THE ACCOUNTING REVIEW
Vol. 91, No. 1
2016
pp. 21–45

American Accounting Association
DOI: 10.2308/accr-51112

Management Team Incentive: Dispersion and Firm Performance

Robert M. Bushman
The University of North Carolina at Chapel Hill

Zhonglan Dai
The University of Texas at Dallas

Weining Zhang
Cheung Kong Graduate School of Business

ABSTRACT: Recent theory suggests that firms incorporate synergistic interrelationships among executives into optimal incentive design (Edmans, Goldstein, and Zhu 2013). We focus on *Pay Performance Sensitivities* (PPS) and use dispersion in PPS across top executives as a proxy for the incentive design component shaped by an executive team's synergy profile. We model optimal PPS dispersion and use residuals from this model to measure deviations from optimal. We find that firm performance is increasing (decreasing) in the residual when PPS dispersion is too low (too high). We conjecture that deviations from optimal are sustained by adjustment costs, finding that firms only close around 60 percent of the gap between target and actual PPS dispersion over the subsequent year. Viewing a team's equity grants as a vector, we provide evidence that firms use subsequent equity grants to actively manage PPS dispersion toward optimality. Cross-sectional analysis reveals that the deleterious effect of deviations from optimal is decreasing in the duration of a team's tenure together, and increasing in the importance of effort coordination across team members for firm performance.

Keywords: *team incentive dispersion; firm performance; PPS; cooperation*.

JEL Classifications: *M41*.

I. INTRODUCTION

Large public corporations are managed by groups of executives operating together as teams. A growing stream of executive compensation research adopts a multi-agent perspective, viewing top executives as a team rather than as isolated individuals. This research considers higher order aspects of compensation contract design as manifested in relations across individual pay packages of management team members. Much of the empirical research on team-based contract design focuses on implications of the distribution of *pay levels* across top executives.[1] The consequences of pay-level patterns across top executives for firm performance have been examined using tournament theory (e.g., Kale, Reis, and Venkateswaran 2009), social comparison theory (e.g., Henderson and Fredrickson 2001), CEO power theory (Bebchuk, Cremers, and Peyer 2011), and the dispersion of knowledge across executives (e.g., Li, Minnis, Nagar, and Rajan 2014).

We thank Ryan Ball, John Harry Evans III (editor), Zhaoyang Gu, Dan Taylor, Bin Wei, Christopher Williams, Yexiao Xu, Donny Zhao, two anonymous referees, and participants at the 2012 CICF Conference, 2013 AAA FARS Conference, 2014 MIT Asia Accounting Conference, Baruch College–CUNY, Temple University, University of Illinois at Urbana-Champaign, The University of Chicago, University of Michigan, Peking University, and The Hong Kong Polytechnic University for their comments and suggestions. Robert M. Bushman thanks Kenan-Flagler Business School, The University of North Carolina at Chapel Hill, and Zhonglan Dai thanks Jindal School of Management, The University of Texas at Dallas, for financial support.

Editor's note: Accepted by John Harry Evans III.

Submitted: November 2012
Accepted: March 2015
Published Online: March 2015

[1] Devers, Cannella, Reilly, and Yoder (2007) provide a review of the literature examining the implications of pay-level dispersion in top management teams from a multidisciplinary perspective.

While pay-level patterns are clearly important, a large literature also posits a critical role for *Pay Performance Sensitivities* (PPS) in aligning managerial incentives. The extant empirical literature on pay performance sensitivities primarily focuses on the design of CEO incentives, motivated by a large agency theory literature that views contract design from the perspective of a single agent in isolation.[2] While this single-agent perspective has provided the basis for many important insights into optimal executive incentive design, it largely ignores the possibility that boards also view executives as a team and incorporate synergistic interrelationships among executives into optimal incentive design.

This paper extends the literature by using a measure of dispersion in PPS levels across top executives as a proxy for the incentive design component shaped by an executive team's synergy profile. We then use this measure to assess the consequences of synergies for firm performance and the equity-granting strategies of firms' boards of directors. We model optimal PPS dispersion and use residuals from this model to capture deviations from optimal levels. We find that firm performance as measured by *Tobin's Q* and return on assets (*ROA*) deteriorates when PPS dispersion falls below or lies above optimal levels. We conjecture that these deviations from optimality persist despite firms' efforts to maintain optimal PPS dispersion, due to adjustment costs that inhibit firms from quickly restoring optimal PPS dispersion. Consistent with this conjecture, our evidence shows that firms choose the overall configuration of subsequent equity grants to individual executives to actively manage PPS dispersion toward optimal dispersion levels. However, our results suggest that firms only partially close the gap between target and actual dispersion due to adjustment costs.

Our paper builds on ideas in Edmans, Goldstein, and Zhu (2013), who demonstrate that variation in PPS levels across executives can reflect an optimal contracting response to the existence of synergistic relationships between executives. Synergistic relationships need not be symmetric between executives, for example, a CEO may have a greater impact on subordinates than *vice versa*. Optimally designed PPS differ across managers due to asymmetric synergies where a manager who wields the larger influence in a synergistic pair receives a higher PPS than the less influential colleague. The simultaneous design of a *team's* incentives to incorporate synergies results in the PPS level of each executive containing a synergy component that is intricately linked to the PPS levels of other executives through a network of interactive relations. Because individual executive PPS levels are designed in relation to the PPS levels of other team members, the overall distribution of PPS levels across executives embeds information about synergies that cannot be discerned by simply looking at individual PPS levels in isolation. In the absence of synergies, the Edmans et al. (2013) model collapses into a classic setting in which the incentives of each individual executive are designed in isolation without considering other members of the team.[3]

Our objective is to investigate the distinct role played by synergies in the optimal design of executive team incentives. Conceptually, we would like to empirically distinguish the synergy component of PPS from the standalone component. The challenge we face is that the nexus of synergies characterizing an executive team is not observable to us as researchers. However, the model of Edmans et al. (2013) provides us with some guidance in confronting this challenge by showing that the incorporation of synergies into optimal incentive design is reflected in the distribution of PPS levels across a team's executives. Building on this idea, our empirical strategy seeks to extract all available information about synergies from the observable distribution of an executive team's PPS levels.

However, Edmans et al. (2013) does not provide guidance on precisely how to extract this information. The approach we take is to characterize the information reflected in the distribution of PPS levels across executives using the standard deviation of the distribution. Our premise in using the standard deviation metric is that, as shown in Edmans et al. (2013), the presence of synergies results in PPS levels that differ across executives as PPS levels are set relatively higher for executives whose effort has greater synergistic influence on the cost functions of other executives. This implies an optimal amount of dispersion in a team's individual PPS levels. We acknowledge that there may be other possible measures that could be used in place of or in conjunction with the standard deviation, and so our approach is admittedly exploratory. However, the standard deviation is a well-established metric used to extract information about the variation of data points in relation to each other in a meaningful fashion and is widely used to distinguish distributions along an important dimension.

An alternate approach for isolating synergies would be to explicitly incorporate the significant nonlinearities and interaction effects inherent in the synergy construct by including squared terms, interaction terms, or both in the empirical specification. However, our focus on the five top executives implies ten possible pairwise interaction terms and five squared terms. We do not know how to coherently interpret and explore characteristics of the resulting 15 different coefficients. However, it is the case that standard deviation measure can be algebraically expressed as the square root of a linear combination

[2] Seminal papers include Holmstrom (1979) and Jensen and Murphy (1990). Surveys of the empirical compensation literature include Murphy (1999), Bushman and Smith (2001), Core, Guay, and Larcker (2003), and Frydman and Jenter (2010).

[3] Such standalone contracts could differ across executives for a number of reasons including cross-executive differences in productivity, cost of effort functions, and risk aversion. For example, Aggarwal and Samwick (2003) view individual executives in isolation, and argue that optimal PPS can differ across executives due to differing responsibilities, authority, or talent levels. A novel contribution of Edmans et al. (2013) is to show that in the presence of value-enhancing synergies, optimal incentive design considers not only each executive in isolation, but also the entire executive team simultaneously.

of five squared PPS terms, one for each executive, and all ten possible pairwise interactions, allowing us to parsimoniously capture these 15 nonlinear terms in a single, interpretable variable.[4]

To empirically isolate the synergy component, our empirical specification includes PPS dispersion as well as individual executives' PPS levels as independent variables. We posit that PPS dispersion serves to pull out the nonlinear synergy effects of the overall team embedded in the distribution of PPS levels, while the individual PPS terms pick up the direct standalone effects of individual executives that are orthogonal to the synergy term. If team considerations and synergy effects are not important aspects of incentive design, then we would not expect PPS dispersion to have explanatory power incremental to the individual PPS levels.

To construct our PPS dispersion measure, we first estimate PPS based on each executive's portfolio holdings of the firm's stock and options. Then using estimates of PPS for each top executive in the firm, we compute PPS dispersion as the standard deviation of PPS across executives. We first examine the association between firm performance (*Tobin's Q* and *ROA*) and PPS dispersion, finding a significant negative coefficient on PPS dispersion. However, interpreting this coefficient is problematic due to the endogeneity of PPS choices (e.g., Himmelberg, Hubbard, and Palia 1999; Fahlenbrach and Stulz 2009).[5] If observed PPS dispersion is always at its optimal performance-maximizing level, then dispersion and firm performance should not be related conditional on controlling for exogenous determinants of dispersion, and so the coefficient on dispersion may simply reflect omitted variable bias. To address this fundamental issue, we focus on deviations from optimal by extending the approach used by Core and Guay (1999) who examine whether firms grant CEOs new equity incentives in a manner consistent with maintaining optimal CEO PPS levels.

Specifically, we expand the scope of incentive design beyond CEOs to encompass the overall configuration of PPS across executives by directly modeling optimal PPS dispersion choices.[6] We use residuals from this model to measure deviations between existing PPS dispersion and optimal PPS dispersion levels. While Core and Guay (1999) take it as given that residuals from their CEO model capture deviations from optimal, we explicitly examine whether residuals from the PPS dispersion model are associated with lower firm performance as would be expected if they truly capture deviations from optimal. We find that performance is increasing in the residual when PPS dispersion is too low (negative residuals) and decreasing when it is too high (positive residuals). We then consider why non-optimal PPS dispersion levels (or deviations) would exist given that they have negative performance consequences.

We hypothesize that incentive design is a process where value-maximizing firms seek to eliminate deviations from optimality and restore optimal dispersion levels but are constrained by adjustment costs.[7] If idiosyncratic shocks differentially impact PPS levels across individual executives and boards are constrained in their ability to immediately re-establish optimality, then observed PPS dispersion may deviate from optimal levels. To examine this hypothesis, we first estimate the speed of partial adjustment back to optimal levels, finding that firms only close around 60 percent of the current gap between target PPS dispersion and actual dispersion over the subsequent year. To the best of our knowledge, this is the first time that partial speed of adjustment analysis has been applied to pay performance sensitivities. While we document partial adjustment back to optimality, it raises the question as to whether this is a passive statistical phenomenon or it reflects active management of incentives by firms.

To investigate this question, we extend Core and Guay's (1999) analysis of equity grants to CEOs and conceptualize equity grants to the management team as a vector wherein each element represents the grant PPS to an individual executive. To assess whether equity grants are actively chosen to restore team incentive alignment, we view the structure of the entire team's vector of equity grant PPS as the object choice, and examine the correlation between this grant PPS vector in the subsequent year and the vector of currently existing PPS levels. We conjecture that if firms actively manage PPS dispersion toward optimality, then boards will choose vectors of subsequent equity grant PPS that are positively (negatively) correlated with the vector of executives' current PPS in order to increase (decrease) PPS dispersion for firms below (above) optimal levels.[8] We provide evidence consistent with this conjecture.

Building on our earlier discussions of the role of PPS dispersion in promoting value-enhancing coordination of activities across team members, we perform cross-sectional analyses to investigate the extent to which key firm characteristics influence the intensity with which deviations from optimal PPS dispersion impact performance. We first consider team longevity and document that deviations from optimal PPS dispersion become less damaging to firm performance as the duration of a team's

[4] Please see Appendix A for more details on this.
[5] This is a well-known problem originally proposed by Demsetz (1983) and Demsetz and Lehn (1985).
[6] Although we believe that PPS dispersion is a plausible and useful proxy for the synergy aspect of PPS design, we do not claim that it is the specific object of a board's incentive design choice or that it captures the "true" synergy component in all respects.
[7] A board of directors' ability to re-align team incentives may, for example, confront frictions arising from intense scrutiny focused on executive compensation by investors, media, regulators, and politicians (Murphy 2012).
[8] A vector of grant PPS that is positively (negatively) correlated with the vector of existing PPS levels can increase (decrease) PPS dispersion in a manner analogous to a positively (negatively) correlated derivative increasing (decreasing) the volatility of an existing risk exposure.

tenure together increases. This suggests that repeated interactions among team members over time foster closer team relationships and a better understanding of value-enhancing synergies that offset deleterious effects of deviations from optimal PPS dispersion. Further, prior research suggests that the importance of executive team cooperation and coordination for firm performance significantly increases with a firm's R&D intensity and geographic diversification (e.g., Carpenter and Sanders 2004; Siegel and Hambrick 2005). We find that higher R&D intensity and larger geographic segment dispersion significantly exacerbate under-performance that is associated with deviations from optimal PPS dispersion, consistent with the importance of cooperation and coordination for these types of firms. While these results are not definitive, they suggest that PPS dispersion reflects an aspect of optimal contract design focused on creating incentives for coordination of effort among executive team members.

