# Risk and CEO Turnover

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**Abstract**

This paper investigates the role played by performance risk in impacting a board's ability to learn about a CEO's unknown talent and influencing their decision to fire or retain a CEO. We posit that idiosyncratic stock return volatility reflects information arrival about the impact of CEO talent on firm performance, enhancing the informativeness of performance with respect to CEO talent, while systematic volatility captures aspects of return variability beyond the CEO's control. We predict that these distinct aspects of volatility will have opposite effects on CEO turnover given their differential implications for the process of learning about CEO talent. We provide robust empirical evidence that the likelihood of CEO turnover is increasing in idiosyncratic risk and decreasing in systematic risk, *after controlling* for firm performance. We also predict and document that turnover-performance-sensitivity increases in idiosyncratic risk and decreases in systematic risk, consistent with the information content of performance with respect to learning about CEO's talent increasing in idiosyncratic risk and decreasing in systematic risk. This result stands in stark contrast to the extant executive compensation literature where higher performance risk from any source is generally expected to decrease pay-performance-sensitivity due to risk aversion considerations. In our turnover setting, risk impacts the learning process, and can either increase or decrease turnover-performance-sensitivity depending on the underlying source of the volatility! Finally, we investigate relations between the threat of termination and CEO compensation, documenting that for retained CEOs, both subsequent pay-performance-sensitivity and pay *levels* decrease in the probability of turnover.

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# Risk and CEO Turnover


## Abstract

This paper investigates the role played by performance risk in impacting a board's ability to learn about a CEO's unknown talent and influencing their decision to fire or retain a CEO. We posit that idiosyncratic stock return volatility reflects information arrival about the impact of CEO talent on firm performance, enhancing the informativeness of performance with respect to CEO talent, while systematic volatility captures aspects of return variability beyond the CEO's control. We predict that these distinct aspects of volatility will have opposite effects on CEO turnover given their differential implications for the process of learning about CEO talent. We provide robust empirical evidence that the likelihood of CEO turnover is increasing in idiosyncratic risk and decreasing in systematic risk, *after controlling* for firm performance. We also predict and document that turnover-performance-sensitivity increases in idiosyncratic risk and decreases in systematic risk, consistent with the information content of performance with respect to learning about CEO's talent increasing in idiosyncratic risk and decreasing in systematic risk. This result stands in stark contrast to the extant executive compensation literature where higher performance risk from any source is generally expected to decrease pay-performance-sensitivity due to risk aversion considerations. In our turnover setting, risk impacts the learning process, and can either increase or decrease turnover-performance-sensitivity depending on the underlying source of the volatility! Finally, we investigate relations between the threat of termination and CEO compensation, documenting that for retained CEOs, both subsequent pay-performance-sensitivity and pay *levels* decrease in the probability of turnover.

## 1. Introduction

A key aspect of corporate governance is embodied in the decision rights granted to a firm's board of directors to hire, compensate, and fire the chief executive officers (CEO). These decision rights are manifested in comprehensive incentive schemes that include both a formal compensation contract and an option, exercisable at a board's discretion, to fire and replace incumbent CEOs. There is a vast literature that examines the design of executive compensation contracts, including a number of papers focusing in particular on the important role that firm performance risk plays in optimal contract design via the pay-performance-sensitivity aspect of CEOs' compensation contracts.[1] While there also exists a significant empirical research stream that investigates relations between CEO turnover and realized firm performance, little attention has been directed towards isolating key channels through which firm performance risk can directly impact CEO turnover decisions.[2] In this paper, we extend the extant literature by establishing fundamental connections between firm performance risk and CEO turnover.[3]

The central focus of our analysis is on the role played by performance risk in impacting a board's ability to learn about a CEO's unknown talent. This focus on interactions between performance risk and learning processes of boards introduces a very different perspective on risk from that typical in the executive compensation literature. The archetypical compensation setting is concerned with designing optimal incentives for executives to take actions that benefit shareholders. In this setting, performance risk represents noise with respect to observing an executive's actions,

