et al. (2021) estimate this variation across time and markets of banks in four geographical areas.

C show that, under these assumptions, prior results are robust to the impact of unobservable factors that have a comparable influence as all observable factors, combined. The test also suggests that unobservable factors would need to be roughly eight times as strong to drive the coefficient on RPE^{cash} to zero, as indicated by the estimated δ parameter.

5.4. Cross-sectional variation

In this section, I examine the cross-sectional implications of the simulations in Section 2 by conducting sample splits based on the proxies for expected relative performance (i.e., *RPE Expected Performance*) and RPE incentive strength (i.e., *RPE Convexity* and *RPE Grant Size*). I use *RPE Threshold* as the cutoff for *RPE Expected Performance*, which divides the sample based on whether the manager is expected to qualify for compensation. For the RPE incentive strength variables, I use the median as the cutoff for dividing the sample. I then estimate equation (2) separately for each subsample, allowing the coefficients on all variables and fixed effects to vary between them.[30] Finally, I test whether the signed differences in the coefficients between the subsamples align with the directional predictions outlined in Hypothesis 4.

The first cross-sectional implication is that the differential risk-taking incentives should be apparent only when managers expect to meet the threshold to qualify for compensation (as depicted in Figure 2 Panel A). In line with this prediction, Table 6 Panel A shows that the previous findings are concentrated in the subset of firms where compensation qualification is expected (with the accompanying one-sided *t*-test confirming statistical significance of the predicted signed difference). Table 6 Panel B repeats the analysis with the composite *Systematic Risk* index as the dependent variable and shows that the relative decrease (increase) in systematic risk for cash-based (share-based) RPE is more prominent among the subset of firms where compensation qualification is expected.

[30] I perform the entropy balancing before dividing the sample into subsamples, ensuring that each firm-year observation maintains its weight as in the main analysis.

The second cross-sectional implication is that the differential idiosyncratic risk-taking incentive increases in the strength of RPE incentives (as depicted in Figure 2 Panel B). Results in Table 7 Panel A support this prediction along the two dimensions of RPE incentive strength. Another prediction—which, as discussed in Section 2, is parameter dependent and, therefore, less robust—posits that the differential *systematic* risk-taking incentive is likely to decrease in RPE incentive strength. This is because higher share-based compensation can overly expose managers to their firms' risk profile through heightened delta, which can motivate them to dynamically adjust (i.e., reduce) volatility stemming from their firms as they target a fixed level of volatility for their overall portfolio of shares and outside wealth. I find some evidence for this prediction in Table 7 Panel B for one of the two dimensions of RPE incentive strength.

In a final analysis, I examine cross-sectional variation in both RPE incentive strength and expected relative performance. Specifically, I split the analyses in Table 7 that produce significant results based on whether managers expect to qualify for compensation. As the simulations in Section 2 suggest, the results should be concentrated in the subset of firms that expect to qualify for compensation. Results in Table 8 empirically support this expectation.

In conclusion, the collective set of cross-sectional results suggests that the differential risk-taking incentives of different RPE plans depend on both expected relative performance and RPE incentive strength: they manifest when risk-averse managers foresee compensation, and their nature depends on the strength of the RPE incentives.

6. Conclusion

This study examines the risk-taking properties of incentive plans that incorporate relative performance evaluation, focusing on the payout form—whether in cash or shares—and analyzing both determinants and consequences of payout form choice. When managers are compensated for their relative performance achievements with shares of their firms' stock, the value of their payouts is inherently linked to stock prices—which are affected by systematic performance trends. This feature runs counter to the conventional agency-theoretic prediction that relative performance evaluation shields managers from such trends. As predicted by subjective expected utility theory and supported by the findings in this paper, this link between managers' pay and systematic performance suggests that share-based payouts provide risk-averse managers with weaker incentives to engage in idiosyncratic risk than do their cash-based counterparts.

The key takeaway from this paper is thus that commonly used share-based relative performance plans might not always encourage managers to pursue innovative projects primarily characterized by idiosyncratic risk, when projects with systematic risk are available. One important question this evidence raises and that only future research will be able to address is why proxy advisors then mainly encourage RPE to be implemented through share-based incentive plans, rather than cash-based incentive plans. Does this preference reflect an underlying belief that share-based plans better align managerial incentives with shareholder interests? While there are clear reasons why that might be case, this paper points out that this preference for share-based plans may inadvertently slow the innovativeness of U.S. firms. The empirical relevance of proxy advisors for firm innovation is thus an important area for future research.

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Appendix A—Examples of relative performance plans

This appendix provides details on PepsiCo Inc.'s (2019, 51–61) cash-based relative performance plan and Intel Corporation's (2019, 82–83) share-based relative performance plan, excerpted from their SEC Form DEF 14A.

A1. PepsiCo Inc.'s (2019) cash-based relative performance plan

Long-Term Cash Award

The LTC Award focuses on relative TSR performance, strengthening alignment with long-term shareholder value creation. The LTC Award is denominated and will pay out in cash, reflecting PepsiCo's responsible use of shares under our LTI program.

TSR performance relative to our proxy peer group over a 3-year performance period[32]

PepsiCo's 3-year TSR ranking:	Threshold (25%ile)	Target (Median)	Max (100%ile)
Payout:	50%	100%	200%

Target payout requires us to deliver positive 3-year TSR. Linear interpolation is used when ranking falls between percentages shown.

Name	Threshold ($)	Target ($)	Maximum ($)
Indra K. Nooyi (former CEO)	–	4,760,000	9,520,000
Ramon Laguarta (CEO)	–	1,593,750	3,187,500
Hugh F. Johnston (CFO)	–	1,859,375	3,718,750
Albert P. Carey (CEO North America)	–	1,487,500	2,975,000
Laxman Narasimhan (CEO Latin America)	–	1,593,750	3,187,500
Silviu Popovici (CEO Europe)	–	977,500	1,955,000

A2. Intel Corporation's (2019) share-based relative performance plan

Grants Of Plan-Based Awards in Fiscal Year 2018

OSUs granted to the listed officers in 2018 have a three-year performance period from the grant date, and a 37-month vesting schedule, meaning that the performance metrics are measured over the first 36 months, and the corresponding number of shares will vest in the 37th month. The number of shares of Intel common stock to be received at vesting will range from 0% to 200% of the target amount, based on the relative TSR of Intel common stock measured against the TSR of the S&P 500 IT Index over a three-year period.

Name	Threshold (# shares)	Target (# shares)	Maximum (# shares)
Robert H. Swan (CEO)	–	122,255	244,510
Steven R. Rodgers (Executive VP)	–	122,255	244,510
Venkata Renduchintala (Group President)	–	122,255	244,510
Navin Shenoy (Executive VP)	–	115,531	231,062
Brian M. Krzanich (former CEO)	–	237,632	475,264

[32] The Compensation Committee primarily identifies companies that are of comparable size (based on revenue and market capitalization), maintain strong consumer brands, have an innovative culture, compete with PepsiCo for executive talent and/or possess significant international operations. There were no changes to our peer group during the 2018 performance year.

The 3M Company	International Business Machines Corp.	Pfizer Inc.
Anheuser-Busch InBev SA/NV	Johnson & Johnson	The Procter & Gamble Company
Apple, Inc.	The Kraft Heinz Company	Starbucks Corporation
The Coca-Cola Company	McDonald's Corporation	Unilever PLC
Colgate-Palmolive Company	Microsoft Corporation	United Parcel Service, Inc.
Danone S.A.	Mondelēz International, Inc.	Walmart Inc.
General Electric Company	Nestlé S.A.	The Walt Disney Company
General Mills, Inc.	Nike, Inc.	

Appendix B—A model of risk-taking incentives

This appendix describes the model and the simulation used to guide the hypothesis development and to calculate the certainty equivalent of an agent's incentive plan for generating Figure 2. The model incorporates risk substitution between the systematic and idiosyncratic components of risk and is based closely on Armstrong and Vashishtha (2012) and Tian (2004). Other modeling choices and assumptions closely follow those that are standard in the literature (Armstrong and Vashishtha 2012; Conyon et al. 2011; Gormley et al. 2013; Hall and Murphy 2000, 2002; Kahl et al. 2003; Lewellen 2006; Tian 2004).