Section II next develops the paper's motivation in the context of the extant literature and discusses our empirical strategies. Section III describes the sample data and key variables, and provides descriptive statistics. Section IV provides our main empirical analysis on the relation between deviations from optimal PPS dispersion and firm performance, and examines whether boards actively adjust PPS dispersion toward optimality. Section V presents cross-sectional analyses examining the importance of team longevity and cooperation among managers in determining the intensity of losses driven by deviations from optimal PPS dispersion levels. Section VI provides robustness analyses, while Section VII summarizes the paper.

II. MOTIVATION, EMPIRICAL STRATEGIES, AND RELATED LITERATURE

A large empirical literature examines the role of executive compensation in alleviating agency conflicts between top managers and shareholders. This research primarily takes a single-agent perspective and focuses on incentive compensation design at the individual executive level, examining either CEO pay alone or treating the management team as a single agent. However, given that large public corporations are managed by groups of executives operating together as a team, this literature ignores the importance of interrelationships and synergies within an executive team. In this regard, a growing stream of executive compensation research adopts a multi-agent perspective, viewing top executives as a team rather than as isolated individuals. Much of the empirical research on team-based contract design, however, focuses on implications of the distribution of *pay levels* across top executives. The consequences of pay-level patterns across top executives for firm performance have been examined from several distinct perspectives.

First, Lazear and Rosen (1981) show that rank-order tournaments create powerful incentives for team members as they compete to win the contest, and that increasing the prize motivates contestants to exert greater effort. Empirical studies, including Main, O'Reilly, and Wade (1993), Eriksson (1999), Carpenter and Sanders (2002), and Lee, Lev, and Yeo (2008), among others, provide evidence consistent with tournament incentives increasing in the pay gap between the CEO and other team members. A paper by Kale et al. (2009) explicitly considers that top executives simultaneously face tournament incentives and equity-based incentives provided by the PPS. Using the pay-level gap between the CEO and other top executives to proxy for tournament incentives, they find that tournament incentives and PPS have independent, positive effects on firm performance.

Second, Bebchuk et al. (2011) investigate the relation between CEO pay slice, computed as the fraction of the aggregate compensation of the top five executive team members captured by the CEO, and the value, performance, and behavior of public firms. They find that "CEO pay slice" is associated with *lower* firm value and performance, among other negative consequences, arguing from this evidence that CEO pay slice reflects unresolved agency problems driven by CEO power and board capture. However, Li et al. (2012) create a proxy for the distribution of knowledge across executives and document that the negative consequences of CEO pay slice on firm value are mitigated as the knowledge distribution becomes more concentrated in the CEO.

Last, there is also literature that focuses on how pay-*level* dispersion (i.e., pay disparity) impacts firm performance by undermining morale (social comparison theory) or more generally interfering with executives' incentives to collaborate and coordinate with other team members. Devers et al. (2007) provide a review of this literature. In light of these above-mentioned studies, we control for pay-level based variables in order to isolate the role of PPS dispersion as an important element of team-based incentive design that has an incremental effect on firm performance.

While pay levels are clearly important, PPS play a critical role in aligning managerial incentives with those of the shareholders.[9] However, there exists little theory that explicitly considers PPS from a team perspective. While there is significant theory concerning incentives in teams (e.g., Alchian and Demsetz 1972; Holmstrom 1982; Rasmusen 1987), this literature is primarily concerned with free-rider problems, rather than explicit contract design features like PPS. An exception is a recent paper by Edmans et al. (2013).

Edmans et al. (2013) argue that effort by a manager not only has a direct productive effect, but may also reduce the marginal cost of effort for one or more colleagues, and the effort of these colleagues may reciprocally reduce the manager's marginal cost of effort. Because effort by one manager reduces his colleague's marginal cost of effort, the principal generally wants more

[9] See for example, Holmstrom (1979) and Jensen and Murphy (1990).

influential executives to work harder. However, executives do not take this externality into account when choosing effort because the influence of their effort on other executives' cost functions does not appear in their objective function. To optimally coordinate effort choices across managers, Edmans et al. (2013) show that PPS are chosen in equilibrium so that managers internalize the consequences of their effort on the marginal costs of others. This results in intricate incentive configurations in which optimal PPS levels vary across managers to reflect the web of synergistic relationships between managers whereby, for example, more influential executives receive higher PPS than less influential ones. While highly stylized, the model clearly demonstrates that synergies can permeate optimal PPS in a complex, nonlinear fashion. The more extensive the potential synergies for a given firm, the more important the effort-coordination role of incentive design for firm performance.

Building on Edmans et al. (2013), we posit that the impact of the executive team on firm performance can be conceptualized as derived from two sources: (1) the direct standalone effects of individual executives on output that are independent of synergies; and (2) synergy effects. Our empirical design attempts to separate these two sources of influence by separately measuring the nonlinear, interactive synergy component using PPS dispersion. The idea of our empirical design is that PPS dispersion serves to pull out the nonlinear synergy effects of the overall team, leaving the individual PPS terms to pick up direct standalone effects of individual executives that are orthogonal to the synergy effects. Having a single measure of the synergy component allows us to model deviations from optimal, to examine the process of convergence back to optimal, and to perform a cross-sectional analysis of how costly deviation from optimal is for firm performance. In Appendix A, we describe in more detail how our empirical design can be conceptualized within the Edmans et al. (2013) model framework.

We take the perspective that firms are value-maximizing and seek to optimally incorporate synergistic interactions into the design of team incentives. We thus interpret an observed association between firm performance and PPS dispersion as deriving from deviations from optimal. To explicitly incorporate this in our research design, we follow an approach similar to that of Core and Guay (1999) who investigate whether firms' grants of equity incentives are consistent with the economic theory of optimal contracting. Core and Guay (1999) note that, over time, CEOs' holdings of equity incentives can deviate from optimal levels, either because the optimal levels shift or because of changes in the incentives provided by CEOs' stock and option portfolios. They model CEOs' optimal level of equity incentives and use the residual from this model to measure the extent to which a CEO's incentives deviate from the optimal level. They document that grants of new incentives from options and restricted stock are negatively related to these residuals (or deviations).

We extend Core and Guay (1999) in several fundamental ways. First, we expand the scope of incentive design beyond CEOs to encompass the overall configuration of PPS across executives and model optimal PPS dispersion levels. Importantly, in addition to including a fundamental set of observable determinants, we also include firm fixed effects when we estimate optimal PPS dispersion levels to control for unobserved firm-specific determinants of PPS dispersion that are time-invariant (e.g., Himmelberg et al. 1999). We use residuals from this model to measure deviations between existing PPS dispersion and optimal levels. The innovation here is that we consider the incentives of the entire executive team as the unit of analysis rather than the individual executive, which allows us to explore whether optimal incentive design incorporates this broader notion of a team.

Second, while Core and Guay (1999) take it as given that residuals from their CEO model capture deviations from optimal, we explicitly examine whether residuals from the PPS dispersion model are associated with lower firm performance. This is an important extension that allows us to provide direct evidence that the residuals from the PPS dispersion model reflect deviations from optimal, and which establishes a basis for us to examine the dynamic adjustment process of PPS dispersion toward optimality over time. We also extend Core and Guay (1999) and the compensation literature more generally by offering a new theory of adjustment costs to explain why deviations from optimal dispersion would persist given negative performance consequences, examining the speed with which PPS dispersion adjusts back to optimality, and considering whether the *entire vector* of future equity grant PPS to team members is consistent with firms actively seeking to restore optimal levels of PPS dispersion.

PPS derive from stock and option portfolios of individual executives and can drift away from optimal levels as, for example, managers exercise options and rebalance portfolios for idiosyncratic reasons. If idiosyncratic shocks differentially impact PPS levels across individual executives and boards are constrained in their ability to immediately re-establish optimality across team members, then observed PPS dispersion may deviate from optimal levels for a period of time. Murphy (2012) notes that significant public visibility surrounding executive compensation decisions and processes subject boards to intense scrutiny from investors, media, regulators, and politicians. To protect themselves, compensation committees, in conjunction with their compensation consultants, justify individual executives' pay packages by calibrating them against those of comparable executives in the market, which may limit degrees of freedom in choosing stock and option grants for each individual executive that fully reestablishes the optimal PPS configuration across team members.[10] For example, boards may not be able to make outsized equity grants to particular executives to bring their PPS into team alignment without attracting unwanted scrutiny.

[10] Papers on the role of compensation consultants in shaping executive pay packages includes Murphy and Sandino (2010), Conyon, Peck, and Sadler (2009) and Cadman, Carter, and Hillegeist (2010), among others.

If shocks push PPS dispersion out of optimal alignment and boards' best efforts to immediately restore optimality are hampered by adjustment costs, then we expect to observe only partial adjustment of PPS dispersion back toward optimal dispersion levels. To explore this possibility, we isolate the speed of partial adjustment back to optimal levels by estimating the percentage of any current gap between actual and target PPS dispersion that is closed by actual changes in PPS dispersion over the subsequent year. The technique of partial speed of adjustment has been widely used in the finance literature to examine firms' capital structure adjustments (e.g., Lemmon, Roberts, and Zender 2008; Flannery and Rangan 2006). To our knowledge partial speed of adjustment has not previously been used to examine the dynamic evolution of PPS over time. A speed-of-adjustment specification regresses actual changes in the endogenous policy variable from $t-1$ to t (e.g., PPS dispersion) on the estimated gap that existed between target PPS dispersion and actual PPS dispersion at time $t-1$. In its simplest terms, the regression takes the form:

$$Actual\ Dispersion_t - Actual\ Dispersion_{t-1} = \delta * (Target\ Dispersion_t - Actual\ Dispersion_{t-1}).$$

Target dispersion represents the predicted value of PPS dispersion at time t estimated using available information at time $t-1$. In this specification a coefficient of $\delta = 1$ implies that 100 percent of the gap between target and actual at $t-1$ has been closed by the choice of actual dispersion at t. Values of $\delta < 1$ imply that the gap has not been completely closed, where δ reflects the fraction of the gap that has been closed by the actual choice of dispersion at t. We discuss this analysis more fully in Section IV, and find that estimated δ is approximately 0.6 in our sample. We next examine how a board uses annual equity grants to each of the executive members to actively manage incentive dispersion.

Core and Guay (1999) examine whether firms use annual grants of options and restricted stock to CEOs to manage the optimal level of equity incentives. They find that grants of new incentives from options and restricted stock are negatively related to estimated deviations from optimal incentives. In a similar spirit, to the extent that boards use equity grants to restore optimal dispersion, we expect there to be a different relation between PPS and future equity grants depending upon whether dispersion needs to be increased or decreased to move toward optimality. We extend Core and Guay's (1999) analysis of equity grants to CEOs by conceptualizing equity grants to the management team as a vector in which each element represents the PPS of the grant to an individual executive. This perspective of team PPS as a vector is new to the empirical literature. We conjecture that if firms actively manage the level of PPS dispersion, then boards will choose vectors of subsequent equity grant PPS that are positively (negatively) correlated with the vector of executives' current PPS in order to increase (decrease) PPS dispersion for firms below (above) optimal levels.

The idea is that if a shock occurs that makes dispersion too low relative to optimal, then the board can issue a grant vector that is positively correlated with the current vector to increase dispersion. That is, adding the grant vector to the current PPS vector, we get:

$$Var[PPS_{t-1} + Grant_t] = Var[PPS_{t-1}] + Var[Grant_t] + 2Cov[PPS_{t-1}, Grant_t] > Var[PPS_{t-1}]$$

as the covariance term is positive. For example, assume there are three executives characterized by a suboptimal vector of existing PPS levels equal to (6, 3, 2) with dispersion of 1.70. Let optimal dispersion be 3.5 > 1.70 and assume the board grants options with PPS vector (4, 3, 0), which has a positive correlation with (6, 3, 2) of 0.846, and results in a post-grant PPS vector of (10, 6, 2) with dispersion of 3.27.

On the other hand, if dispersion is too high, then the board can issue a negatively correlated grant as:

$$Var[PPS_{t-1} + Grant_t] = Var[PPS_{t-1}] + Var[Grant_t] - 2\,|\,Cov[PPS_{t-1}, Grant_t]\,|.$$

Dispersion decreases as long as $Var[Grant_t] < 2\,|\,Cov[PPS_{t-1}, Grant_t]\,|$, which is likely to hold because the PPS from a grant is small compared to the existing PPS. So when dispersion is too high it is more likely that a firm will choose a negatively correlated grant. Now, let optimal dispersion be $0 < 1.70$, and assume the board grants options with PPS vector (0, 3, 4), which has a negative correlation with the original vector (6, 3, 2) of -1. This negatively correlated equity grant PPS vector results in a new PPS vector of (6, 6, 6) with dispersion = 0.

We empirically explore this concept by examining the correlation between the vector of current team PPS levels and the vector of equity grant PPS in the subsequent year. We predict that the correlation between the PPS vector and the equity grant PPS vector will be greater and more likely to be positive for firms below the optimal value (negative residuals) than for firms above optimal (positive residuals).