[1] Key empirical papers on the relations between pay-performance-sensitivity (PPS) and performance measure risk include Jin (2002) and Aggarwal and Samwick (1999), among many others. Useful reviews of the executive compensation literature are Murphy (2000), Bushman and Smith (2001), and Core, Guay and Larcker (2003).
[2] Major extant results include: CEO turnover is inversely related to firm performance (Coughlan and Schmidt, 1985; Warner, Watts and Wruck, 1988; Barro and Barro, 1990; Kaplan, 1994a,b; Brickley and Van Horn, 2002); sensitivity of turnover to performance increases with the fraction of outsiders on the board (Weisbach, 1988), industry homogeneity in product market (Parrino, 1997) and product market competition (DeFond and Park, 1999); and CEO turnover varies with the business cycle (Eisfeldt and Rampini, 2008). Engel, Hayes and Wang (2003) study the properties of accounting information and CEO turnover, while Farrell and Whidbee (2003) examine performance expectations and CEO turnover. Brickley (2003) offers a useful perspective on the literature.
[3] The terms risk, variability, and volatility are used interchangeably throughout this paper.

and risk-averse executives must be paid a risk premium for bearing performance risk, regardless of the source of the risk. In contrast to the role of firm performance in the provision of incentives, CEO turnover decisions instead utilize firm performance to learn about a CEO's unobservable talent. A key element in a board of director's decision to retain or dismiss an incumbent CEO is the board's assessment of the CEO's talent relative to the assessed talent of potential replacement CEOs. This learning perspective shifts the focus from the impact of performance risk on the risk premium demanded by risk-averse executives, to the role played by performance risk in facilitating or impeding a board's ability to learn about CEO talent from realized performance.[4]

The fundamental insight of our paper is that the impact of performance risk on the ability of boards to learn about CEO talent from firm performance depends crucially on the underlying sources of the risk. The idea is that if volatility in performance outcomes is driven primarily by unobservable CEO talent, firm performance will be diagnostic about such talent, allowing boards to accurately assess CEO talent and to replace low talent incumbents. On the other hand, if volatility in performance outcomes is driven by factors unrelated to CEO talent (e.g., noise, economy-wide effects, etc.), then a board's ability to infer CEO talent from performance is more limited, making it difficult to cleanly distinguish an incumbent's talent level from the assessed talent of potential replacement CEOs.

To isolate these two fundamental economic forces, we first analyze a simple, two-period model with symmetric learning about unknown CEO talent. We derive the optimal firing rule as a function of two sources of risk: risk deriving from uncertainty about a CEO's unobservable talent level, and risk deriving from sources outside the CEO's control. The model produces three

[4] We are not arguing here that the compensation contract is independent of the board's firing option. In fact, as discussed further below, we show in our model of section 2 and in the empirical analyses of section 6, that the firing option does indeed impact the compensation contract both by necessitating that the CEO be compensated for bearing the risk of being fired (see also Hermalin and Weisbach (2008) on this point) and by creating implicit incentives for CEOs to work hard in order to avoid being fired. What we are arguing is that because the board cannot commit not to fire the CEO after observing firm performance, the role of performance risk in CEO turnover can be studied independently of any risk premium due to firing risk or implicit incentives as these will not be factored into the turnover decision.

empirical implications concerning the relation between performance risk and CEO turnover. First, the probability of CEO turnover is increasing in the variance of the distribution over CEO talent. When uncertainty over CEO talent increases relative to other sources of variability, firm performance becomes relatively more diagnostic about CEO talent, increasing the board's ability to detect low talent incumbents and exercise their firing option when warranted. Second, the probability of CEO turnover is decreasing in volatility unrelated to talent and beyond the CEO's control. Such volatility represents noise from the perspective of learning about a CEO's talent from observed performance. More noise increases the difficulty of distinguishing the talent of incumbents from those of potential rookie CEOs, increasing the board's reluctance to incur the costs of exercising their firing option. Finally, the third implication is that the sensitivity of CEO turnover to observed performance is increasing in the variance of the distribution of CEO talent and decreasing in volatility unrelated to talent.