A risk-averse agent with a coefficient of relative risk aversion ρ has preferences over terminal wealth W that can be represented with the power utility function:

$$U(W) = \begin{cases} \dfrac{W^{(1-\rho)}}{(1-\rho)} & \text{if } \rho \neq 1 \\ \ln W & \text{otherwise.} \end{cases} \tag{B.1}$$

The agent's terminal wealth consists of both firm-unrelated (i.e., private) initial wealth and firm-related wealth from future relative performance provisions. Formally, let w denote the agent's initial wealth and n^{RPE} denote the provisions the agent receives. The agent can invest outside wealth in both the risk-free asset (e.g., a money-market fund) and the market portfolio (e.g., an index fund tracking the performance of a market index). Given the structure of the overall incentive-compensation arrangement and the firm's risk profile, the agent maximizes expected utility from terminal wealth by optimally allocating, both long and short, private wealth between the risk-free asset and the market portfolio. If θ denotes the portion of outside wealth invested in the market portfolio, the agent's wealth is:

$$W_T = \theta w M_T + (1 - \theta) w (1 + r_f)^T + n^{RPE} \max(\widetilde{RPE}_T - RPE_T, 0), \tag{B.2}$$

where M_T is the realized market price at time T, r_f is the return on the risk-free asset, and $\widetilde{RPE}_T$ and RPE_T are the firm's realized and targeted relative performance rank at time T, respectively.

The provisions the agent receives for relative firm performance, n^{RPE}, are expressed either in shares or cash and are determined based on a simple “threshold-target-maximum” incentive plan. This plan has the following payout structure:

$\widetilde{RPE}_T$	< threshold	≥ threshold and < target	≥ target and < max	≥ max
Awards	0	t^c	$2t^c$	$3t^c$

where t is the threshold award and c is payout convexity. I model different levels of expected relative performance by altering the agent’s current stock price vis-à-vis the threshold (and, thus, target and maximum) hurdle, and different levels of incentive strength by altering payout convexity, while holding constant the agent’s total wealth.

To focus on the characteristics of relative performance plans, I make two simplifying assumptions that are standard in the literature. First, the firm’s end-of-period stock price and the market portfolio follow a joint geometric Brownian motion with parameters μ and σ for the expected value and standard deviation of the distributions, respectively. This implies that the value of the firm and market at time T are joint log-normally distributed and are described by:

$$P_T = P_0 e^{\left(\left[\mu_p - \frac{1}{2}\sigma_p^2\right]T + \sigma_p \varepsilon_p \sqrt{T}\right)}, \text{ and} \tag{B.3}$$

$$M_T = M_0 e^{\left(\left[\mu_m - \frac{1}{2}\sigma_m^2\right]\mathrm{T} + \sigma_m \varepsilon_m \sqrt{T}\right)}, \tag{B.4}$$

where P_0 and M_0 are the firm’s initial stock price and the initial value of the market portfolio, respectively. μ_p and σ_p are the expected return and expected return volatility of the firm’s stock, whereby the latter can be further decomposed into two distinct components: systematic risk (β) and idiosyncratic risk ($\sigma_{p_{idio}}$) (Tian 2004). μ_m and σ_m are the expected return and expected return volatility of the market portfolio. ε_p and ε_m are joint normal shocks with correlation η.

Second, the firm’s expected return is given by the Capital Asset Pricing Model:

$$\mu_p = r_f + \beta(\mu_m - r_f), \tag{B.5}$$

where $\beta = \eta \frac{\sigma_p}{\sigma_m}$. For simplicity and consistency with previous work, I use a single-factor model of returns but note this point can be generalized to multi-factor models of returns.

The unique feature of any relative performance plan is that it shields the agent from systematic performance trends that affect the firm's realized relative *performance* rank $\widetilde{RPE}_T$. Whether the ultimate *payouts* remain a function of systematic performance trends depends on the payout structure. With share-based payouts the ultimate payouts remain a function of systematic performance trends, which implies that the provisions are a function of the firm's end-of-period stock price, expressed in equation (B.3). By contrast, with cash-based payouts, the ultimate payouts are shielded from systematic performance trends, which implies that the provisions are only affected by the idiosyncratic performance movements:

$$P_T^{RPE^{cash}} = P_0 e^{\left(\left[r_f - \frac{1}{2}\sigma_{P_{idio}}^2\right]T + \sigma_{P_{idio}}\varepsilon_P\sqrt{T}\right)}. \tag{B.6}$$

To maximize expected utility from terminal wealth (i.e., private and firm-related wealth), the agent can allocate, both long and short, private wealth between the risk-free asset and the market portfolio. Because the agent cannot sell the firm-related component of wealth, the optimal portfolio allocation may differ from the portfolio allocation of unconstrained investors who do not face such constraints and are not exposed to the incentive-compensation arrangement and the firm's risk profile. As a result, the agent may subjectively discount the value of the incentive plan from its market value (Ingersoll 2006; Lambert et al. 1991).

The agent chooses the optimal long-short allocation of private wealth θ to maximize the expected utility of terminal wealth $E^*[U(W)]$. Formally, this is expressed as:

$$E^*[U(W)] = \max_{\theta} E\left[\iint U(W_T) f(M_T, P_T)\, dM_T\, dP_T\right]. \tag{B.7}$$

Appendix C—Variable definitions

See Table C1.

Table C1. Variable definitions

Panel A. Risk outcomes

Variable	Description	Data source(s)
R&D	The firm's research and development intensity (in %), computed as expenditures on research and development scaled by the book value of total assets at the beginning of the year. Missing values of expenditures on research and development are set to zero.	Compustat.
Systematic Risk	This variable refers to several measures of firm risk computed based on realized volatility of stock returns over 36 months periods (i.e., a typical RPE performance period), using the imputed returns-method in Armstrong and Vashishtha (2012), a market and an industry factor-method (Campbell et al. 2001), and typical models based on three factors (i.e., *MKTRF*, *HML*, and *SMB*) and four factors (i.e., three factors plus *UMD*) (Carhart 1997; Fama and French 1992). To streamline the paper, I use the first principal component of all seven measures to create an index that combines the variation. This variable accounts for ~67% of the variance in all seven measures, with its first eigenvalue exceeding one at 0.668 × 7 ≈ 4.676.	CRSP, Compustat Segments, and Fama-French Portfolios and Factors

Panel B. RPE plan characteristics

Variable	Description	Data source(s)
RPE^{cash}	An indicator equal to one if the firm's proxy statement shows that at least one component of executive compensation is determined based on the firm's performance relative to the performance of other firms and payouts are not based on the firm's stock price, zero otherwise.	ISS Incentive Lab.
RPE^{share}	An indicator equal to one if the firm's proxy statement shows that at least one component of executive compensation is determined based on the firm's performance relative to the performance of other firms and payouts are based on the firm's stock price, zero otherwise.	ISS Incentive Lab.
RPE Threshold	The first threshold to be met to qualify for compensation in the RPE incentive plan.	ISS Incentive Lab.
RPE Horizon	Natural logarithm of one plus the length of the RPE performance period (in months).	ISS Incentive Lab.
RPE Expected Performance	The firm's expected ranking within the peer group. Expected returns are simulated based on analyst forecasts of the firm's and peers' price in twelve months. For this variable, larger values correspond to easier-to-beat peer groups, *ex ante*—i.e., the focal firm's expected relative performance is higher.	CRSP, I/B/E/S, and ISS Incentive Lab.

Panel B. RPE plan characteristics (continued)

Variable	Description	Data source(s)
RPE Convexity	Non-linearity slope of the RPE payout structure, estimated using a firm-year-specific regression of payouts (in $) on percentiles and percentiles squared: $Payout_{jt} = \alpha_{0jt} + \beta_{1jt}Percentile_{jt} + \beta_{2jt}Percentile_{jt}^2 + \varepsilon_{jt}$, where $\hat{\beta}_{2jt}$ measures plan *j*'s payout convexity in year *t*. This variable has a larger value when the RPE plan has, *ceteris paribus*: (1) larger payouts for extraordinary performance; (2) lower hurdles for ordinary performance; (3) fewer hurdles for the same payouts; and (4) no interpolation.	ISS Incentive Lab.
RPE Grant Size	Value of the RPE plan's target payouts. For RPE grants with equity awards, the value equals the number of shares the manager can receive multiplied by the firm's current stock price. For RPE grants with cash awards, the value equals the cash the manager can receive. I scale this variable by prior cash compensation, so it is more comparable in the cross-section of firms.	ExecuComp and ISS Incentive Lab.