As discussed above, Edmans et al. (2013) show that, in the presence of potential value-enhancing synergies, optimal incentive design not only considers each executive in isolation, but also incorporates incentives for optimal coordination of efforts across executives. Further, the more extensive the potential synergies, the more important is the effort for the coordination for firm performance. To show that PPS dispersion captures incentives designed to motivate coordination, we would ideally like to directly measure the importance of coordination for firms' value creation. However, it is not obvious how to measure a firm's demand for coordination. We examine three firm characteristics that we argue are at least plausible proxies for the importance of executive team coordination: executive team longevity, R&D intensity, and geographic segment dispersion. We do not view the analyses using these three variables as definitive tests of the Edmans et al. (2013) theory, but we posit that these variables provide a solid basis for exploring the role played by coordination in incentive design.

We first examine whether the negative performance effects of deviations from optimal PPS dispersion diminish as the duration of the team's tenure together increases. The idea is that if there are value-enhancing synergies that can be realized only with proper effort coordination, then repeat interactions between executives over time would allow for substantive information sharing about the sources of potential value from coordination. We hypothesize that closer team relationships and a deeper understanding of value-enhancing synergies within the team evolve over time so as to foster better cooperation, which, in turn, helps offset deleterious effects of deviations from optimal (less negative) PPS dispersion.[11]

Next, we focus on two fundamental firm characteristics that have been linked to the importance of cooperation within executive teams: R&D intensity and geographic segment dispersion. With respect to R&D intensity, prior literature posits that high-technology firms, as gauged by R&D intensity, require intensive collaboration and coordination among executives in order to manage the design, production, and selling of an ever-evolving set of offerings. The idea is that technology intensiveness is associated with significant uncertainty that creates interdependencies that necessitate coordination and collaboration among executives. For example, successful development of a new product may require coordination between the R&D, marketing, manufacturing, finance, and human resources functions (e.g., Siegel and Hambrick 2005; Schoonhoven and Jelinek 1990). With regard to geographic segment dispersion, Sanders and Carpenter (1998) argue that the more extensive a firm's degree of internationalization, the greater the level of complexity confronting its top management team. Carpenter and Sanders (2004) contend that the complexity inherent in multi-national corporations corresponds to an increased level of responsibility for members of the top executive team and requires more tasks to be shifted toward the collective effort of the executive team. We hypothesize that higher R&D intensity and more geographic diversification is indicative of the importance of achieving team coordination and will be associated with a greater negative impact of deviations from optimal dispersion on firm performance.

III. DATA, VARIABLE DEFINITIONS, AND DESCRIPTIVE STATISTICS

Our compensation data are from the Compustat ExecuComp database, and span the years 1992–2013. We supplement these data with firm financial information from Compustat and stock return data from CRSP. Following Bebchuk et al. (2011), we delete firm-years when the number of top-paid executives is less than five and keep only the top five highest-paid executives if there are more than five reported in a given year. All results are robust to using all executives instead of only the top five.[12] After merging the data, our sample contains 17,735 firm-years, consisting of 3,966 CEOs and 22,496 other top-paid executives (termed as VPs) for 2,342 firms.[13]

We measure an executive's PPS as the total incentives provided by her entire portfolio holdings of the firm's stock and options. Following Edmans, Gabaix, and Landier (2009), we measure PPS as the dollar change in an executive's wealth for a one-percentage-point change in firm value, divided by annual pay. For each executive, we construct his/her equity portfolio holdings of stock and stock options (exercisable and unexercisable) in the firm. The PPS of each executive is then computed as:

$$PPS = (\#\,of\ Shares + \#\,of\ Options * Option\ Delta) * (Price/100) \div Annual\ Compensation. \quad (1)$$

Option deltas in Equation (1) are estimated using the methodology of Core and Guay (2002).[14] Price refers to the firm's stock price and executives' annual compensation is measured as TDC1 from ExecuComp.

The Edmans et al. (2009) PPS measure is an empirical proxy for the construct percentage change in executive wealth for a one-percentage-point change in firm value, where annual compensation is used in place of an executive's total wealth due to data limitations. While there is no consensus on how to measure PPS, the percent-percent incentive construct has been used or advocated by a number of previous papers, including Murphy (1985), Gibbons and Murphy (1992), and Rosen (1992). Alternative incentive constructs used in the literature include dollar-dollar incentives, which are equivalent to an executive's

---

11 This hypothesis bears some relation to the implicit contracting literature. See for example, Arya, Fellingham, and Glover (1997), Che and Yoo (2001), and Baker, Gibbons, and Murphy (2002), among others.

12 The number of executives varies from one to 15 in the ExecuComp dataset in any given year. Although it is required that a minimum of five executives' compensation information be disclosed, 8.5 percent of firm-years in our sample reported less than five executives (most is concentrated at four, which is 5.1 percent).

13 We delete first-year and last-year observations associated with CEO turnover to eliminate transitional effect. We also delete observations when CEOs' annual compensation is \$1 to eliminate an adverse scaling effect from our use of annual compensation to scale PPS (Guthrie, Sokolowsky, and Wan 2012). However, our results are unaffected if we drop either or both constraints.

14 The parameters used to compute option delta are no longer available (or provided) in ExecuComp for years after 2006. As such, we estimate those parameters first and then compute option delta based on Core and Guay (2002). This computation also affects the total compensation measure (TDC1). See Kini and Williams (2012, Appendix A) for a detailed explanation. We thank Ryan Williams for helpful discussion regarding the computation.

fractional ownership of the firm (e.g., Jensen and Murphy 1990), and dollar-percent incentives, which are equivalent to an executive's dollar ownership of the firm (e.g., Core and Guay 2002).[15] As discussed in Edmans et al. (2009), documented relations between firm size and CEO incentives measured using both dollar-dollar and dollar-percent are indicative of potential problems with these measures, where percent-percent incentives are not related to firm size. Incentive measures for non-CEO executives are also likely to be related to firm size conditioned by idiosyncratic aspects of a specific position, making it difficult to create PPS dispersion measures that are comparable across firms. By normalizing executives' incentives with annual compensation levels, the Edmans et al. (2009) measure allows us to compute a dispersion measure that is more comparable across firms by controlling for important characteristics that vary across executives such as opportunity wages, cost of effort, and the impact of firm size on the importance of an executive's actions for firm value.

Using PPS measures for each executive in each firm-year, we compute PPS dispersion (*STD_PPS*) as the standard deviation of PPS across executives for each firm-year. Given that the CEO bears responsibility for the entire firm while the other top-paid executives have more limited spheres of influence, the CEO's PPS may differ significantly from other members of the management team. As such, we also try an alternate specification where all team-related incentive measures, including PPS dispersion, are constructed after CEOs are removed from the management team definition. In untabulated analyses, we find that all results are robust to this specification.

Table 1 reports descriptive statistics for our final sample with Panel A for mean, median and standard deviation and Panel B for correlation (key variables only for brevity). The definition and measurement for all variables are provided in Appendix B. In this sample, the average *Tobin's Q* is 1.78 and return on assets (*ROA*) is 4 percent. *STD_PPS* is on average 10.8 percent and exhibits substantial cross-sectional variation. Not surprisingly, CEOs have the largest PPS followed by other executives and then CFOs. With respect to other team-related incentive variables, the *pay gap* between CEO and rest of the management team is \$4,197 thousand, which is larger than the \$2,766 thousand reported by Kale et al. (2009). This difference likely occurs due to different restrictions imposed on the number of executives counted in the top team and different sample periods (their sample period ends 2004). We follow Bebchuk et al. (2011) and delete firm-years for which the number of top-paid executives is less than five, while Kale et al. (2009) require only four reported team members. Finally, *CEO Pay Slice* is on average 38 percent of aggregate team annual compensation, which is comparable to the 36 percent reported in Bebchuk et al. (2011).

Regarding the correlation matrix in Table 1, Panel B, we note that *STD_PPS* is highly correlated with *CEO PPS, CFO PPS,* and *Other PPS* (Pearson/Spearman correlations ranging from 0.20 to 0.79/0.13 to 0.81). This is not surprising as the PPS levels for individual executives are direct inputs into the calculation of PPS dispersion. While these high correlations raise potential multicollinearity issues, it does not appear to be a problem for our analyses because we find that *STD_PPS* has incremental explanatory power after including *CEO PPS, CFO PPS,* and *Other PPS* in the performance regressions (Table 2).[16]

IV. MAIN ANALYSES

This section presents three analyses. The "OLS Repression Analysis" section examines the simple relation between PPS dispersion and firm performance using OLS. In the "Deviations from Optimal PPS Dispersion and Firm Performance" section, we extend the analysis by estimating the relation between deviations from optimal PPS dispersion and firm performance using residuals from a model of optimal dispersion. In the "PPS Dispersion Adjustment Process" section, we estimate the speed with which any current gap between actual and target PPS dispersion is closed over the subsequent year, and investigate whether annual grants of stock and options to the executive team members are consistent with firms' active efforts to move toward optimality.

OLS Regression Analysis

In this subsection, we report the results on the association between PPS dispersion and future *Tobin's Q* and *ROA* assuming a simple linear relation between the two. We estimate the following empirical specification:

$$\begin{aligned} Tobin's\ Q_t/ROA_t = {} & \alpha + \beta STD\_PPS_{t-1} + \gamma Other\ Compensation\ Controls_{t-1} + \lambda Firm\ Controls_{t-1} \\ & + Industry\ and\ Year\ Fixed\ Effects + \varepsilon_t. \end{aligned} \tag{2}$$

The main variable of interest is *STD_PPS,* our proxy for the dispersion of team incentives. The category entitled *Other Compensation Controls* includes a number of important compensation-related variables. First, to isolate the impact of any effort

[15] Dollar-dollar incentives can be represented as the change in an executive's dollar wealth for a \$1,000 change in firm value, where dollar-percent incentives can be represented as the change in an executive's dollar wealth for a 1 percent change in firm value.

[16] Using variance inflation factors to detect potential problems in our main analysis (Panel B of Table 3), we find that none of these variables have VIF greater than 10. Additionally, in untabulated analyses we show that our results are robust to dropping out observations chosen at random.

TABLE 1
Summary Statistics

Panel A: Mean, Median, and Standard Deviation

	Mean	STD	Q1	Median	Q3
Tobin's Q_t	1.782	0.997	1.134	1.452	2.058
ROA_t	0.040	0.082	0.015	0.044	0.080
STD_PPS_{t-1}	0.108	0.237	0.011	0.025	0.067
$NEG\_RD\_PPS_{t-1}$	−0.030	0.067	−0.030	−0.004	0.000
$POS\_RD\_PPS_{t-1}$	0.030	0.086	0.000	0.000	0.021
CEO PPS_{t-1}	0.193	0.435	0.030	0.062	0.134
CFO PPS_{t-1}	0.035	0.100	0.000	0.014	0.040
Other PPS_{t-1}	0.075	0.145	0.019	0.035	0.067
$Corr(PPS_{t-1}, Grant_t)$	0.111	0.655	−0.473	0.208	0.715
$Range\_PPS_{t-1}$	0.253	0.543	0.028	0.060	0.163
$NEG\_RRange\_PPS_{t-1}$	−0.074	0.177	−0.072	−0.010	0.000
$POS\_RRange\_PPS_{t-1}$	0.074	0.229	0.000	0.000	0.048
Pay Gap_{t-1}	4196.7	7893.0	1552.1	2502.2	4681.5
$Log(Pay\ Gap)_{t-1}$	7.949	0.797	7.347	7.825	8.451
CEO Pay $Slice_{t-1}$	0.384	0.110	0.317	0.380	0.445
$STD\_VP\_Pay_{t-1}$	772.0	1817.1	170.0	356.4	776.7
$Log(STD\_VP\_Pay)_{t-1}$	5.904	1.178	5.136	5.876	6.655
Team $Length_{t-1}$	4.459	3.376	2.000	4.000	6.000
Geographic Segment $Dispersion_{t-1}$	0.257	0.275	0.000	0.164	0.501
R&D to $Capital_{t-1}$	0.295	1.332	0.000	0.000	0.140
Industry $Homogeneity_{t-1}$	0.215	0.111	0.124	0.184	0.301
Firm $Size_{t-1}$	7.349	1.541	6.300	7.255	8.352
Firm $Size^2_{t-1}$	56.377	23.269	39.692	52.639	69.762
Return $Volatility_{t-1}$	0.016	0.020	0.006	0.010	0.019
Capital to $Sales_{t-1}$	0.483	3.052	0.112	0.207	0.439
$Leverage_{t-1}$	0.223	0.180	0.076	0.211	0.332
Advertising to $Capital_{t-1}$	0.093	0.617	0.000	0.000	0.041
Dividend $Yield_{t-1}$	0.016	0.034	0.000	0.009	0.024
Tobin's Q_{t-1}	1.844	1.372	1.141	1.466	2.088
ROA_{t-1}	0.041	0.111	0.015	0.045	0.082
$Return_{t-1}$	0.132	0.582	−0.126	0.044	0.269
$Return_{t-2}$	0.152	0.635	−0.122	0.052	0.284