Turning to our empirical analysis, we use stock returns as our empirical measure of firm performance and decompose return volatility into its idiosyncratic and systematic components. We posit that idiosyncratic volatility reflects information arrival related to the impact of CEO talent on firm performance, while systematic volatility captures aspects of return variability unrelated to CEO talent and beyond the CEO's control. We predict that these distinct aspects of volatility will have opposite effects on CEO turnover given their differential implications for the process of learning about CEO talent. Consistent with this prediction, we provide robust empirical evidence that the likelihood of CEO turnover is increasing in idiosyncratic risk and decreasing in systematic risk, *after controlling* for firm performance.

We also predict and document that turnover-performance-sensitivity increases in idiosyncratic risk and decreases in systematic risk, consistent with the information content of performance with respect to learning about CEO's talent increasing in idiosyncratic risk and decreasing in systematic risk.[5] This result stands in stark contrast to the extant executive compensation literature where higher performance risk from any source is generally expected to decrease pay-performance-sensitivity due to risk aversion considerations. In our turnover setting, risk impacts the learning process, and can either increase or decrease turnover-performance-sensitivity depending on the underlying source of the volatility!

It is instructive to contrast our analysis of risk and CEO turnover to Jin's (2002) analysis of risk and CEO pay-performance-sensitivity. Analogous to our study, Jin (2002) also decomposes the volatility of stock returns into idiosyncratic and systematic components. Using data on executive compensation contracts, he documents that idiosyncratic risk is *negatively* related to pay-performance-sensitivity, but finds little relation between systematic risk and incentive level. These results are consistent with Jin's (2002) model where all (unhedged) sources of performance volatility represent risk that the CEO must be compensated for bearing, resulting in the classic trade-off between CEO incentives and the cost of CEOs' bearing risk.[6] In contrast, in our setting higher volatility driven by factors related to CEO talent (i.e., idiosyncratic risk) makes firm performance more diagnostic about talent, where volatility unrelated to CEO talent (i.e., systematic risk) is noise from a learning perspective. Thus, our paper complements Jin (2002) by exploring the impact of performance volatility in a different, but interrelated context, revealing distinct channels through which performance risk impacts contracting relations between boards and CEOs. .

In section 6, we complete our empirical analysis by exploring interrelations between the firing option and CEO compensation. First, we document that for retained CEOs, pay-performance-sensitivity is decreasing in the probability of turnover. This is consistent with the insight from our

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[5] By turnover-performance-sensitivity, we are referring to the relation of turnover to *firm-specific* returns. We do not examine the determinants of the relation of turnover to the systematic component of stock returns. We discuss this further below.

[6] A central point in Jin (2002) is that CEOs may be able to hedge the systematic aspects of performance risk, obviating the need to pay a risk premium for this aspect of risk.

model that when the probability of turnover is high, the CEO faces high-powered implicit incentives and so requires less explicit incentives.[7] We also document that for CEOs who are retained, subsequent pay *levels* are a decreasing function of the probability of turnover, consistent with Gao, Harford and Li (2008), who show that pay cuts can be a short-term substitute for dismissal. They find that after a pay cut, a CEO with continued poor performance is just as likely to be fired as a CEO with similar performance whose pay was not cut.

Finally, it is important to relate our paper with Jenter and Kanaan (2008) and Kaplan and Minton (2006), who document that the systematic component of returns significantly influences the likelihood of CEO turnover, contrary to the received theory of relative performance evaluation.[8] In contrast, we investigate how both idiosyncratic and systematic return *volatility* impacts CEO turnover. We do incorporate the Jenter and Kanaan (2008) and Kaplan and Minton (2006) results in our empirical analyses by including the systematic component of returns in our analyses to mitigate potential model misspecification (and indeed replicate their results). However, we are not aware of any theory connecting systematic return volatility to violations of relative performance evaluation. It is important to stress that our analysis only requires that systematic return volatility impede ability to learn about talent from performance, and we provide evidence consistent with this story, including that the likelihood of turnover is decreasing in systematic risk, *after controlling* for idiosyncratic and systematic returns.