Panel C. CEO and firm characteristics

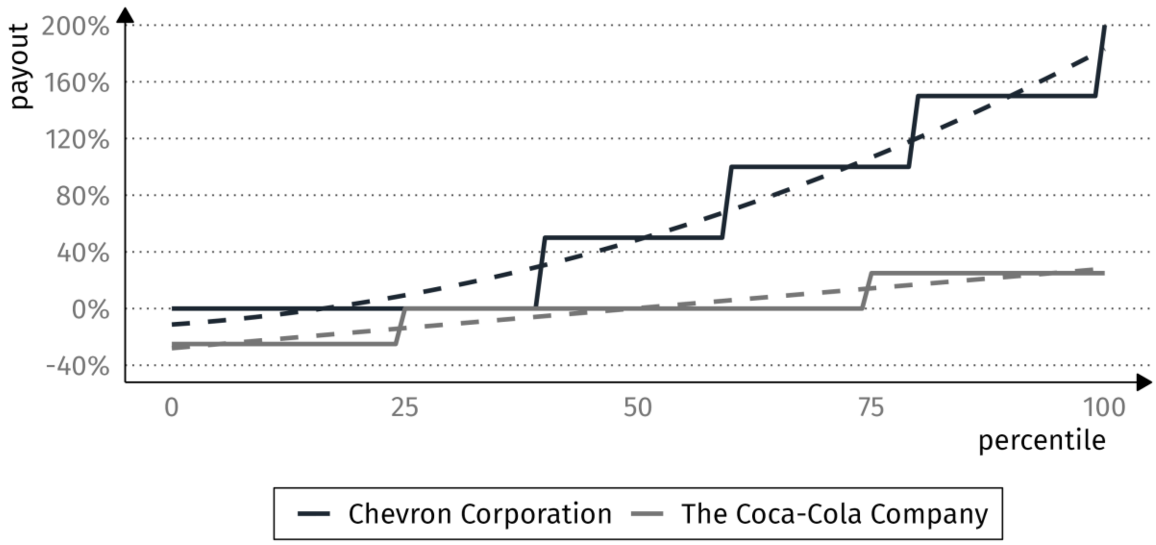
Variable	Description	Data source(s)
Delta	Sensitivity of the risk-neutral value of the CEO's portfolio of stock and stock options to a 1% change in the price of the underlying stock. I estimate the risk-neutral value of the CEO's option portfolio using the Black and Scholes (1973) model, as modified by Merton (1973) to account for dividend payouts. Because this variable is skewed, I use the natural logarithm of one plus the raw value in my analyses.	CRSP and ExecuComp.
Vega	Sensitivity of the risk-neutral value of the CEO's portfolio of stock options to a 0.01 change in the volatility of the underlying stock. Because this variable is skewed, I use the natural logarithm of one plus the raw value in my analyses.	CRSP and ExecuComp.
Share-based Non-RPE	Total number of share-based non-RPE metrics in the CEO's incentive-compensation contract. Because this variable is skewed, I use the natural logarithm of one plus the raw value in my analyses.	ISS Incentive Lab.
Cash-based Non-RPE	Total number of cash-based non-RPE metrics in the CEO's incentive-compensation contract. Because this variable is skewed, I use the natural logarithm of one plus the raw value in my analyses.	ISS Incentive Lab.
Age	The CEO's age. Because this variable is skewed, I use the natural logarithm of one plus the raw value in my analyses.	ExecuComp.
Tenure	Number of years the CEO has held his/her office. Because this variable is skewed, I use the natural logarithm of one plus the raw value in my analyses.	ExecuComp.
Number of Rivals	Number of product market rivals, as identified by Hoberg and Phillips (2010, 2016). Because this variable is skewed, I use the natural logarithm of one plus the raw value in my analyses.	Hoberg-Phillips Data Library. See https://hobergphillips.tuck.dartmouth.edu/
Rival Similarity	Mean of the firm's similarity score to its product market rivals, as identified by Hoberg and Phillips (2010, 2016).	

Panel C. CEO and firm characteristics (continued)

Variable	Description	Data source(s)
Sales	Annual revenue. Because this variable is skewed, I use the natural logarithm of one plus the raw value in my analyses.	Compustat.
Book-to-Market	Ratio of book value of total assets to the firm's market value.	Compustat.
Leverage	Book value of total long-term debt, scaled by total assets.	Compustat.
Sales Growth	Growth in annual revenue over the prior year.	Compustat.
PP&E	Net investment in property, plant and equipment, scaled by total assets.	Compustat.
Non-Co-Opted Independence	Fraction of board comprised of directors who are independent and were appointed before the CEO assumed office.	BoardEx.
Co-Option	The proportion of the board comprised of directors who joined the board after the CEO assumed office.	BoardEx.
CEO Duality	An indicator equal to one if the CEO is also the Chairman of the Board, zero otherwise.	BoardEx.
Board Size	Number of board members. Because this variable is skewed, I use the natural logarithm of one plus the raw value in my analyses.	BoardEx.
Board Experience	Fraction of board members that sits on at least three boards.	BoardEx.
Long-Term Investors	Fraction of institutional investors that is long-term oriented (i.e., "dedicated" and "quasi-index" investors).	Bushee (2001) and Bushee and Noe (2000). See https://accounting-faculty.wharton.upenn.edu/bushee/
Short-Term Investors	Fraction of institutional investors that is short-term oriented (i.e., "transient" investors).	
Options-Luck Sensitivity	Sensitivity of the CEO's past realized options-based pay to the industry component of stock returns, estimated using rolling regressions with 5 years of compensation data. To determine the firm's industry component of stock returns, I estimate rolling regressions of monthly stock returns on monthly two-digit SIC industry returns over the similar past 5 years (i.e., 60 months).	CRSP and ExecuComp.
Horizon Problem	An indicator equal to one for CEOs in the top quartile of age in my sample, zero otherwise.	ExecuComp.
Segments	The number of two-digit SIC segments the firm operates in. Because this variable is skewed, I use the natural logarithm of one plus the raw value in my analyses.	Compustat Segments.
Segments HHI	The asset-weighted Herfindahl-Hirschman index of a firm's own segments.	Compustat Segments.
SOP Votes	Say-on-pay voting percentage in favor of the CEO's incentive-compensation contract.	ISS Incentive Lab.
% Ownership	The percentage of the firm's total shares outstanding held by the firm's executives that are covered by ExecuComp.	Compustat and ExecuComp.

This table presents definitions of all variables used in the empirical analysis. Panels A through C present, respectively, definitions of the variables grouped according to risk outcomes, RPE plan characteristics, and CEO and firm characteristics.

Figure 1. Examples of relative performance plans

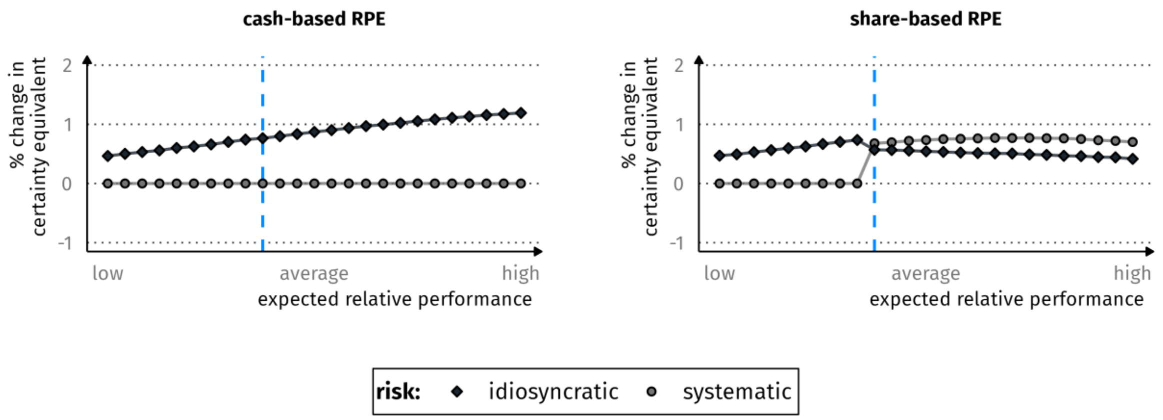


Chevron Corporation	BP plc, ExxonMobil Corporation, Royal Dutch Shell plc, Total S.A., and S&P 500 Total Return Index.
The Coca-Cola Company	AT&T Inc., Colgate-Palmolive Company, Danone S.A., General Mills, Inc., International Business Machines Corporation, Johnson & Johnson, Kimberly-Clark Corporation, McDonald's Corporation, Mondelēz International, Inc., Nestlé S.A., NIKE, Inc., PepsiCo, Inc., Philip Morris International Inc., Pfizer, Inc., The Procter & Gamble Company, Unilever plc, and Wal-Mart Stores, Inc.