Panel B: Correlation Matrix for Key Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. *Tobin's* Q_t		*0.31*	*0.18*	*−0.05*	*0.13*	*0.20*	*0.10*	*0.16*	*0.08*	*−0.01*	*0.12*	*0.02*	*0.17*	*0.19*
2. ROA_t	*0.63*		*0.12*	*−0.03*	*0.07*	*0.12*	*0.07*	*0.11*	*0.10*	*0.06*	*0.05*	*0.08*	*0.06*	*−0.15*
3. *STD_PPS*	*0.32*	*0.22*		*0.05*	*0.75*	*0.79*	*0.20*	*0.67*	*−0.12*	*−0.17*	0.01	*0.12*	*−0.05*	*−0.02*
4. $NEG\_RD\_PPS_{t-1}$	*−0.03*	*−0.03*	*0.15*		*0.16*	*0.02*	*0.03*	*0.04*	0.01	*0.04*	*−0.03*	*−0.03*	0.00	0.01
5. $POS\_RD\_PPS_{t-1}$	*0.06*	*0.04*	*0.33*	*0.85*		*0.51*	*0.19*	*0.60*	*−0.03*	*−0.09*	*0.05*	*0.03*	0.00	*−0.01*
6. *CEO PPS*	*0.30*	*0.21*	*0.81*	*0.08*	*0.21*		*0.16*	*0.25*	*−0.12*	*−0.17*	−0.01	*0.10*	*−0.03*	*−0.02*
7. *CFO PPS*	*0.09*	*0.08*	*0.13*	*0.10*	*0.11*	*0.15*		*0.20*	*0.02*	−0.01	*0.04*	*0.06*	0.00	0.00
8. *Other PPS*	*0.35*	*0.24*	*0.66*	*0.07*	*0.19*	*0.58*	*0.15*		*−0.03*	*−0.09*	*0.07*	*0.14*	*−0.04*	*−0.02*
9. $Log(Pay\ Gap)_{t-1}$	*0.12*	*0.11*	*−0.06*	*0.05*	*0.06*	*−0.02*	*0.11*	*0.07*		*0.64*	*0.62*	*−0.01*	*0.19*	−0.01
10. *CEO Pay* $Slice_{t-1}$	*0.04*	*0.07*	*−0.12*	*0.03*	0.00	*−0.06*	*0.08*	*−0.07*	*0.65*		*−0.04*	*0.02*	*0.07*	−0.01
11. $Log(STD\_VP\_Pay)_{t-1}$	*0.12*	*0.07*	*0.08*	*0.02*	*0.06*	*0.05*	*0.04*	*0.16*	*0.63*	0.00		*−0.06*	*0.14*	−0.01
12. *Team* $Length_{t-1}$	*0.02*	*0.08*	*0.13*	*−0.05*	*−0.03*	*0.17*	*0.08*	*0.20*	*−0.03*	*0.03*	*−0.09*		*−0.06*	*−0.03*
13. *Geo. Seg.* $Disp._{t-1}$	*0.25*	*0.15*	−0.01	0.01	*0.03*	*−0.02*	*0.04*	0.01	*0.20*	*0.09*	*0.14*	*−0.07*		*0.11*
14. *R&D to* $Capital_{t-1}$	*0.38*	*0.13*	*0.02*	−0.01	0.01	0.01	*0.03*	*0.02*	*0.06*	*0.04*	*0.02*	*−0.08*	*0.54*	

(continued on next page)

TABLE 1 (continued)

Italics indicate the correlation is significant at the 0.05 level.
The sample period is from 1992 to 2013 and sample size is 17,735 firm-years after imposing the following restrictions: we delete the first year or the last year when there is a CEO turnover; we delete firm-years when there are less than five executives reported and firm-years when the CEO's annual compensation was $1. Panel A provides mean, median, and standard deviation for all variables used in the paper and Panel B provides correlation matrix only for key variables for brevity: the upper right is Pearson correlation and bottom-left is Spearman correlation.
See Appendix B for variable definition and measurement.

of coordinating incentives embedded in PPS dispersion on firm performance, we include the PPS levels of each executive individually in the regression to control for the direct effect of standalone incentives on firm performance.[17] Next, we control for team-related compensation aspects including the annual pay-level gap (*Pay Gap*) between the CEO and the rest of the management team (Kale et al. 2009), CEO pay slice (Bebchuk et al. 2011), and the standard deviation of annual compensation levels (i.e., pay-level dispersion or disparity) across VPs (*STD_VP_Pay*). Our firm control variables are comparable to those used in Kale et al. (2009) and include industry homogeneity, firm size, return volatility, leverage, R&D, advertising expenditures (*Advertising to Capital*), and dividend yield. In addition, we further control for past performance by including lagged *Tobin's Q,* lagged *ROA,* and lagged annual stock returns (*Return*) from the previous two years in all analyses. Finally, we include industry and year fixed effects.

Results for this specification are reported in Table 2. Note that right-hand side variables are measured at year $t-1$ or earlier, while the dependent variable is measured at year t. We first note in Table 2 that PPS dispersion (*STD_PPS*) is significantly and negatively associated with both *Tobin's Q* and *ROA*. We also note that each individual executive's PPS has a strong positive association with both *Tobin's Q* and *ROA,* while coefficients on the *Pay Gap* and *CEO Pay Slice* have the predicted signs and are statistically significant (insignificant) in the *Tobin's Q* (*ROA*) specification. We find that the coefficients on the other firm-specific control variables are intuitive and generally consistent with prior literature.

Deviations from Optimal PPS Dispersion and Firm Performance

In the previous subsection, we show that both *Tobin's Q* and *ROA* are decreasing in PPS dispersion. We next dig deeper into this result and explore the possibility that it is driven by deviations from optimal PPS dispersion levels. To the extent that there is an optimal level of dispersion, we would expect *Tobin's Q* (*ROA*) to increase in PPS dispersion for values of dispersion below the optimal level, and to decrease in PPS dispersion for higher values that exceed the optimum. To model optimal PPS dispersion, we run the following specification:

$$STD\_PPS_{t-1} = \alpha + \lambda * Firm/Industry\text{-}Level\ Determinants_{t-1} + Firm\ Fixed\ Effects + Year\ Fixed\ Effects + \varepsilon. \tag{3}$$

In modeling PPS dispersion, we include a wide range of firm- and industry-level determinants that can vary over time, as well as including a firm fixed effect to control for unobserved, time-invariant heterogeneity across firms, and time fixed effects. We do not include any compensation variables as they are not exogenous determinants of dispersion, but rather are determined simultaneously with dispersion as part of optimal contract design. Given a lack of explicit guidance from extant theory, our choice of determinants is in some sense exploratory. However, as we see in Table 3, Panel A, the determinants and fixed effects explain a substantial amount of variation in *STD_PPS* with a reported R^2 of 68 percent. We use the residuals from Equation (3) to capture deviations from optimal dispersion. Using these residuals, we define two new variables:

NEG_RD_PPS = the actual residual when residual < 0, and is set equal to 0 otherwise; and
POS_RD_PPS = the actual residual when residual > 0, and is set equal to 0 otherwise.

We extend the empirical specification described in Equation (2) by replacing *STD_PPS* with these two variables: *NEG_RD_PPS* and *POS_RD_PPS*. The control variables are identical to those used in the Table 2 analysis, including the other compensation variables and industry and year fixed effects. The results are reported in Table 3, Panel B where we find that the coefficient on *NEG_RD_PPS* is positive and significant, while that on *POS_RD_PPS* is negative and significant for both *Tobin's Q* and *ROA*. This result is consistent with the existence of an optimal level of PPS dispersion for which both positive and negative deviations from this optimal level result in deterioration of firm value and operating performance. When the deviation from optimal goes up by one standard deviation from below (above) optimal, *Tobin's Q* will go up (down) by 2.7

[17] Due to the wide variation in executive titles in the sample, we include PPS levels for CEOs and CFOs, and group the remaining three executives together regardless of their titles. In Table 7 we consider a reduced sample for which executive titles are all the same consisting of CEO, CFO, COO, and general counsel.

TABLE 2

PPS Dispersion and Firm Performance
Linear Regression

	Dependent =			
	Tobin's Q_t		*ROA_t*	
	Estimate	**p-value**	**Estimate**	**p-value**
Intercept	1.235	0.000	−0.114	< 0.0001
STD_PPS_{t-1}	−0.567	< 0.0001	−0.019	0.005
CEO PPS_{t-1}	0.393	< 0.0001	0.014	< 0.0001
CFO PPS_{t-1}	0.314	0.007	0.017	0.001
Other PPS_{t-1}	0.883	< 0.0001	0.036	< 0.0001
Log(Pay Gap)$_{t-1}$	0.090	0.002	0.004	0.107
CEO Pay Slice$_{t-1}$	−0.281	0.028	−0.003	0.821
Log(STD_VP_Pay)$_{t-1}$	0.011	0.373	−0.004	< 0.0001
Team Length$_{t-1}$	0.001	0.665	0.000	0.012
Geographic Segment Dispersion$_{t-1}$	0.100	0.031	0.000	0.980
R&D to Capital$_{t-1}$	0.034	0.002	−0.003	0.000
Industry Homogeneity$_{t-1}$	−0.088	0.331	−0.010	0.209
Firm Size$_{t-1}$	−0.148	0.055	0.038	< 0.0001
Firm Size$^2{}_{t-1}$	0.007	0.126	−0.002	< 0.0001
Return Volatility$_{t-1}$	−0.702	0.142	−0.413	< 0.0001
Capital to Sales$_{t-1}$	−0.007	0.085	0.000	0.595
Leverage$_{t-1}$	−0.189	0.003	−0.027	< 0.0001
Advertising to Capital$_{t-1}$	0.027	0.204	0.003	0.063
Dividend Yield$_{t-1}$	0.187	0.443	−0.057	0.059
Tobin's Q_{t-1}	0.402	< 0.0001	0.010	< 0.0001
ROA_{t-1}	0.757	0.001	0.286	< 0.0001
Return$_{t-1}$	−0.012	0.552	0.000	0.876
Return$_{t-2}$	0.021	0.128	−0.001	0.723
Industry Fixed Effect	Included		Included	
Year Fixed Effect	Included		Included	
R^2	0.5682		0.3558	
n	17,735		17,735	

The sample period is from 1992 to 2013. The models are estimated with pooled time-series and cross-sectional data, and the standard errors are clustered by firms. Reported p-values are for a two-sided test.
See Appendix B for variable definition and measurement.

percent (3.5 percent), corresponding to a 1.5 percent (1.9 percent) change relative to the sample mean of 1.78.[18] The impact on ROA would be 0.15 percent higher (0.27 percent lower) when the deviation from the optimal goes up by one standard deviation from below (or above), a 3.7 percent (6.7 percent) change relative to the sample mean of 0.04.[19]

PPS Dispersion Adjustment Process

As discussed earlier, we consider the possibility that deviations from optimal dispersion are sustained by adjustment costs that inhibit boards from immediately re-aligning deviations from optimal PPS dispersion. If shocks push PPS dispersion out of alignment, and board efforts to counteract these shocks and restore optimality are subject to adjustment costs, then we would expect these shocks to only partially dissipate as boards manage PPS dispersion toward optimality. To explore this, we estimate how much of the current gap between target PPS dispersion and actual dispersion is closed over the subsequent year.

[18] The economic significance of 2.7 percent is calculated as the product of 0.327 (estimate for $NEG\_RD\_PPS_{t-1}$) and its standard deviation of 0.08169 (this standard deviation is computed after all zeros are dropped). The economic significance of 3.5 percent is calculated as the product of 0.291 (estimate for $POS\_RD\_PPS_{t-1}$) and its standard deviation of 0.11907 (this standard deviation is computed after all zeros are dropped).

[19] Note that the standard deviations we use for these calculations are 0.08169 for *NEG_RD_PPS* and 0.1191 for *POS_RD_PPS* instead of those reported in Table 1. These are larger because we drop zeros for this exercise.