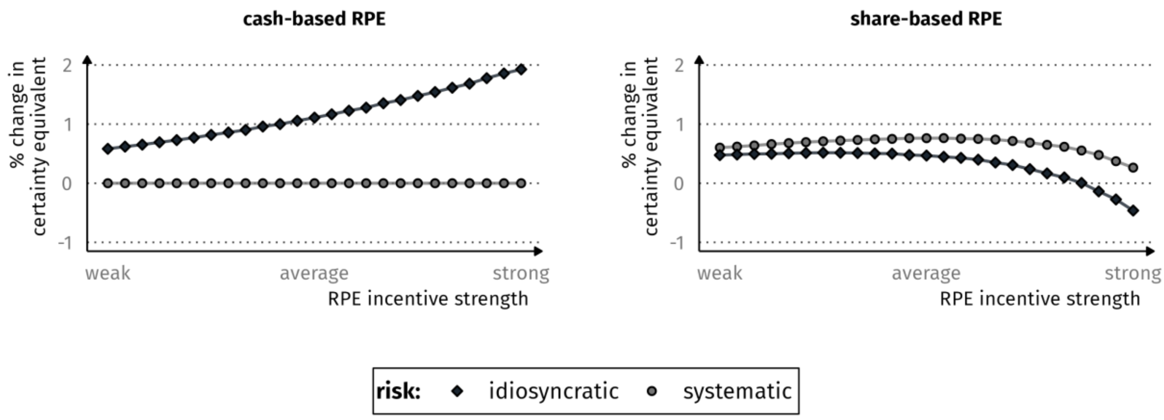
This figure illustrates the payout structures and peer groups of the RPE plans of Chevron Corporation (2019) (in black) and The Coca-Cola Company (2019) (in gray). The dashed lines represent the plans' payout convexity. The *y*-axis displays the payouts that are tied to the performance hurdles displayed on the *x*-axis.

Figure 2. Risk-taking properties of relative performance plans

Panel A. Risk-taking properties by expected relative performance

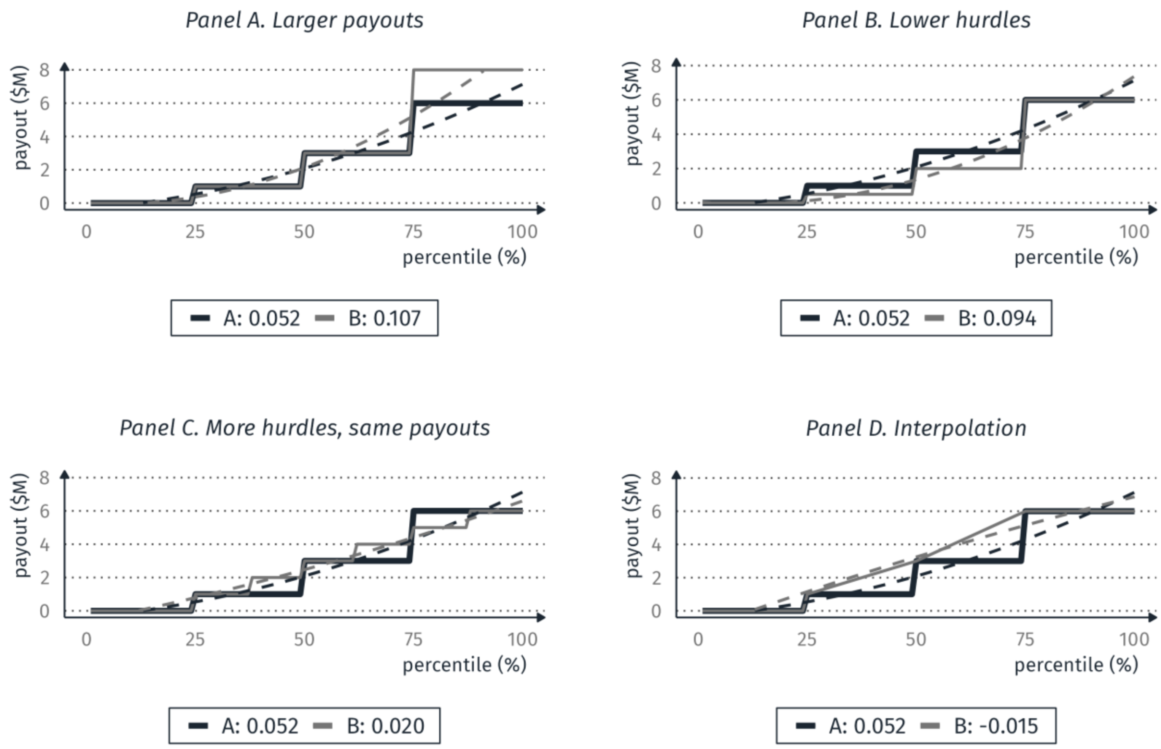


Panel B. Risk-taking properties by RPE incentive strength



This figure illustrates a risk-averse agent's incentives to increase idiosyncratic and systematic risk in response to RPE plans with distinct payout forms, different levels of expected relative performance, and different levels of RPE incentive strength. Specifically, this figure depicts results of simulating the model in Appendix B for one holding period separately for cash-based RPE plans and share-based RPE plans, with the two panels depicting, respectively, results for different levels of expected relative performance and different levels of RPE incentive strength. In Panel A, the dashed vertical line represents the first threshold to be met to qualify for compensation in the RPE incentive plan. Idiosyncratic risk-taking incentives are measured as the percentage change in the certainty equivalent of the agent's wealth caused by a ten percentage-point increase in idiosyncratic-return volatility, holding constant the systematic-return volatility. Systematic risk-taking incentives are measured analogously for a change in the systematic-return volatility, holding constant the idiosyncratic-return volatility. RPE payouts in shares increase the agent's delta (i.e., the sensitivity of the agent's wealth to changes in stock price). Given the exposure to the firm's risk profile, the agent chooses the optimal long-short allocation of private wealth θ to maximize the expected utility of terminal wealth $E^{*}[U(W)] = \max_{\theta} E[\iint U(W_T) f(M_T, P_T) dM_T dP_T]$. The agent has power utility with a coefficient of relative risk aversion of three and constant total wealth of \$10 million. Thus, for a given level of expected RPE payouts, the agent's outside wealth is determined such that total wealth equals \$10 million. The parameters for the stock-price and the market-value processes are: stock price = \$100; idiosyncratic-return volatility = 30%; systematic-return volatility = 30%; market-return volatility = 20%; market-risk premium = 7%; and risk-free rate = 2%.

Figure 3. Sensitivity of *RPE Convexity* to first order contract-design features



This figure illustrates the *ceteris paribus* effect of design choices in payout structures on the measure for payout convexity. Panels A through D modify, respectively, payout levels, hurdle levels, the number of hurdles, and the interpolation rules. In each panel, the bolded black line represents a basic incentive plan with payouts \$1.5M, \$3M, and \$6M for performance at the 25th, 50th, 75th percentile, respectively, without interpolation between percentiles; its convexity is illustrated by the dashed black line. The gray line represents the modified incentive plan; its convexity is illustrated by the dashed gray line. In each panel, the *x*-axis represents the performance hurdles that result in the payouts displayed on the *y*-axis.