TABLE 3
Deviations from Optimal PPS Dispersion and Firm Performance

Panel A: Estimating the Residual PPS Dispersion

	Dependent = STD_PPS_{t-1}	
	Estimate	**p-value**
$Team\ Length_{t-1}$	0.003	< 0.0001
$Geographic\ Segment\ Dispersion_{t-1}$	−0.015	0.202
$R\&D\ to\ Capital_{t-1}$	0.000	0.973
$Industry\ Homogeneity_{t-1}$	0.004	0.852
$Firm\ Size_{t-1}$	0.006	0.541
$Firm\ Size^2{}_{t-1}$	0.000	0.946
$Return\ Volatility_{t-1}$	−0.185	0.055
$Capital\ to\ Sales_{t-1}$	0.000	0.677
$Leverage_{t-1}$	−0.021	0.082
$Advertising\ to\ Capital_{t-1}$	−0.002	0.617
$Dividend\ Yield_{t-1}$	−0.114	0.016
$Tobin's\ Q_{t-1}$	0.006	< 0.0001
ROA_{t-1}	0.012	0.359
$Return_{t-1}$	0.005	0.005
$Return_{t-2}$	0.002	0.221
Firm Fixed Effect	Included	
Year Fixed Effect	Included	
R^2	0.6800	
n	17,735	

Panel B: The Impact of Residual PPS Dispersion on Firm Performance

	Dependent =			
	$Tobin's\ Q_t$		ROA_t	
	Estimate	**p-value**	**Estimate**	**p-value**
Intercept	1.217	0.000	−0.115	< 0.0001
$NEG\_RD\_PPS_{t-1}$	0.327	0.008	0.018	0.033
$POS\_RD\_PPS_{t-1}$	−0.291	0.048	−0.023	0.006
$CEO\ PPS_{t-1}$	0.209	< 0.0001	0.009	< 0.0001
$CFO\ PPS_{t-1}$	0.325	0.005	0.018	0.002
$Other\ PPS_{t-1}$	0.485	< 0.0001	0.026	< 0.0001
$Log(Pay\ Gap)_{t-1}$	0.091	0.002	0.004	0.103
$CEO\ Pay\ Slice_{t-1}$	−0.281	0.027	−0.003	0.822
$Log(STD\_VP\_Pay)_{t-1}$	0.013	0.327	−0.004	< 0.0001
$Team\ Length_{t-1}$	0.001	0.548	0.000	0.013
$Geographic\ Segment\ Dispersion_{t-1}$	0.106	0.024	0.000	0.926
$R\&D\ to\ Capital_{t-1}$	0.034	0.002	−0.003	0.000
$Industry\ Homogeneity_{t-1}$	−0.068	0.449	−0.010	0.245
$Firm\ Size_{t-1}$	−0.148	0.056	0.038	< 0.0001
$Firm\ Size^2{}_{t-1}$	0.007	0.117	−0.002	< 0.0001
$Return\ Volatility_{t-1}$	−0.705	0.140	−0.412	< 0.0001
$Capital\ to\ Sales_{t-1}$	−0.007	0.088	0.000	0.590
$Leverage_{t-1}$	−0.182	0.004	−0.027	< 0.0001
$Advertising\ to\ Capital_{t-1}$	0.026	0.209	0.003	0.064
$Dividend\ Yield_{t-1}$	0.165	0.510	−0.057	0.056
$Tobin's\ Q_{t-1}$	0.405	< 0.0001	0.010	< 0.0001
ROA_{t-1}	0.767	0.001	0.286	< 0.0001

(continued on next page)

TABLE 3 (continued)

	Dependent =			
	Tobin's Q_t		***ROA_t***	
	Estimate	**p-value**	**Estimate**	**p-value**
$Return_{t-1}$	−0.009	0.630	0.000	0.847
$Return_{t-2}$	0.021	0.121	−0.001	0.722
Industry Fixed Effect	Included		Included	
Year Fixed Effect	Included		Included	
R^2	0.5665		0.3558	
n	17,735		17,735	

The sample period is from 1993 to 2013. In Panel A, we predict the optimal PPS dispersion and the residual of PPS dispersion would be the difference between the actual dispersion and predicted dispersion. We define two variables based on the residuals: *NEG_RD_PPS* (when the difference is negative) and *POS_RD_PPS* (when the difference is positive). In Panel B, we regress firm value/performance on these two variables and all other controls. The models are estimated with pooled time-series and cross-sectional data, and the standard errors are clustered by firms. Reported p-values are for a two-sided test.
See Appendix B for variable definition and measurement.

Specifically, we use the following specification:

$$STD\_PPS_t - STD\_PPS_{t-1} = \alpha + \delta * (Target_t - STD\_PPS_{t-1}) + \varepsilon_t. \tag{4a}$$

$$STD\_PPS_t = \alpha + (1-\delta) * STD\_PPS_{t-1} + \delta * Target_t + \varepsilon_t, \tag{4b}$$

where $Target_t = \alpha + \lambda * Determinants_{t-1} + Firm\ and\ Time\ Fixed\ Effects$.

$Target_t$ is the predicted value of STD_PPS_t at time t using data available at time t−1 (Equation (3) above). To understand the intuition of the analysis, note that Equation (4a) regresses the actual change in PPS dispersion from t−1 to t on the gap between the predicted value of STD_PPS_t (the target) and actual PPS dispersion at t−1. The coefficient δ in Equation (4a) is often referred to as the speed of adjustment, and can be interpreted as the percentage of the gap between target dispersion and actual PPS dispersion at time t−1 that is closed by the actual change in PPS dispersion from year t−1 to t (e.g., Lemmon et al. 2008). Equation (4b) simply rearranges the terms in Equation (4a) in a manner that is conducive for directly estimating the speed of adjustment, δ.

We report the results from estimating Equation (4b) using OLS in column (1) of Table 4. We see that the coefficient on STD_PPS_{t-1} is 0.44 (p-value $<$ 0.0001), indicating that only 56 percent of the gap is closed over the subsequent year ($(1-\delta) =$ 0.44). However, to eliminate potential bias due to inclusion of lagged values of the dependent variable and firm fixed effects in our dynamic panel (Hsiao 2003), we present in column (2) of Table 4 results using system GMM estimation (Blundell and Bond 1998). We see that the coefficient on STD_PPS_{t-1} in the GMM specification is 0.34 (p-value $<$ 0.0001), indicating that around 66 percent of the gap is closed over the subsequent year. These results provide evidence consistent with the existence of adjustment costs for which boards' actively, but only partially, adjust executives' incentive toward the optimal level of PPS dispersion.

While the Table 4 results document that deviations from optimal dispersion are partially reversed over the subsequent year, it is important to consider whether the dynamics reflected in these results derive from firms' active management toward desired PPS dispersion or from more passive behavior. As discussed previously in Section II, if firms use future grants to move PPS dispersion toward optimal levels, for grants designed to increase (decrease) dispersion, then the PPS of the vector of such grants to individual executives should, in general, be positively (negatively) correlated with the vector of current PPS levels. To examine these correlation predictions, we create the variable $Corr(PPS_{t-1}, Grant_t)$, which is computed as the correlation between the vector of PPS levels for individual executives at time t−1 and the vector of equity grant PPS for these same executives for year t. As shown in Table 1, $Corr(PPS_{t-1}, Grant_t)$ has a mean (median) of 0.11 (0.21) and exhibits substantial variation, with a value of −0.47 at the first quartile and 0.72 at the third quartile.

In our first analysis, we define a dummy variable, *Positive Sub-optimal Dispersion*$_{t-1}$, which is set equal to 1 if (*PPS Dispersion*$_{t-1}$ − *Target PPS Dispersion*$_t$) is positive, and 0 otherwise, where *Target PPS Dispersion* is estimated from the column (1) of Table 4. We then regress $Corr(PPS_{t-1}, Grant_t)$ on *Positive Sub-optimal Dispersion*$_{t-1}$ and control variables. Consistent with our predictions, column (1) of Table 5 reports that the coefficient on *Positive Sub-optimal Dispersion*$_{t-1}$ is negative and significant ($p < 0.0001$), indicating that firms with positive deviations from optimal exhibit $Corr(PPS_{t-1}, Grant_t)$ that are significantly smaller than for firms with negative deviations from optimal.

TABLE 4

Speed of Adjustment of PPS Dispersion

	Dependent = STD_PPS_t			
	(1) OLS Estimation		**(2) GMM Estimation**	
	Estimate	**p-value**	**Estimate**	**p-value**
STD_PPS_{t-1}	0.439	< 0.0001	0.341	0.000
$Team\ Length_{t-1}$	0.002	< 0.0001	0.002	0.017
$Geographic\ Segment\ Dispersion_{t-1}$	−0.006	0.580	−0.062	0.006
$R\&D\ to\ Capital_{t-1}$	0.000	0.799	0.001	0.832
$Industry\ Homogeneity_{t-1}$	0.002	0.934	−0.033	0.456
$Firm\ Size_{t-1}$	0.005	0.668	−0.022	0.446
$Firm\ Size^2{}_{t-1}$	−0.001	0.469	0.002	0.442
$Return\ Volatility_{t-1}$	−0.148	0.126	0.056	0.766
$Capital\ to\ Sales_{t-1}$	0.000	0.895	0.007	0.477
$Leverage_{t-1}$	−0.001	0.958	−0.007	0.758
$Advertising\ to\ Capital_{t-1}$	0.004	0.493	0.001	0.908
$Dividend\ Yield_{t-1}$	−0.005	0.912	0.025	0.703
$Tobin's\ Q_{t-1}$	0.004	0.001	0.006	0.007
ROA_{t-1}	0.003	0.835	−0.033	0.137
$Return_{t-1}$	0.001	0.764	−0.001	0.834
$Return_{t-2}$	0.003	0.157	−0.002	0.457
Firm Fixed Effect	Included		Not Included	
Year Fixed Effect	Included		Included	
R^2	0.7727			
n	13,959		13,959	

The sample period is from 1992 to 2013. In this table, we examine how *STD_PPS* evolves over time. One minus the coefficient on lagged *STD_PPS* captures the speed with which the gap between target and actual PPS dispersion at year $t-1$ is closed by the actual change in PPS dispersion between $t-1$ and t. See Equation (4) in the paper for a discussion of this specification. While column (1) uses OLS regression, column (2) uses the system GMM method of Blundell and Bond (1998) to eliminate potential bias due to inclusion of lagged values of the dependent variable and firm fixed effects in a dynamic panel. All regressions are run with pooled time-series and cross-sectional data, and the standard errors are clustered by firms. Reported p-values are for a two-sided test.
See Appendix B for variable definition and measurement.

We also examine the probability of $Corr(PPS_{t-1}, Grant_t)$ being negative for firms with positive relative to those with negative deviations from optimal. We define a dummy variable *Dummy_Negative_Corr* that equals 1 if $Corr(PPS_{t-1}, Grant_t)$ is negative, and 0 otherwise, and regress this on $Positive\ Sub\text{-}optimal\ Dispersion_{t-1}$ using a logit specification. Column (2) of Table 5 reports that the coefficient on $Positive\ Sub\text{-}optimal\ Dispersion_{t-1}$ is positive and significant ($p < 0.0001$), indicating that firms with positive deviations from optimal exhibit $Corr(PPS_{t-1}, Grant_t)$ are significantly more likely to be negative than for firms with negative deviations from optimal. This evidence is consistent with boards actively using grants to counteract deviations from optimal in an attempt to restore optimality.

V. PPS DISPERSION AND EXECUTIVES' INCENTIVES TO COOPERATE

Our analyses to this point provide evidence consistent with deviations from optimal dispersion degrading firm performance, with such deviations being sustained by adjustment costs that inhibit boards from immediately fully reestablishing optimality, and with firms using subsequent equity grants to manage PPS dispersion toward optimality. In this section, we extend the analysis to investigate further whether optimal PPS dispersion reflects team-based incentive considerations designed to coordinate the behavior of team members as opposed to solely reflecting the outcome of a process that designs each individual executive's incentives in isolation. We argue that if, in contrast to the implications of the Edmans et al. (2013), PPS dispersion only reflects differences in PPS designed optimally for each individual executive in isolation, then negative performance consequences of deviations from optimal dispersion should not systematically vary with the length of time a team has been together or with cross-sectional differences in the importance of team coordination for firm performance.

We first examine the hypothesis that repeated interactions among team members over time develop closer team relationships and a deeper understanding of value-enhancing synergies within the team, which in turn helps mitigate the

TABLE 5

Adjustment of PPS Dispersion through Annual Grants

	Dependent =			
	$Corr(PPS_{t-1}, Grant_t)$		$Dummy\_Negative\_Corr$	
	Estimate	**p-value**	**Estimate**	**p-value**
Intercept	0.160	0.442	−0.051	0.939
Positive Sub-optimal Dispersion$_{t-1}$	−0.127	< 0.0001	0.356	< 0.0001
Team Length$_{t-1}$	−0.003	0.277	0.002	0.823
Geographic Segment Dispersion$_{t-1}$	−0.010	0.811	0.023	0.857
R&D to Capital$_{t-1}$	0.026	0.823	−0.174	0.625
Industry Homogeneity$_{t-1}$	0.020	0.592	−0.086	0.447
Firm Size$_{t-1}$	−0.002	0.447	0.007	0.358
Firm Size$^2{}_{t-1}$	0.439	0.325	−1.749	0.196
Return Volatility$_{t-1}$	0.023	0.073	−0.057	0.167
Capital to Sales$_{t-1}$	−0.106	0.046	0.303	0.064
Leverage$_{t-1}$	0.007	0.190	−0.022	0.330
Advertising to Capital$_{t-1}$	0.009	0.538	−0.036	0.515
Dividend Yield$_{t-1}$	0.407	0.196	−0.470	0.624
Tobin's Q$_{t-1}$	−0.002	0.780	−0.002	0.917
ROA$_{t-1}$	−0.130	0.079	0.307	0.187
Return$_{t-1}$	−0.011	0.265	0.032	0.312
Return$_{t-2}$	−0.016	0.124	0.022	0.520
Industry Fixed Effect	Included		Included	
Year Fixed Effect	Included		Included	
R^2	0.0261		0.0209	
n	12,263		12,263	

The sample period is from 1992 to 2013. $Corr(PPS_{t-1}, Grant_t)$ is the Pearson correlation between grant PPS in year t and PPS level in year $t-1$. *Dummy_Negative_Corr* is a dummy variable that equals 1 if $Corr(PPS_{t-1}, Grant_t)$ is negative, and 0 otherwise. *Positive Sub-optimal Dispersion*$_{t-1}$ is a dummy variable that equals 1 if *PPS Dispersion*$_{t-1}$ − *Target PPS Dispersion*$_t$ is positive, and 0 otherwise, where *Target PPS Dispersion* is estimated from column (1) of Table 4. All regressions are run with pooled time-series and cross-sectional data, and the standard errors are clustered by firms. Model (2) is estimated with logit regression. Reported p-values are for a two-sided test.
See Appendix B for variable definition and measurement.

negative effects of deviations from optimal PPS dispersion. We construct the variable *Team Length,* which is the number of consecutive years the top executive team remains the same. We begin the count in the first year the firm enters the sample and treat it as the original team. *Team Length* is the number of years this team stays together, defining the end of a team when two original team members drop off. We alternatively define a team change when one original member drops off, without changing the results. We then interact *Team Length* with our negative and positive deviation variables: *NEG_RD_PPS* and *POS_RD_PPS*. To the extent that team length mitigates the negative impact of deviations from optimal PPS dispersion, we expect the coefficients on *NEG_RD_PPS* ∗ *Team Length* to be negative and the coefficients on *POS_RD_PPS* ∗ *Team Length* to be positive. For this exercise, we similarly interact this variable with individual executive's PPS levels.