Table 1. Sample composition

Panel A. Share-based RPE

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Overall
Consumer Non-Durables	0.188	0.220	0.239	0.186	0.178	0.220	0.354	0.400	0.413	0.425	0.500	0.511	0.561	0.550	0.667	0.370
Consumer Durables	0.125	0.267	0.357	0.222	0.350	0.444	0.364	0.318	0.364	0.440	0.500	0.478	0.619	0.500	0.455	0.397
Manufacturing	0.198	0.259	0.276	0.321	0.341	0.356	0.410	0.465	0.476	0.463	0.505	0.511	0.549	0.617	0.638	0.427
Oil, Gas, and Coal Extraction	0.321	0.267	0.303	0.333	0.471	0.484	0.595	0.579	0.718	0.675	0.800	0.814	0.795	0.853	0.824	0.606
Chemicals and Allied Products	0.211	0.250	0.211	0.238	0.286	0.318	0.364	0.273	0.346	0.400	0.462	0.552	0.500	0.536	0.654	0.389
Business Equipment	0.036	0.095	0.098	0.132	0.147	0.216	0.299	0.338	0.403	0.449	0.509	0.522	0.565	0.556	0.600	0.339
Telephone and Television	0.200	0.455	0.273	0.273	0.455	0.357	0.286	0.353	0.389	0.412	0.444	0.412	0.412	0.357	0.312	0.363
Utilities	0.510	0.532	0.647	0.704	0.755	0.778	0.863	0.939	0.940	0.870	0.875	0.936	0.944	0.875	0.976	0.803
Wholesale and Retail	0.057	0.087	0.056	0.076	0.096	0.123	0.138	0.241	0.228	0.250	0.253	0.314	0.298	0.303	0.377	0.190
Healthcare and Medical	0.128	0.128	0.170	0.178	0.227	0.212	0.288	0.356	0.400	0.367	0.379	0.459	0.509	0.603	0.638	0.348
Finance	0.113	0.132	0.110	0.124	0.161	0.205	0.279	0.309	0.400	0.409	0.401	0.508	0.479	0.521	0.630	0.346
Other	0.101	0.087	0.099	0.133	0.169	0.183	0.231	0.333	0.388	0.447	0.473	0.524	0.517	0.494	0.511	0.324
Overall	0.155	0.193	0.197	0.217	0.253	0.280	0.337	0.392	0.438	0.450	0.483	0.533	0.544	0.556	0.606	0.384

Panel B. Cash-based RPE

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Overall
Consumer Non-Durables	0.083	0.146	0.087	0.093	0.067	0.073	0.063	0.044	0.044	0.075	0.091	0.089	0.073	0.075	0.026	0.075
Consumer Durables	0.063	0.000	0.000	0.056	0.200	0.111	0.091	0.091	0.091	0.080	0.091	0.087	0.048	0.136	0.136	0.089
Manufacturing	0.099	0.111	0.092	0.099	0.091	0.067	0.060	0.030	0.019	0.042	0.021	0.046	0.049	0.037	0.013	0.057
Oil, Gas, and Coal Extraction	0.071	0.100	0.091	0.121	0.118	0.194	0.189	0.263	0.154	0.200	0.100	0.116	0.128	0.059	0.029	0.131
Chemicals and Allied Products	0.105	0.150	0.053	0.095	0.048	0.046	0.046	0.046	0.039	0.040	0.000	0.000	0.000	0.000	0.000	0.040
Business Equipment	0.073	0.076	0.090	0.091	0.060	0.040	0.041	0.047	0.042	0.047	0.026	0.007	0.008	0.008	0.031	0.045
Telephone and Television	0.000	0.000	0.091	0.091	0.091	0.143	0.048	0.059	0.000	0.000	0.000	0.000	0.059	0.000	0.000	0.036
Utilities	0.204	0.191	0.157	0.130	0.122	0.093	0.078	0.020	0.020	0.044	0.021	0.021	0.028	0.025	0.000	0.080
Wholesale and Retail	0.029	0.022	0.056	0.063	0.084	0.062	0.069	0.069	0.063	0.053	0.038	0.029	0.018	0.000	0.029	0.048
Healthcare and Medical	0.021	0.085	0.021	0.022	0.000	0.039	0.068	0.068	0.067	0.117	0.035	0.098	0.094	0.059	0.021	0.057
Finance	0.099	0.088	0.098	0.067	0.138	0.120	0.110	0.103	0.100	0.068	0.042	0.046	0.050	0.066	0.039	0.080
Other	0.044	0.058	0.049	0.048	0.036	0.075	0.077	0.069	0.082	0.032	0.043	0.038	0.000	0.024	0.011	0.046
Overall	0.078	0.091	0.080	0.080	0.082	0.079	0.076	0.070	0.061	0.063	0.040	0.044	0.040	0.037	0.026	0.062

This table presents the sample composition by year and industry, following the classification in Fama and French (1997). Panels A and B present, respectively, the percentage of firm-year observations using share-based RPE and the percentage of firm-year observations using cash-based RPE.

Table 2. Summary statistics

Panel A. Whole sample

Risk outcomes	Mean	Std. Dev.	10^{th}	25^{th}	50^{th}	75^{th}	90^{th}
R&D	2.589	5.023	0.000	0.000	0.000	2.593	9.435
Systematic Risk	–0.014	0.982	–1.085	–0.731	–0.219	0.471	1.314
RPE plan characteristics	**Mean**	**Std. Dev.**	10^{th}	25^{th}	50^{th}	75^{th}	90^{th}
RPE	0.446	0.497					
RPE^{share}	0.384	0.486					
RPE^{cash}	0.062	0.242					
RPE Horizon	3.557	0.294	3.497	3.555	3.611	3.611	3.689
RPE Threshold	41.421	20.745	25.000	30.000	33.333	46.667	66.667
RPE Expected Performance	55.603	27.928	16.667	33.333	57.143	78.571	94.444
RPE Convexity	0.177	0.134	0.135	0.135	0.145	0.165	0.216
RPE Grant Size	6.519	18.355	0.872	1.527	2.719	4.788	8.245
Other	**Mean**	**Std. Dev.**	10^{th}	25^{th}	50^{th}	75^{th}	90^{th}
Delta	5.797	1.518	3.920	4.843	5.831	6.745	7.647
Vega	3.798	2.253	0.000	2.369	4.465	5.509	6.245
Share-based Non-RPE	0.627	0.578	0.000	0.000	0.693	1.099	1.386
Cash-based Non-RPE	1.166	0.746	0.000	0.693	1.386	1.609	2.079
Age	4.047	0.110	3.892	3.970	4.060	4.127	4.174
Tenure	1.939	0.690	1.099	1.386	1.946	2.398	2.833
Number of Rivals	3.413	1.511	1.386	2.197	3.367	4.543	5.531
Rival Similarity	0.028	0.025	0.008	0.013	0.021	0.031	0.057
Sales	8.316	1.253	6.694	7.470	8.306	9.260	10.139
Book-to-Market	0.624	0.265	0.275	0.415	0.614	0.834	0.981
Leverage	0.253	0.219	0.004	0.098	0.220	0.346	0.501
Sales Growth	0.071	0.194	–0.105	–0.012	0.056	0.133	0.252
PP&E	0.266	0.261	0.017	0.066	0.167	0.399	0.706
Non-Co-Opted Independence	0.298	0.248	0.000	0.000	0.313	0.500	0.625
Co-Option	0.413	0.345	0.000	0.111	0.333	0.667	1.000
CEO Duality	0.476	0.499					
Board Size	2.392	0.206	2.079	2.303	2.398	2.565	2.639
Board Experience	0.097	0.128	0.000	0.000	0.063	0.154	0.267
Long-Term Investors	0.552	0.225	0.000	0.498	0.603	0.691	0.766
Short-Term Investors	0.194	0.118	0.000	0.118	0.185	0.267	0.349
Options-Luck Sensitivity	0.004	0.098	–0.092	–0.013	0.000	0.015	0.111
Horizon Problem	0.259	0.438					
Segments	0.935	0.305	0.693	0.693	0.693	1.099	1.386
Segments HHI	0.875	0.202	0.513	0.788	1.000	1.000	1.000
SOP Votes	0.891	0.145	0.693	0.881	0.951	0.973	0.985
% Ownership	0.021	0.061	0.001	0.002	0.005	0.012	0.043

Table 2. Summary statistics (continued)

Panel B. Subsamples

Risk outcome	RPE^{share} == 1	RPE^{cash} == 1	Normalized difference
R&D	2.405	2.280	–0.019
Systematic Risk	–0.098	0.052	0.105
RPE plan characteristics	RPE^{share} == 1	RPE^{cash} == 1	Normalized difference
RPE Horizon	3.610	3.225	–0.691†
RPE Threshold	40.284	51.037	0.311†
RPE Expected Performance	56.232	52.438	–0.093
RPE Convexity	0.181	0.147	–0.226
RPE Grant Size	7.152	1.884	–0.270†
Other	RPE^{share} == 1	RPE^{cash} == 1	Normalized difference
Delta	5.601	6.022	0.212
Vega	3.502	4.182	0.214
Share-based Non-RPE	0.869	0.285	–0.866†
Cash-based Non-RPE	1.380	1.272	–0.105
Age	4.055	4.058	0.022
Tenure	1.863	1.995	0.134
Number of Rivals	3.544	3.670	0.059
Rival Similarity	0.028	0.032	0.103
Sales	8.602	8.478	–0.070
Book-to-Market	0.659	0.662	0.009
Leverage	0.283	0.245	–0.128
Sales Growth	0.055	0.054	–0.003
PP&E	0.328	0.285	–0.106
Non-Co-Opted Independence	0.340	0.303	–0.104
Co-Option	0.398	0.419	0.044
CEO Duality	0.471	0.540	0.098
Board Size	2.426	2.410	–0.053
Board Experience	0.114	0.112	–0.010
Long-Term Investors	0.551	0.548	–0.012
Short-Term Investors	0.185	0.179	–0.037
Options-Luck Sensitivity	0.006	0.001	–0.041
Horizon Problem	0.247	0.303	0.088
Segments	0.966	1.000	0.076
Segments HHI	0.860	0.845	–0.051
SOP Votes	0.906	0.840	–0.297†
% Ownership	0.009	0.020	0.182

This table presents summary statistics of the variables grouped according to risk outcomes, RPE plan characteristics, and CEO and firm characteristics. Panel A presents summary statistics for the whole sample. Panel B presents means by treatment status and the difference in means scaled by the square root of the sum of the variances to conform to Imbens and Wooldridge (2009). † indicates that the normalized difference exceeds the critical value of one quarter (Imbens and Rubin 2015, 277). Appendix C defines all variables.

Table 3. Economic determinants of cash- and share-based RPE

Panel A. Main specification

	(1)		(2)	
	Dependent variable:			
Variable:	*RPE*^{cash}		*RPE*^{share}	
Cash-based RPE factors:				
Long-Term Investors	0.680**	(0.282)	0.323**	(0.155)
Short-Term Investors	–1.550**	(0.612)	–0.138	(0.303)
Horizon Problem	0.265**	(0.112)	–0.178***	(0.063)
Segments	0.453*	(0.264)	0.261	(0.178)
Segments HHI	0.404	(0.385)	0.102	(0.270)
Non-Co-Opted Independence	1.138***	(0.326)	0.397**	(0.200)
Share-based RPE factors:				
Options-Luck Sensitivity	–0.107	(0.340)	0.444**	(0.216)
Number of Rivals	0.079	(0.050)	0.162***	(0.029)
Co-Option	–0.005	(0.217)	0.431***	(0.134)
CEO Duality	0.024	(0.109)	0.170**	(0.068)
Controls:				
Delta	–0.035	(0.060)	–0.088***	(0.030)
Vega	0.050	(0.031)	–0.008	(0.015)
Share-based Non-RPE	–1.372***	(0.142)	0.755***	(0.049)
Cash-based Non-RPE	0.842***	(0.066)	0.214***	(0.043)
Tenure	0.314**	(0.127)	–0.146**	(0.070)
Rival Similarity	–0.354	(2.597)	–0.602	(1.564)
Sales	0.371***	(0.071)	0.311***	(0.039)
Book-to-Market	0.333	(0.272)	0.606***	(0.152)
Leverage	–0.594**	(0.285)	–0.280*	(0.166)
Sales Growth	–0.720***	(0.220)	–0.183**	(0.088)
PP&E	0.458	(0.391)	0.945***	(0.213)
Board Size	–0.418	(0.306)	0.314*	(0.184)
Board Experience	0.690*	(0.366)	0.823***	(0.242)
Fixed effects	industry, year			
Estimator	multinomial logit			
Observations	10,906			
McFadden (1974) pseudo R^2	24.327%			

Table 3. Economic determinants of cash- and share-based RPE (continued)

Panel B. The role of say-on-pay votes

	(1)		(2)	
	Dependent variable:			
Variable:	RPE^{cash}		RPE^{share}	
SOP Votes	–0.750***	(0.262)	0.435**	(0.186)
Cash-based RPE factors:				
Long-Term Investors	0.919***	(0.327)	0.269	(0.174)
Short-Term Investors	–1.694**	(0.679)	–0.019	(0.340)
Horizon Problem	0.249*	(0.132)	–0.139*	(0.072)
Segments	0.374	(0.275)	0.234	(0.193)
Segments HHI	0.578	(0.389)	–0.051	(0.298)
Non-Co-Opted Independence	1.136***	(0.363)	0.460**	(0.222)
Share-based RPE factors:				
Options-Luck Sensitivity	0.039	(0.415)	0.352	(0.283)
Number of Rivals	0.017	(0.050)	0.167***	(0.033)
Co-Option	–0.066	(0.223)	0.385***	(0.146)
CEO Duality	0.114	(0.124)	0.154**	(0.075)
Panel A controls included	yes			
Fixed effects	industry, year			
Estimator	multinomial logit			
Observations	7,587			
McFadden (1974) pseudo R^2	23.346%			

This table presents results of estimating equation (1), a multinomial logit equation predicting the probabilities of not using RPE, using cash-based RPE, or using share-based RPE. Panels A and B present, respectively, results without and with the say-on-pay voting percentage in favor of the CEO's incentive-compensation contract (*SOP Votes*). Coefficients are log odds of the respective RPE category compared to the reference category of not using RPE. Standard errors are in parentheses and are adjusted for within-cluster correlation at the level of treatment (i.e., firm) to conform to Abadie et al. (2023). The industry indicators follow the 48 industry groups identified by Fama and French (1997). *, **, and *** denote statistical significance at two-tailed probability levels of 10%, 5%, and 1%, respectively. Appendix C defines all variables.

Table 4. Cash- and share-based RPE and the firm's risk profile

Panel A. Main specification

Subsample	(1) whole sample		(2) whole sample		(3) whole sample		(4) whole sample		(5) variation in *R&D*		(6) variation in *R&D*		(7) variation in RPE^{cash}		(8) variation in RPE^{cash}	
Variable:	Dependent variable: $R\&D_{t+1}$															
RPE^{cash}	0.363***	(0.115)	0.294***	(0.095)	0.276*	(0.143)	0.214*	(0.123)	0.862**	(0.395)	0.636**	(0.269)	0.470**	(0.190)	0.359**	(0.137)
RPE Threshold					0.005	(0.032)	–0.009	(0.030)	0.017	(0.072)	0.021	(0.064)	0.186**	(0.081)	0.115**	(0.049)
RPE Horizon					–0.325	(0.268)	–0.247	(0.225)	–0.574	(0.522)	–0.571	(0.442)	–0.081	(0.152)	0.047	(0.081)
Delta					–0.057	(0.059)	–0.063	(0.061)	–0.185	(0.145)	–0.170	(0.134)	–0.016	(0.082)	–0.122	(0.105)
Vega					–0.017	(0.028)	–0.021	(0.027)	–0.010	(0.060)	–0.045	(0.055)	0.019	(0.033)	0.015	(0.030)
Share-based Non-RPE					0.130	(0.107)	0.118	(0.098)	0.349	(0.250)	0.303	(0.238)	0.270	(0.265)	0.223	(0.137)
Cash-based Non-RPE					0.015	(0.044)	0.031	(0.047)	0.053	(0.105)	0.101	(0.112)	–0.019	(0.105)	0.085	(0.119)
Age					0.945	(0.584)	0.982*	(0.595)	1.989	(1.294)	2.056	(1.271)	1.234	(0.823)	1.927*	(1.090)
Tenure					0.216	(0.151)	0.206	(0.150)	0.592*	(0.330)	0.527*	(0.311)	0.168	(0.225)	0.177	(0.155)
Number of Rivals					0.019	(0.049)	0.067	(0.055)	0.159	(0.107)	0.248**	(0.099)	0.124	(0.078)	0.144**	(0.065)
Rival Similarity					1.298	(1.334)	1.467	(1.484)	2.982	(3.572)	3.763	(3.923)	–2.935	(2.945)	–0.216	(2.581)
Sales					–0.208	(0.204)	–0.186	(0.196)	–0.828	(0.525)	–0.698	(0.464)	0.183	(0.216)	0.123	(0.179)
Book-to-Market					–0.928*	(0.398)	–0.857**	(0.372)	–2.130**	(1.016)	–1.831**	(0.863)	–0.564	(0.360)	–0.858**	(0.344)
Leverage					–0.284	(0.618)	–0.298	(0.580)	–0.968	(0.944)	–1.120	(1.001)	–0.951**	(0.462)	–1.145***	(0.409)
Sales Growth					–0.282	(0.191)	–0.234	(0.182)	–0.825	(0.561)	–0.598	(0.466)	–0.121	(0.182)	–0.100	(0.163)
PP&E					1.180*	(0.570)	0.958*	(0.546)	2.701	(1.713)	1.599	(1.694)	0.180	(0.532)	0.152	(0.452)
Non-Co-Opted Independence					0.352	(0.334)	0.353	(0.294)	1.154	(0.933)	1.081	(0.769)	0.031	(0.361)	0.127	(0.438)
Co-Option					–0.184	(0.212)	–0.218	(0.202)	–0.307	(0.464)	–0.347	(0.386)	–0.449	(0.332)	–0.439*	(0.245)
CEO Duality					0.055	(0.089)	0.081	(0.094)	0.179	(0.230)	0.243	(0.236)	–0.179	(0.118)	–0.138	(0.093)
Board Size					0.250	(0.210)	0.493*	(0.284)	0.577	(0.524)	1.015*	(0.607)	0.814*	(0.445)	1.115**	(0.468)
Board Experience					–0.271	(0.309)	–0.398	(0.342)	–0.909	(0.738)	–1.102	(0.754)	–0.853**	(0.419)	–0.950**	(0.437)
Long-Term Investors					–0.158	(0.275)	–0.382	(0.323)	–0.698	(0.634)	–0.978	(0.634)	–0.339	(0.358)	–0.565	(0.369)
Options-Luck Sensitivity					–0.071	(0.217)	–0.114	(0.212)	–0.339	(0.552)	–0.388	(0.533)	0.158	(0.259)	–0.182	(0.229)
Segments					–0.159	(0.290)	–0.279	(0.292)	–0.351	(0.681)	–0.389	(0.651)	–0.476	(0.389)	–0.867**	(0.416)
Segments HHI					0.479	(0.546)	0.121	(0.580)	0.714	(1.215)	0.338	(1.229)	–0.345	(0.660)	–0.438	(0.722)
Fixed effects	firm, year		firm, year		firm, year		firm, year		firm, year		firm, year		firm, year		firm, year	
Entropy balancing	yes		no		yes		no		yes		no		yes		no	
Observations	3,198		3,198		3,198		3,198		1,317		1,342		637		637	
Adjusted R^2	95.127%		94.744%		95.247%		94.869%		93.069%		92.354%		97.123%		96.835%	
Adjusted within-R^2	0.391%		0.301%		2.854%		2.656%		7.855%		6.930%		17.211%		17.439%	
Within *F*-statistic	11.300		8.924		4.082		3.863		4.751		4.276		5.491		5.562	