Panel A of Table 6 shows that, as predicted, the coefficient on the interaction term *POS_RD_PPS* ∗ *Team Length* is positive and significant for both *Tobin's Q* and *ROA*. The coefficient on *NEG_RD_PPS* ∗ *Team Length* is positive for *ROA* (contrary to our prediction) but negative for *Tobin's Q*, although both coefficients are insignificantly different from zero. These results provide some support for the idea that the negative performance consequences of PPS dispersion diminish as the management team stays together longer.[20]

Next, we focus on two fundamental firm characteristics that have been linked to the importance of cooperation within executive teams: R&D intensity and geographic dispersion. We hypothesize that higher R&D intensity and more geographic diversification are indicative of the importance of team coordination and cooperation for firm performance and, as such, will be associated with deviations from optimal dispersion being more costly to the firm (i.e., more positive (negative) marginal

[20] To mitigate potential survivorship bias issues associated with this analysis, we have also restricted the sample to firms that are in ExecuComp for a minimum of three, four, or five years. Our results remain robust to these restrictions.

TABLE 6

Impact of PPS Dispersion on Firm Performance
Cross-Sectional Analysis

Panel A: *Team Length*

	Dependent =			
	Tobin's Q_t		*ROA_t*	
	Estimate	**p-value**	**Estimate**	**p-value**
Intercept	0.942	$<$ 0.0001	−0.089	$<$ 0.0001
$NEG\_RD\_PPS_{t-1}$	0.357	0.010	0.020	0.050
$POS\_RD\_PPS_{t-1}$	−0.501	0.015	−0.037	0.001
*$NEG\_RD\_PPS_{t-1}$ * $Team\ Length_{t-1}$*	−0.013	0.502	0.001	0.443
*$POS\_RD\_PPS_{t-1}$ * $Team\ Length_{t-1}$*	0.058	0.037	0.004	0.015
*$CEO\ PPS_{t-1}$ * $Team\ Length_{t-1}$*	−0.009	0.064	0.000	0.118
*$CFO\ PPS\ _{t-1}$ * $Team\ Length_{t-1}$*	−0.032	0.119	0.000	0.728
*$Other\ PPS\ _{t-1}$ * $Team\ Length_{t-1}$*	−0.031	0.045	−0.002	0.036
$CEO\ PPS_{t-1}$	0.229	$<$ 0.0001	0.011	$<$ 0.0001
$CFO\ PPS_{t-1}$	0.456	0.008	0.015	0.054
$Other\ PPS_{t-1}$	0.613	$<$ 0.0001	0.034	$<$ 0.0001
$Team\ Length_{t-1}$	0.002	0.369	0.000	0.990
$Geographic\ Segment\ Dispersion_{t-1}$	0.091	0.013	0.001	0.723
$R\&D\ to\ Capital_{t-1}$	0.028	0.148	0.003	0.008
Other Controls Variables	Included		Included	
Industry Fixed Effect	Included		Included	
Year Fixed Effect	Included		Included	
R^2	0.6036		0.3529	
n	17,735		17,735	

Panel B: *R&D*

	Dependent =			
	Tobin's Q_t		*ROA_t*	
	Estimate	**p-value**	**Estimate**	**p-value**
Intercept	1.133	0.000	−0.057	0.005
$NEG\_RD\_PPS_{t-1}$	0.144	0.048	0.016	0.018
$POS\_RD\_PPS_{t-1}$	−0.215	0.041	−0.013	0.049
*$NEG\_RD\_PPS_{t-1}$ * $R\&D_{t-1}$*	0.466	0.029	0.030	0.025
*$POS\_RD\_PPS_{t-1}$ * $R\&D_{t-1}$*	−0.990	0.001	−0.037	0.050
*$CEO\ PPS\ _{t-1}$ * $R\&D_{t-1}$*	0.069	0.167	0.003	0.297
*$CFO\ PPS\ _{t-1}$ * $R\&D_{t-1}$*	0.534	0.019	0.003	0.800
*$Other\ PPS\ _{t-1}$ * $R\&D_{t-1}$*	0.867	0.000	0.026	0.052
$CEO\ PPS_{t-1}$	0.173	$<$ 0.0001	0.006	$<$ 0.0001
$CFO\ PPS_{t-1}$	0.145	0.023	0.013	0.003
$Other\ PPS_{t-1}$	0.368	$<$ 0.0001	0.017	$<$ 0.0001
$Team\ Length_{t-1}$	0.000	0.985	0.000	0.004
$Geographic\ Segment\ Dispersion_{t-1}$	0.097	0.002	0.001	0.665
$R\&D\ to\ Capital_{t-1}$	0.028	0.035	0.003	0.011
Other Controls Variables	Included		Included	
Industry Fixed Effect	Included		Included	
Year Fixed Effect	Included		Included	
R^2	0.5576		0.3556	
n	17,735		17,735	

(continued on next page)

TABLE 6 (continued)

Panel C: ***Geographic Segment Dispersion***

	Dependent =			
	Tobin's Q_t		***ROA_t***	
	Estimate	**p-value**	**Estimate**	**p-value**
Intercept	0.964	0.003	−0.111	< 0.0001
$NEG\_RD\_PPS_{t-1}$	−0.299	0.053	0.010	0.300
$POS\_RD\_PPS_{t-1}$	−0.352	0.013	−0.014	0.049
$NEG\_RD\_PPS_{t-1}$ ∗ Geographic Segment $Dispersion_{t-1}$	1.565	0.001	0.020	0.448
$POS\_RD\_PPS_{t-1}$ ∗ Geographic Segment $Dispersion_{t-1}$	−1.327	0.008	−0.067	0.017
CEO PPS_{t-1} ∗ Geographic Segment $Dispersion_{t-1}$	0.404	0.001	0.006	0.139
CFO PPS_{t-1} ∗ Geographic Segment $Dispersion_{t-1}$	0.802	0.072	0.031	0.118
Other PPS_{t-1} ∗ Geographic Segment $Dispersion_{t-1}$	1.132	0.005	0.043	0.054
CEO PPS_{t-1}	0.109	0.001	0.007	< 0.0001
CFO PPS_{t-1}	0.150	0.112	0.009	0.072
Other PPS_{t-1}	0.270	0.000	0.018	< 0.0001
Team $Length_{t-1}$	0.001	0.777	0.000	0.050
Geographic Segment $Dispersion_{t-1}$	0.123	0.011	0.002	0.552
R&D to $Capital_{t-1}$	0.028	0.204	0.003	0.007
Other Controls Variables	Included		Included	
Industry Fixed Effect	Included		Included	
Year Fixed Effect	Included		Included	
R^2	0.5590		0.3393	
n	17,735		17,735	

The sample period is from 1992 to 2013. In Panel A, we consider *Team Length* and interact it with our main variables. In Panels B and C, we consider *R&D* and *Geographic Dispersion* and interact them with our main variables. The models are estimated with pooled time-series and cross-sectional data, and the standard errors are clustered by firms. For brevity, we omit estimates for some firm control variables. Reported p-values are for a two-sided test. *NEG_RD_PPS* and *POS_RD_PPS* are as defined in Table 3 notes. See Appendix B for other variable definitions and measurements.

effects of negative (positive) deviations). As discussed earlier, while it is not obvious how to proxy for a firm's demand for coordination, we believe these two variables are at least plausible proxies. *R&D* is defined as research and development expenditures divided by net fixed assets and geographic segment dispersion is measured as (1 − Herfindahl Index). We use the Compustat Business Industry Segment File to compute revenue-based Herfindahl indices for each firm-year, calculated as the sum of the squares of each geographic segment's sales as a percentage of the total firm sales. Higher values of the Herfindahl index indicate more geographic concentration of the overall firm, so (1 − Herfindahl) represents geographic segment dispersion (Bushman, Chen, Engel, and Smith 2004). Again, we similarly interact these two variables with individual executives' PPS.

In Panels B and C of Table 6, we present the results from including the interaction terms *NEG_RD_PPS ∗ R&D* and *POS_RD_PPS ∗ R&D* (*NEG_RD_PPS ∗ Geographic Segment Dispersion* and *POS_RD_PPS ∗ Geographic Segment Dispersion*). We find that all eight coefficients on the interactions terms have the predicted sign where the coefficients on *NEG_RD_PPS ∗ R&D/Geographic Segment Dispersion* terms are positive and those on the *POS_RD_PPS ∗ R&D/Geographic Segment Dispersion* terms are negative. Seven out of the eight coefficients are statistically significant. This suggests that it is more costly for high R&D or more geographically dispersed firms to have PPS dispersion deviate from its optimal level.

The results presented in this section suggest that repeated interactions among team members over time can foster closer team relationships and a better understanding of value-enhancing synergies that can offset deleterious effects of deviations from optimal PPS dispersion. Further, our results suggest that the performance consequences of non-optimal PPS dispersion vary with the extent to which a firm's performance is dependent on cooperation and coordination within the management team. These results from our cross-sectional analyses using team longevity, R&D, and geographic segment dispersion, while not definitive, are highly suggestive of PPS dispersion reflecting incentive considerations designed to coordinate the behavior of team members as opposed to solely reflecting the outcome of a process that designs each individual executive's incentives in isolation.

VI. ROBUSTNESS TESTS

Directly Controlling for Executive Job Titles

The first sensitivity test that we conduct is to use a reduced sample to directly control for executive job titles. This exercise serves two purposes. First, in our previous analyses, we estimate optimal PPS dispersion using a wide range of determinants, including firm fixed effects. Firm fixed effects control for unobservable, time-invariant characteristics of the firm, including firm-specific aspects of the nature and design of executive positions within the executive team. To the extent that the executive positions within the firm are stable over time, the firm fixed effect allows us to filter out cross-sectional differences in the underlying nature of the specific positions comprising the executive team. In an attempt to control for the possibility that the executive job titles comprising the team vary over time within a firm, we limit our sample to firm years during which the team is comprised of only the titles CEO, CFO, COO, and General Counsel due to the fact that these titles have the highest frequencies in our sample: 36 percent, 34 percent, 16 percent and 10 percent, respectively.[21] Second, with this sample, we can better control for individual executive PPS because we have COOs' PPS and general counsels' PPS instead of other executives' PPS. With this restriction, our sample size drops to 2,022 from the original 17,735 used in Table 3 analysis. In Table 7 we report results from estimating the relation between firm performance and deviations from optimal dispersion using this restricted sample. It shows that our main results continue to hold in this subsample. The evidence here suggests that while the composition of the management team itself may affect the PPS dispersion, it does not drive our results. It also suggests that the *STD_PPS* effect on firm value/performance is over and above those from the individual executives' PPS.

Alternative Measure of Team-Based Incentives

In this subsection, we focus on the sensitivity of our results to an alternate measure of PPS dispersion. Thus far, we have presented results measuring team-based incentives as the standard deviation of the executive teams' PPS levels (dispersion). Now we consider *Range_PPS* as an alternative measure of team-based incentives. *Range_PPS* is computed as the difference between the largest and smallest PPS in the top five highest-paid executives in a given firm-year. Table 8 reports that our results are robust to using this alternate measure.

VII. SUMMARY

Recent theory suggests that firms incorporate synergistic interrelationships among executives into optimal incentive design (Edmans et al. 2013). In this paper we focus on *Pay Performance Sensitivities* (PPS) and extend the literature by using a measure of PPS dispersion across top executives as a proxy for the incentive design component shaped by an executive team's synergy profile. Using this measure we assess the consequences of synergies for firm performance and the equity-granting strategies of firms' boards of directors. We directly model optimal PPS dispersion levels and use residuals from this model to capture deviations from optimal. We show that firm performance is increasing when PPS dispersion is too low (negative residuals) and decreasing when it is too high (positive residuals), after controlling for the PPS levels of each individual executive separately. This is an important contribution that provides evidence consistent with residuals from the PPS dispersion model actually reflecting deviations from optimal and establishes a basis for us to examine the dynamic adjustment process of PPS dispersion toward optimality over time.

To investigate why non-optimal PPS dispersion levels persist given negative performance consequences, we offer a new theory of adjustment costs, hypothesizing that incentive design is a process during which value-maximizing firms seek to eliminate deviations and restore optimal dispersion levels but are constrained by adjustment costs. To explore this theory, we isolate the speed of partial adjustment back to optimal, finding that firms only close around 60 percent of the current gap between target PPS dispersion and actual dispersion over the subsequent year. We examine whether this is a passive statistical phenomenon or it reflects active management of incentives by firms using the correlation between the vector of existing PPS levels and the vector of equity grant PPS in the subsequent year. Consistent with firms actively managing the level of PPS dispersion toward optimality, we find that the vectors of subsequent equity grant PPS are more positively (negatively) correlated with the vector of executives' current PPS in order to increase (decrease) PPS dispersion for firms below (above) optimal levels.

In our final set of analyses, we investigate whether optimal PPS dispersion reflects incentive considerations designed to coordinate the behavior of team members in addition to reflecting variation in PPS levels designed for each individual executive in isolation. We examine three firm characteristics that we argue are at least plausible proxies for the importance of executive

[21] The next executives will be Chief Marketing Officers whose frequency is 3 percent only, which will make our sample too small if we choose to consider five instead of four executives for this exercise.

TABLE 7

Sensitivity Test
Estimation Requiring the Same Functioning Executives

Panel A: Estimating the Residual PPS Dispersion

	Dependent = STD_PPS_{t-1}	
	Estimate	**p-value**
$Team\ Length_{t-1}$	0.005	0.004
$Geographic\ Segment\ Dispersion_{t-1}$	−0.045	0.240
$R\&D\ to\ Capital_{t-1}$	−0.015	0.263
$Industry\ Homogeneity_{t-1}$	0.007	0.927
$Firm\ Size_{t-1}$	−0.038	0.431
$Firm\ Size^2_{t-1}$	0.002	0.571
$Return\ Volatility_{t-1}$	0.455	0.353
$Capital\ to\ Sales_{t-1}$	−0.001	0.511
$Leverage_{t-1}$	−0.084	0.012
$Advertising\ to\ Capital_{t-1}$	−0.001	0.961
$Dividend\ Yield_{t-1}$	−0.055	0.699
$Tobin's\ Q_{t-1}$	0.016	0.000
ROA_{t-1}	−0.007	0.811
$Return_{t-1}$	−0.004	0.533
$Return_{t-2}$	−0.006	0.371
Firm Fixed Effect	Included	
Year Fixed Effect	Included	
R^2	0.7102	
n	2,022	

Panel B: The Impact of Residual PPS Dispersion on Performance

	Dependent =			
	$Tobin's\ Q_t$		ROA_t	
	Estimate	**p-value**	**Estimate**	**p-value**
Intercept	0.590	0.506	−0.298	< 0.0001
$NEG\_RD\_PPS_{t-1}$	1.490	0.007	0.119	0.024
$POS\_RD\_PPS_{t-1}$	−0.724	0.021	−0.060	0.047
$CEO\ PPS_{t-1}$	0.213	0.068	0.015	0.131
$CFO\ PPS_{t-1}$	0.132	0.582	−0.005	0.825
$COO\ PPS_{t-1}$	0.744	0.008	0.071	0.015
$General\ Counsel\ PPS_{t-1}$	1.686	0.001	0.127	0.000
$Log(Pay\ Gap)_{t-1}$	0.062	0.367	0.004	0.599
$CEO\ Pay\ Slice_{t-1}$	−0.071	0.831	0.004	0.904
$Log(STD\_VP\_Pay)_{t-1}$	−0.004	0.908	−0.008	0.012
$Team\ Length_{t-1}$	−0.003	0.488	0.000	0.621
$Geographic\ Segment\ Dispersion_{t-1}$	0.122	0.223	−0.008	0.487
$R\&D\ to\ Capital_{t-1}$	0.003	0.802	−0.007	< 0.0001
$Industry\ Homogeneity_{t-1}$	−0.274	0.146	−0.003	0.916
$Firm\ Size_{t-1}$	−0.081	0.720	0.077	< 0.0001
$Firm\ Size^2_{t-1}$	0.005	0.722	−0.005	< 0.0001
$Return\ Volatility_{t-1}$	−1.328	0.211	−0.409	0.081
$Capital\ to\ Sales_{t-1}$	−0.020	0.000	0.000	0.765
$Leverage_{t-1}$	−0.438	0.100	−0.046	0.011
$Advertising\ to\ Capital_{t-1}$	−0.043	0.038	0.008	< 0.0001
$Dividend\ Yield_{t-1}$	−0.377	0.287	−0.139	0.007
$Tobin's\ Q_{t-1}$	0.554	< 0.0001	0.020	< 0.0001

(continued on next page)

TABLE 7 (continued)

	Dependent =			
	Tobin's Q_t		***ROA_t***	
	Estimate	**p-value**	**Estimate**	**p-value**
ROA_{t-1}	0.407	0.081	0.177	< 0.0001
$Return_{t-1}$	−0.004	0.908	0.003	0.484
$Return_{t-2}$	−0.053	0.150	−0.001	0.834
Industry Fixed Effect	Included		Included	
Year Fixed Effect	Included		Included	
R^2	0.7021		0.4010	
n	2,022		2,022	

The sample period is from 1992 to 2013. We require the sample to have the following executives: CEO, CFO, COO, and General Counsel, four with the highest frequencies (34 percent, 33 percent, 18 percent, and 11 percent, respectively). In Panel A, we predict the optimal *PPS Dispersion* and the residual of *PPS Dispersion* would be the difference between the actual dispersion and predicted dispersion. We define two variables based on the residuals: *NEG_RD_PPS* (when the difference is negative) and *POS_RD_PPS* (when the difference is positive). In Panel B, we regress firm value/performance on these two variables and all other controls. The models are estimated with pooled time-series and cross-sectional data, and the standard errors are clustered by firms. Reported p-values are for a two-sided test.
See Appendix B for variable definition and measurement.

team coordination: executive team longevity, R&D intensity, and geographic segment dispersion. We find that deviations from optimal PPS dispersion become less damaging to firm performance as the duration of a team's tenure together increases. This suggests that repeated interactions among team members over time foster closer team relationships and a better understanding of value-enhancing synergies that offset deleterious effects of deviations from optimal PPS dispersion. We also find that higher

TABLE 8

Sensitivity Test
Using Range of PPS as an Alternative Measure

Panel A: Estimating the Residual PPS Range

	Dependent = ***$Range\_PPS_{t-1}$***	
	Estimate	**p-value**
$Team\ Length_{t-1}$	0.007	< 0.0001
$Geographic\ Segment\ Dispersion_{t-1}$	−0.035	0.191
$R\&D\ to\ Capital_{t-1}$	0.000	0.948
$Industry\ Homogeneity_{t-1}$	0.012	0.825
$Firm\ Size_{t-1}$	0.018	0.446
$Firm\ Size^2{}_{t-1}$	0.000	0.851
$Return\ Volatility_{t-1}$	−0.402	0.067
$Capital\ to\ Sales_{t-1}$	0.000	0.626
$Leverage_{t-1}$	−0.047	0.089
$Advertising\ to\ Capital_{t-1}$	−0.005	0.653
$Dividend\ Yield_{t-1}$	−0.270	0.012
$Tobin's\ Q_{t-1}$	0.014	< 0.0001
ROA_{t-1}	0.029	0.332
$Return_{t-1}$	0.013	0.004
$Return_{t-2}$	0.005	0.217
Firm Fixed Effect	Included	
Year Fixed Effect	Included	
R^2	0.6790	
n	17,735	

(continued on next page)

TABLE 8 (continued)

Panel B: The Impact of Residual PPS Range on Performance

	Dependent =			
	Tobin's Q_t		*ROA_t*	
	Estimate	**p-value**	**Estimate**	**p-value**
Intercept	1.148	0.002	−0.125	< 0.0001
$NEG\_RRange\_PPS_{t-1}$	0.150	0.023	0.030	< 0.0001
$POS\_RRange\_PPS_{t-1}$	−0.140	0.024	−0.011	0.000
CEO PPS_{t-1}	0.203	< 0.0001	0.007	0.000
CFO PPS_{t-1}	0.369	0.003	0.014	0.009
Other PPS_{t-1}	0.502	< 0.0001	0.024	< 0.0001
$Log(Pay\ Gap)_{t-1}$	0.097	0.002	0.004	0.107
CEO Pay $Slice_{t-1}$	−0.362	0.010	−0.009	0.433
$Log(STD\_VP\_Pay)_{t-1}$	0.013	0.332	−0.004	< 0.0001
Team $Length_{t-1}$	0.002	0.420	0.000	0.007
Geographic Segment $Dispersion_{t-1}$	0.104	0.029	−0.001	0.821
R&D to $Capital_{t-1}$	0.027	0.007	−0.003	0.001
Industry $Homogeneity_{t-1}$	−0.014	0.881	−0.009	0.297
Firm $Size_{t-1}$	−0.162	0.048	0.040	< 0.0001
Firm $Size^2_{t-1}$	0.007	0.113	−0.002	< 0.0001
Return $Volatility_{t-1}$	−0.986	0.037	−0.365	< 0.0001
Capital to $Sales_{t-1}$	−0.008	0.086	0.000	0.603
$Leverage_{t-1}$	−0.140	0.061	−0.026	< 0.0001
Advertising to $Capital_{t-1}$	0.030	0.198	0.003	0.052
Dividend $Yield_{t-1}$	0.255	0.295	−0.051	0.095
Tobin's Q_{t-1}	0.445	< 0.0001	0.012	< 0.0001
ROA_{t-1}	1.006	0.001	0.300	< 0.0001
$Return_{t-1}$	−0.005	0.816	0.001	0.508
$Return_{t-2}$	0.014	0.335	−0.001	0.512
Industry Fixed Effect	Included		Included	
Year Fixed Effect	Included		Included	
R^2	0.6034		0.3876	
n	17,735		17,735	

The sample period is from 1992 to 2013. In Panel A, we predict the optimal PPS range and the residual of PPS range is the difference between the actual PPS range and predicted PPS range. We define two variables based on the residuals: *NEG_RRange_PPS* (when the difference is negative) and *POS_RRange_PPS* (when the difference is positive). In Panel B, we regress firm value/performance on these two variables and all other controls. The models are estimated with pooled time-series and cross-sectional data, and the standard errors are clustered by firms. Reported p-values are for a two-sided test. See Appendix B for variable definition and measurement.

R&D intensity and larger geographic segment dispersion significantly exacerbate under-performance associated with deviations from optimal PPS dispersion, consistent with the importance of cooperation and coordination for these types of firms.

REFERENCES

Aggarwal, R., and A. Samwick. 2003. Performance incentives within firms: The effect of managerial responsibilities. *Journal of Finance* 58: 1613–1649.

Alchian, A., and H. Demsetz. 1972. Production, information costs and economic organization. *American Economic Review* 62: 777–795.

Arya, A., J. Fellingham, and J. Glover. 1997. Teams, repeated tasks, and implicit incentives. *Journal of Accounting and Economics* 23: 7–30.

Baker, G., R. Gibbons, and K. Murphy. 2002. Relational contracts and the theory of the firm. *Quarterly Journal of Economics* (Feb): 39–84.

Bebchuk, L., M. Creamers, and U. Peyer. 2011. The CEO pay slice. *Journal of Financial Economics* 102: 199–221.

Blundell, R., and S. Bond. 1998. Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics* 87 (1): 115–143.

Bushman, R., and A. Smith. 2001. Financial accounting information and corporate governance. *Journal of Accounting and Economics* 32: 237–333.

Bushman, R., Q. Chen, E. Engel, and A. Smith. 2004. Financial accounting information, organizational complexity and corporate governance systems. *Journal of Accounting and Economics* 37: 167–201.

Cadman, B., M. Carter, and S. Hillegeist. 2010. The incentives of compensation consultants and CEO pay. *Journal of Accounting and Economics* 49: 263–280.

Carpenter, M., and W. M. Sanders. 2002. Top management team compensation: The missing link between CEO pay and firm performance. *Strategic Management Journal* 23: 367–375.

Carpenter, M., and W. M. Sanders. 2004. The effects of top management team pay and firm internationalization on MNC performance. *Journal of Management* 30 (4): 509–528.

Che, Y., and S. Yoo. 2001. Optimal incentives for teams. *American Economic Review* 91: 525–540.

Conyon, M., S. Peck, and G. Sadler. 2009. Compensation consultants and executive pay: Evidence from the United States and the United Kingdom. *The Academy of Management Perspectives* 23 (1): 43–55.

Core, J., and W. Guay. 1999. The use of equity grants to manage optimal equity incentive levels. *Journal of Accounting and Economics* 28: 151–184.

Core, J., and W. Guay. 2002. Estimating the value of employee stock option portfolios and their sensitivities to price and volatility. *Journal of Accounting Research* 40 (3): 613–630.

Core, J., W. Guay, and D. Larcker. 2003. Executive equity compensation and incentives: A survey. *Economic Policy Review* (Apr): 27–50.

Demsetz, H. 1983. The structure of ownership and the theory of the firm. *Journal of Law and Economics* 26: 375–390.

Demsetz, H., and K. Lehn. 1985. The structure of corporate ownership: Causes and consequences. *Journal of Political Economy*: 1155–1177.

Devers, C., A. Cannella, G. Reilly, and M. Yoder. 2007. Executive compensation: A multidisciplinary review of recent development. *Journal of Management* 33: 1016–1072.