Table 4. Cash- and share-based RPE and the firm's risk profile (continued)

Panel B. Alternative outcome variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Risk computation (method and model)	principal component score	Armstrong and Vashishtha three-factor	Armstrong and Vashishtha four-factor	Campbell, Lettau, Malkiel and Xu two-digit SIC	Campbell, Lettau, Malkiel and Xu four-digit SIC	Fama and French one-factor	Fama and French three-factor	Carhart four-factor
Variable:	Dependent variable: $Systematic\ Risk_{t+1}$	Dependent variable: $[Systematic\ Risk_{t+1}]$		Dependent variable: $[Systematic\ Risk_{t \to t+3}]$				
RPE^{cash}	–0.184**	–0.015**	–0.015**	–0.023***	–0.022**	–0.007*	–0.008*	–0.009**
	(0.082)	(0.007)	(0.007)	(0.008)	(0.009)	(0.004)	(0.004)	(0.004)
Manager-year controls	yes	yes	yes	yes	yes	yes	yes	yes
Firm-year controls	yes	yes	yes	yes	yes	yes	yes	yes
Governance-year controls	yes	yes	yes	yes	yes	yes	yes	yes
Fixed effects	firm, year	firm, year	firm, year	firm, year	firm, year	firm, year	firm, year	firm, year
Entropy balancing	yes	yes	yes	yes	yes	yes	yes	yes
Observations	2,262	2,800	2,800	2,551	2,551	2,743	2,743	2,743
Adjusted R^2	80.400%	62.600%	62.000%	75.500%	79.300%	76.000%	77.100%	76.300%
Adjusted within-R^2	6.620%	2.180%	2.080%	3.440%	5.610%	5.520%	6.620%	7.120%
Within F-statistic	6.170	3.050	2.950	3.940	5.900	6.200	7.310	7.820

This table presents results of estimating equation (2) within firms and controlling for time-varying manager-, firm-, and governance-level characteristics. Panel A presents results of estimating firms' research and development intensity. Columns (1) through (4) present results without and with control variables and entropy balancing. Columns (5) through (8) present results after restricting the sample to firms with variation in the dependent and treatment variables. Panel B presents results of estimating firms' systematic risk profile. Column (1) presents results using the index of firms' risk profile, which is the first principal component score of the proxies used in the seven other columns. Columns (2) and (3) present results using risk proxies computed as in Armstrong and Vashishtha (2012), with three-factor and four-factor models, respectively. Columns (4) and (5) present results using risk proxies computed over the next 36 months as in Campbell et al. (2001), with two-digit SIC and four-digit SIC factor models, respectively. Columns (6) and (7) present results using risk proxies computed over the next 36 months as in Fama and French (1993), with one-factor (i.e., CAPM) and three-factor models, respectively. Column (8) presents results using risk proxies computed over the next 36 months as in Carhart (1997), i.e., Fama and French's (1993) three-factor model plus a momentum factor. To achieve covariate balance, the cash- and share-based RPE subsamples are entropy balanced on the first moment of all control variables in the odd columns in Panel A and all columns in Panel B. Standard errors are in parentheses and are adjusted for within-cluster correlation at the level of treatment (i.e., firm) to conform to Abadie et al. (2023). *, **, and *** denote statistical significance at two-tailed probability levels of 10%, 5%, and 1%, respectively. Appendix C defines all variables.

Table 5. Cash- and share-based RPE and the firm's risk profile—unobservable selection

Panel A. Two-stage least squares

	(1)	(2)
Stage	first	second
	Dependent variable:	
Variable:	RPE^{cash}	$R\&D_{t+1}$
% Ownership	0.889***	
	(0.294)	
RPE^{cash}		2.921**
		(1.299)
Manager-year controls	yes	yes
Firm-year controls	yes	yes
Governance-year controls	yes	yes
Fixed effects	firm, year	firm, year
Observations	3,174	3,174
Weak identification tests:		
(1) Cragg and Donald (1993) Wald *F*-statistic	9.498	
(2) Olea and Pflueger (2013) effective *F*-statistic	6.855	
Endogeneity test:		
(1) Durbin (1954)–Wu (1973)–Hausman (1978) test statistic		3.531*

Panel B. Modified control function

	(1)	(2)
	Dependent variable:	
Variable:	$R\&D_{t+1}$	
RPE^{cash}	2.294***	1.711***
	[1.442, 3.137]	[0.734, 2.710]
ρ	–0.208***	–0.189***
	[–0.272, –0.142]	[–0.271, –0.109]
First-stage determinants	yes	yes
Second-stage controls	no	yes
Observations	3,198	3,198
Adjusted R^2	1.910%	29.770%

Panel C. Coefficient stability test

	(1)
	Dependent variable:
Variable:	$R\&D_{t+1}$
RPE^{cash}	[0.220, 0.209]
	δ = 7.87
Manager-year controls	yes
Firm-year controls	yes
Governance-year controls	yes
Fixed effects	firm, year
Observations	3,198

This table presents results of estimating equation (2) using alternative estimation methods. Panel A presents results of two-stage least squares estimation using prior managerial stock ownership as an instrument for the payout decision. In this panel, standard errors are in parentheses and are adjusted for within-cluster correlation at the level of treatment (i.e., firm) to conform to Abadie et al. (2023). Panel B presents results of modified control function estimation (Klein and Vella 2010). In this panel, 90% confidence intervals based on 1,000 bootstrapped samples are in brackets for both RPE^{cash} and ρ, which is the endogeneity variable that captures the degree to which an unobservable factor is correlated with variation in both the dependent variable and the treatment variable. Panel C presents coefficient stability results. In this panel, Oster (2019) confidence intervals are in brackets, based on the assumption that the degree of model misspecification is 30 percent and the impact of unobservable factors equals the impact of observable factors (i.e., the interval for $\delta = -1$ and $\delta = 1$). Below this confidence interval is the estimated δ parameter that is needed to drive the coefficient of interest to zero. *, **, and *** denote statistical significance at two-tailed probability levels of 10%, 5%, and 1%, respectively. Appendix C defines all variables.