Edmans, A., X. Gabaix, and A. Landier. 2009. A multiplicative model of optimal CEO incentives in market equilibrium. *Review of Financial Studies* 22 (12): 4881–4917.

Edmans, A., I. Goldstein, and J. Zhu. 2013. *Contracting with Synergies*. Working paper, University of Pennsylvania, Wharton School of Business.

Eriksson, T. 1999. Executive compensation and tournament theory: Empirical tests on Danish data. *Journal of Labor Economics* 17 (2): 262–280.

Fahlenbrach, R., and R. Stulz. 2009. Managerial ownership dynamics and firm value. *Journal of Financial Economics* 92: 342–361.

Flannery, M., and K. Rangan. 2006. Partial adjustment toward target capital structures. *Journal of Financial Economics* 79: 469–506.

Frydman, C., and D. Jenter. 2010. CEO compensation. *Annual Review of Financial Economics* (2): 75–102.

Gibbons, R., and K. Murphy. 1992. Optimal incentive contracts in the presence of career concerns: Theory and evidence. *Journal of Political Economy* 100: 468–505.

Guthrie, K., J. Sokolowsky, and K. Wan. 2012. CEO compensation and board structure revisited. *Journal of Finance* 67 (3): 1149–1168.

Henderson, A., and J. Fredrickson. 2001. Top management team coordination needs and the CEO pay gap: A competitive test of economic and behavioral views. *Academy of Management Journal* 44 (1): 96–117.

Himmelberg, C., R. Hubbard, and D. Palia. 1999. Understanding the determinants of managerial ownership and performance. *Journal of Financial Economics* 53: 333–384.

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

Holmstrom, B. 1982. Moral hazard in teams. *Bell Journal of Economics* (Autumn): 324–340.

Hsiao, C. 2003. *Analysis of Panel Data*. Boston, MA: Cambridge University Press.

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

Kale, J., E. Reis, and A. Venkateswaran. 2009. Rank-order tournaments and incentive alignment: The effect on firm performance. *Journal of Finance* 64: 1479–1512.

Kini, O., and R. Williams. 2012. Tournament incentives, firm risk, and corporate policies. *Journal of Financial Economics* 103: 350–376.

Lazear, E., and S. Rosen. 1981. Rank-order tournaments as optimum labor contracts. *Journal of Political Economy* 89: 841–864.

Lee, K., B. Lev, and G. Yeo. 2008. Executive pay dispersion, corporate governance, and firm performance. *Review of Quantitative Finance and Accounting* 30: 315–338.

Lemmon, M. L., M. R. Roberts, and J. F. Zender. 2008. Back to the beginning: Persistence and the cross-section of corporate capital structure. *Journal of Finance* LXIII (4): 1575–1608.

Li, F., M. Minnis, V. Nagar, and M. Rajan. 2014. Knowledge, compensation, and firm value: An empirical analysis of firm communication. *Journal of Accounting and Economics* 58 (1): 96–116.

Main, B., C. O'Reilly III, and J. Wade. 1993. Top executive pay: Tournament or teamwork. *Journal of Labor Economics* 11 (4): 606–628.

Murphy, K. 1985. Corporate performance and managerial remuneration: An empirical investigation. *Journal of Accounting and Economics* 7: 11–42.

Murphy, K. J. 1999. Executive compensation. In *Handbook of Labor Economics,* Vol. 3A, edited by O. Ashenfelter, and D. Card, 2485–2563. Amsterdam, The Netherlands: Elsevier Science.

Murphy, K. J. 2012. The politics of pay: A legislative history of executive compensation. In *Research Handbook on Executive Pay*, edited by J. Hill, and R. Thomas. Cheltenham, U.K.: Edward Elgar Publishers.

Murphy, K. J., and T. Sandino. 2010. Executive pay and "independent" compensation consultants. *Journal of Accounting and Economics* 49 (3): 247–262.

Parrino, R. 1997. CEO turnover and outside succession: A cross-sectional analysis. *Journal of Financial Economics* 46: 165–197.

Rasmusen, E. 1987. Moral hazard in risk-averse teams. *RAND Journal of Economics* 18 (3): 428–435.

Rosen, S. 1992. Contracts and the market for executives. In *Contract Economics*, edited by L. Werin, and H. Wijkander. Cambridge, MA: Blackwell.

Sanders, W. M., and M. Carpenter. 1998. Internationalization and firm governance: The roles of CEO compensation, top team composition, and board structure. *Academy of Management Journal* 41: 157–178.

Schoonhoven, C. B., and M. Jelinek. 1990. Dynamic tension in innovative, high-technology firms: Managing rapid technological change through organizational structure. In *Managing Complexity in High Technology Organizations*, edited by M. Van Glinow, and S. Albers Mohrman, 90–118. New York, NY: Oxford University Press.

Siegel, P., and D. Hambrick. 2005. Pay disparities within top management groups: Evidence of harmful effects on performance of high-technology firms. *Organization Science* 16 (3): 259–274.

APPENDIX A

Conceptualizing the Empirical Design within the Edmans et al. (2013) Framework

In this appendix, we sketch how our empirical design can be conceptualized within the Edmans et al. (2013; hereafter, Edmans) model framework. Edmans models a setting in which effort by a manager has not only a direct productive effect, but also may reduce the marginal cost of effort for one or more colleagues, and the effort of whose colleagues may reciprocally reduce the manager's marginal cost of effort. We focus on the case of two executives as this allows us to make our point in the simplest possible terms. We abstract only those results from Edmans necessary for our discussion. For a more complete treatment of the model and derivation of the results, the interested reader is referred to Edmans.

There are two executives whose effort choices impact the firms' output. Let p_i denote the effort choice of agent i, with cost of effort given by:

$$C^i(p_i) = \frac{1}{4}p_i^2(1 - h_{ji}p_j). \tag{A1}$$

Synergies are captured by the term $h_{ji} \geq 0$, which reflects the extent to which executive j's effort reduces executive i's cost of effort. As h_{ji} increases, effort by executive j has a greater effect in reducing the cost level and the marginal cost of executive i's effort. Letting $s = h_{12} + h_{21}$, Edmans shows that optimal effort is a nonlinear function of s, denoted $p_i(s)$, and that PPS for each executive is given by:

$$PPS_i = p_i(s)(1 - h_{ji}p_j) = p_i(s) - h_{ji}p_j(s)p_i(s). \tag{A2}$$

Note that synergies permeate optimal PPS in a complex, nonlinear fashion both through effort choice $p_i(s)$ and the interaction term $h_{ji}p_j(s)p_i(s)$. The interaction term is subtracted because the cost of effort of an executive is reduced by the effort of the other executive, which allows the principal to motivate a given level of effort with lower PPS. Edmans shows that $p_i(s)$ is increasing in s, where it collapses to $p_i(0)$ in the absence of synergies. Because an executive's PPS given no synergies would be $p_i(0)$, we refer to $p_i(0)$ as an executive's standalone incentives.

While Edmans does not derive a functional form for $p_i(s)$, we assume for purposes of this discussion that it is given by the additively separable structure $p_i(s) = p_i(0) + f_i(s)$, where $f_i(s)$ is an arbitrary, potentially nonlinear function of s that reflects the effect of synergies on optimal effort choices. With this assumption, PPS for each of the two executives can be written as:

$$\begin{aligned} &PPS_i = p_i(s) - h_{ji}p_j(s)p_i(s) \Rightarrow \\ &p_1(0) + f_1(s) - h_{21}p_2(s)p_1(s) \text{ and } p_2(0) + f_2(s) - h_{12}p_2(s)p_1(s). \end{aligned} \tag{A3}$$

Using A3, consider first the following OLS regression specification:

$$\begin{aligned} E[Performance] &= \beta_1 PPS_1 + \beta_2 PPS_2 \\ &= \beta_1[p_1(0) + f_1(s) - h_{21}p_2(s)p_1(s)] + \beta_2[p_2(0) + f_2(s) - h_{12}p_2(s)p_1(s)]. \end{aligned} \tag{A4}$$

Specification A4 is not conducive for directly examining the role of synergies as PPS_i embeds both the standalone incentives for an executive and the nonlinear effects of synergies incorporated into optimal incentives. However, given our objective of investigating the distinct role played by synergies in optimal incentive design, we conceptually want to separate the synergy component of PPS from the standalone component. Again using A3, we consider the following alternative specification:

$$E[Performance] = \beta^1_{alone}\, p_1(0) + \beta^2_{alone}\, p_2(0) + \beta_{synergies}[f_1(s) + f_2(s) - s * p_1(s)p_2(s)]. \tag{A5}$$

Specification A5 incorporates standalone effects as separate independent variables while extracting the synergy component from each PPS term and rolling them into a single synergy factor. A5 represents the conceptual framework underpinning our empirical design. An important feature of A5 is that the synergy effects are rolled into a single term.

An alternative to representing the nonlinear aspects of synergy in a single variable as in A5 would be to include separate nonlinear terms for each executive and each pairwise interaction between executives. In our empirical analyses we examine five top executives that together produce ten pairwise interaction terms and five squared terms. It is not clear how we could coherently interpret these 15 different coefficients. As discussed in the paper, we proxy for the synergy factor in A5 with the standard deviation of the individual PPS terms, or PPS dispersion, which is given by the formula:

$$\left[\left(\frac{n-1}{n}\right)\left(\sum_{i=1}^{n} PPS_i^2 - \sum_{i}\sum_{j\,>\,i} PPS_i * PPS_j\right)\right]^{\frac{1}{2}}. \tag{A6}$$

When $n = 5$, the standard deviation consists of five squared PPS terms, one for each individual executive, and each of the ten possible pairwise interactions. Putting it all together we operationalize the conceptual framework A5 as:

$$\begin{aligned} E[Performance] = \\ & \underbrace{\beta^1_{alone}\, p_1(0) + \beta^2_{alone}\, p_2(0)}_{\downarrow} \quad + \beta_{synergies}\underbrace{\left[f_1(s) + f_2(s) - s\left(p_1(s)p_2(s)\right)\right]}_{\downarrow} \\ & \approx \sum_{i=1}^{5} \beta^i_{alone}\, PPS_i \qquad + \beta_{synergies}\left[\left(\frac{n-1}{n}\right)\left(\sum_{i=1}^{n} PPS_i^2 - \sum_{i}\sum_{j>i} PPS_i * PPS_j\right)\right]^{\frac{1}{2}}. \end{aligned} \tag{A7}$$

The idea is that in an OLS regression PPS dispersion serves to pull out the nonlinear synergy effects of the overall team embedded in the distribution of PPS levels, while the individual PPS terms pick up the direct standalone effects of individual executives that are orthogonal to the synergy term.

APPENDIX B

Variable Definition and Measurement

Variable	Definition and Measurement
Tobin's Q	measured as ((Total asset − Book value of equity + Market value of equity)/Total asset).
ROA	the return on asset (Income before extraordinary items/Total asset).
PPS	based on Edmans et al. (2009) and computed as Core and Guay (1999) *PPS* scaled by total annual compensation.
STD_PPS	the standard deviation of PPS among the top five highest-paid executives.
POS_RD_PPS (*NEG_RD_PPS*)	positive (or negative) *STD_PPS* residual based on *STD_PPS* determinant regression.
Range_PPS	alternative measure for PPS dispersion, computed as difference between the largest and the smallest PPS in a team for each firm-year.
POS_RRange_PPS (*NEG_RRange_PPS*)	positive (or negative) *Range_PPS* residual based on *Range_PPS* determinant regression.
$Corr(PPS_{t-1}, Grant_t)$	correlation between the vector of current grant PPS and the vector of lagged PPS level for each firm-year.
CEO PPS	PPS of CEO.
CFO PPS	PPS of CFO.
Other PPS	the average PPS for the remaining three among the top five highest-paid executives other than CEO and CFO.
Pay Gap	the difference between the CEO's total annual compensation and the median of other four top executives' (VPs) total annual compensation.

(continued on next page)

APPENDIX B (continued)

Variable	Definition and Measurement
CEO Pay Slice	the ratio of CEO total compensation to the sum of all five top executives' total compensation (CEO included).
STD_VP_Pay	standard deviation among VPs' annual total compensation.
Team Length	the number of years the management team stays the same.
Geographic Segment Dispersion	computed as (1 − sum of (squared geographic segment sales/total firm sales)), based on Bushman et al. (2004); the larger the measure, the less concentrated the firm.
R&D to Capital	research and development expenditure divided by net fixed assets.
Industry Homogeneity	mean partial correlation between firm's returns and an equally weighted industry index, for all firms in the same two-digit SIC industry code, holding market return constant (see Parrino 1997), estimated based on 60 monthly returns prior to sample year.
Firm Size	log of sales.
Return Volatility	variance of 60 monthly returns preceding sample year.
Capital to Sales	net fixed assets divided by sales.
Leverage	book value of total debt divided by total assets.
Advertising to Capital	advertising expenditure divided by net fixed assets.
Dividend Yield	the dividends per share ex-date divided by close price for the fiscal year.
Return	the annual buy-and-hold return adjusted for two-digit SIC industry median.
Industry Fixed Effect	industry classification is based on Fama-French 48 industry groups.

Copyright of Accounting Review is the property of American Accounting Association and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.