Table 6. Cash- and share-based RPE and the firm's risk profile—cross-sectional variation in expected relative performance

Panel A. Main specification

	(1)	(2)
Subsample—expected relative performance	*RPE Expected Performance > RPE Threshold*	
	no	yes
	Dependent variable:	
Variable:	$R\&D_{t+1}$	
RPE^{cash}	–0.309	0.420*
	(0.203)	(0.218)
Manager-year controls	yes	yes
Firm-year controls	yes	yes
Governance-year controls	yes	yes
Fixed effects	firm, year	firm, year
Entropy balancing	yes	yes
Observations	932	1,042
Adjusted R^2	94.700%	95.700%
Adjusted within-R^2	6.140%	3.350%
Within F-statistic	2.610	2.050
Test of signed difference in RPE^{cash}	0.730***	

Panel B. Alternative outcome variable

	(1)	(2)
Subsample—expected relative performance	*RPE Expected Performance > RPE Threshold*	
	no	yes
	Dependent variable:	
Variable:	$Systematic\ Risk_{t+1}$	
RPE^{cash}	–0.178	–0.440***
	(0.119)	(0.131)
Manager-year controls	yes	yes
Firm-year controls	yes	yes
Governance-year controls	yes	yes
Fixed effects	firm, year	firm, year
Entropy balancing	yes	yes
Observations	661	710
Adjusted R^2	82.400%	81.400%
Adjusted within-R^2	2.820%	13.000%
Within F-statistic	1.490	3.940
Test of signed difference in RPE^{cash}	–0.262*	

This table presents results of estimating equation (2) separately for subsamples of firms based on whether the firm's expected relative performance is below or above the first threshold in the RPE incentive plan, which allows the coefficients on all variables and fixed effects to vary across the subsamples. Panels A and B present, respectively, results of estimating firms' research and development intensity and firms' systematic risk profile. To achieve covariate balance, the cash- and share-based RPE subsamples are entropy balanced on the first moment of all control variables prior to creating the subsamples. Standard errors are in parentheses and are adjusted for within-cluster correlation at the level of treatment (i.e., firm) to conform to Abadie et al. (2023). *, **, and *** denote statistical significance at two-tailed probability levels of 10%, 5%, and 1%, respectively. Signed differences in coefficients are tested using one-sided pair t-tests. Appendix C defines all variables.

Table 7. Cash- and share-based RPE and the firm's risk profile—cross-sectional variation in RPE incentive strength

Panel A. Main specification

Subsample—RPE incentive strength	(1) *RPE Convexity* low	(2) *RPE Convexity* high	(3) *RPE Grant Size* low	(4) *RPE Grant Size* high
Variable:	Dependent variable: $R\&D_{t+1}$		Dependent variable: $R\&D_{t+1}$	
RPE^{cash}	–0.246	0.262*	–0.096	0.357*
	(0.267)	(0.146)	(0.205)	(0.211)
Manager-year controls	yes	yes	yes	yes
Firm-year controls	yes	yes	yes	yes
Governance-year controls	yes	yes	yes	yes
Fixed effects	firm, year	firm, year	firm, year	firm, year
Entropy balancing	yes	yes	yes	yes
Observations	1,618	1,580	1,603	1,595
Adjusted R^2	95.300%	96.100%	95.300%	95.100%
Adjusted within-R^2	4.570%	3.590%	3.940%	4.210%
Within F-statistic	3.270	2.770	2.890	3.140
Test of signed difference in RPE^{cash}	0.508**		0.453*	

Panel B. Alternative outcome variable

Subsample—RPE incentive strength	(1) *RPE Convexity* low	(2) *RPE Convexity* high	(3) *RPE Grant Size* low	(4) *RPE Grant Size* high
Variable:	Dependent variable: $Systematic\ Risk_{t+1}$		Dependent variable: $Systematic\ Risk_{t+1}$	
RPE^{cash}	–0.384***	–0.055	–0.284**	–0.166
	(0.112)	(0.143)	(0.120)	(0.109)
Manager-year controls	yes	yes	yes	yes
Firm-year controls	yes	yes	yes	yes
Governance-year controls	yes	yes	yes	yes
Fixed effects	firm, year	firm, year	firm, year	firm, year
Entropy balancing	yes	yes	yes	yes
Observations	1,156	1,106	1,131	1,131
Adjusted R^2	81.100%	83.100%	80.300%	84.200%
Adjusted within-R^2	10.900%	4.260%	7.580%	12.300%
Within F-statistic	5.080	2.430	3.610	5.720
Test of signed difference in RPE^{cash}	0.329**		0.118	

This table presents results of estimating equation (2) separately for subsamples of firms based on the convexity and size of the RPE incentive plan, which allows the coefficients on all variables and fixed effects to vary across the subsamples. Panels A and B present, respectively, results of estimating firms' research and development intensity and firms' systematic risk profile. To achieve covariate balance, the cash- and share-based RPE subsamples are entropy balanced on the first moment of all control variables prior to creating the subsamples. Standard errors are in parentheses and are adjusted for within-cluster correlation at the level of treatment (i.e., firm) to conform to Abadie et al. (2023). *, **, and *** denote statistical significance at two-tailed probability levels of 10%, 5%, and 1%, respectively. Signed differences in coefficients are tested using one-sided pair t-tests. Appendix C defines all variables.

Table 8. Cash- and share-based RPE and the firm's risk profile—cross-sectional variation in both RPE incentive strength and expected relative performance

Panel A. Main specification

	(1)	(2)	(3)	(4)
Subsample—RPE incentive strength	high *RPE Convexity*		high *RPE Grant Size*	
Subsample—expected RPE performance	below threshold	above threshold	below threshold	above threshold
Variable:	Dependent variable: $R\&D_{t+1}$		Dependent variable: $R\&D_{t+1}$	
RPE^{cash}	0.011	0.448**	–0.337	0.291
	(0.179)	(0.191)	(0.275)	(0.196)
Manager-year controls	yes	yes	yes	yes
Firm-year controls	yes	yes	yes	yes
Governance-year controls	yes	yes	yes	yes
Fixed effects	firm, year	firm, year	firm, year	firm, year
Entropy balancing	yes	yes	yes	yes
Observations	450	521	463	521
Adjusted R^2	97.300%	97.300%	97.100%	97.600%
Adjusted within-R^2	9.810%	1.390%	13.900%	0.812%
Within *F*-statistic	2.100	0.815	2.750	1.110
Test of signed difference in RPE^{cash}	0.438**		0.629**	

Panel B. Alternative outcome variable

	(1)	(2)	(3)	(4)
Subsample—RPE incentive strength	low *RPE Convexity*		low *RPE Grant Size*	
Subsample—expected RPE performance	below threshold	above threshold	below threshold	above threshold
Variable:	Dependent variable: $Systematic\ Risk_{t+1}$		Dependent variable: $Systematic\ Risk_{t+1}$	
RPE^{cash}	–0.210	–0.634**	0.114	–0.534*
	(0.183)	(0.250)	(0.157)	(0.302)
Manager-year controls	yes	yes	yes	yes
Firm-year controls	yes	yes	yes	yes
Governance-year controls	yes	yes	yes	yes
Fixed effects	firm, year	firm, year	firm, year	firm, year
Entropy balancing	yes	yes	yes	yes
Observations	371	392	352	386
Adjusted R^2	84.000%	83.600%	86.100%	80.700%
Adjusted within-R^2	19.300%	18.600%	22.800%	19.900%
Within *F*-statistic	2.950	3.120	3.250	3.200
Test of signed difference in RPE^{cash}	–0.424*		–0.648**	

This table presents results of estimating equation (2) separately for subsamples of firms based on both the convexity and size of the RPE incentive plan and whether the firm's expected relative performance is below or above the first threshold in the RPE incentive plan, which allows the coefficients on all variables and fixed effects to vary across the subsamples. Panels A and B present, respectively, results of estimating firms' research and development intensity and firms' systematic risk profile. To achieve covariate balance, the cash- and share-based RPE subsamples are entropy balanced on the first moment of all control variables prior to creating the subsamples. Standard errors are in parentheses and are adjusted for within-cluster correlation at the level of treatment (i.e., firm) to conform to Abadie et al. (2023). *, **, and *** denote statistical significance at two-tailed probability levels of 10%, 5%, and 1%, respectively. Signed differences in coefficients are tested using one-sided pair *t*-tests. Appendix C defines all variables.