The paper is organized as follows. In section 2, we analyze a two-period model and develop empirical implications. Section 3 describes the data underlying our empirical analyses and provides descriptive statistics. Section 4 presents our empirical analyses about the relations between CEO turnover and distinct components of risk, while section 5 presents our results on the relation

[7] This idea is closely related to the career concerns results of Gibbons and Murphy (1992) and Holmström (1999).
[8] In the theory of relative performance evaluation (e.g., Holmström, 1982 and Gibbons and Murphy, 1992), aspects of performance that are not influenced by the CEO should be filtered out in optimal contract design.

between turnover-performance-sensitivity and risk. Section 6 examines the implications of CEO turnover decisions for CEO compensation contracts and Section 7 summarizes and concludes.

## 2. The Model and Empirical Implications

### 2.1 Basic Assumptions and Model Setup

CEOs are endowed with a given level of talent. The CEO and the firm have common knowledge about the distribution over CEO talent, but neither party knows the actual level of CEO talent (i.e., it is a symmetric learning process).[9] CEOs are *ex ante* identical, with all market participants holding identical prior beliefs over talent. The firm operates for two periods, t = 1, 2. A contract is signed between the firm and the CEO at the beginning of period one. The firm updates beliefs about the incumbent CEO's talent at the end of the first period based on the observable, period one performance, and decides whether to fire or retain the CEO at that point.

Following Gibbons and Murphy (1992), we assume that two-period contracts are not feasible, and that one-period contracts are linear in observable output. The per-period production technology is given by:

$$y_t = \theta_t + e_t + \varepsilon_t \qquad t = 1,2 \tag{1}$$

where $y_t$ is period *t* output, $\theta_t$ represents unknown CEO talent, $e_t$ represents CEO effort, and $\varepsilon_t$ is a normally distributed random shock with mean zero and variance $\sigma^2$ for $t = 1,2$ .We assume that $\theta_t$ is independent of $\varepsilon_t$. The prior distribution over talent is normal, with mean $\theta_0$ and variance $\sigma_0^2$.[10] Per-period CEO compensation is given as:

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[9] This assumption is also made in Gibbons and Murphy (1992), Holmstrom (1999) and Hermalin and Weisbach (2008), among others.

[10] True CEO talent, $\theta$, is assumed fixed in the model. However, as noted also in Hermalin and Weisbach (2008), one concern is that CEO's ability would be quickly revealed in repeated version of the model. Holmstrom (1999) however, shows that rapid learning can be eliminated by allowing $\theta$ to follow a random walk across periods.

$$w_t = a_t + b_t y_t, \qquad t = 1,2 \tag{2}$$

where $w_t$ is the CEO's compensation for period *t*, and $a_t$ and $b_t$ are compensation parameters.

We assume that the CEO is risk-averse and the firm is risk-neutral. Further, we assume that the period utility function for the CEO is mean-variance with $\gamma$ as a risk-aversion parameter for tractability.[11] Without loss of generality, we also assume that there is no discounting for either the CEO or the firm. Assuming no borrowing or lending, the CEO derives his period utility only from current period compensation.[12] If the incumbent CEO is fired at the end of period one, he receives severance pay, *S*, and exits the labor market. In this case, the firm then hires a rookie CEO with talent drawn from a normal distribution with mean $\theta_0$ and variance $\sigma_0^2$.

Figure 1 illustrates the time line. At the beginning of period one the firm signs a compensation contract with a CEO. The CEO exerts effort and period one output is realized. The firm pays the CEO, updates its belief about talent, and decides whether or not to fire the CEO (the decision is denoted as *F*). In period two, the firm works either with the incumbent (*F=0*), or with a newly hired CEO (*F=1*). The CEO exerts effort for period two, output is realized, the CEO is paid, and the firm is dissolved.

### 2.2 The Optimal Firing Rule

Using backward induction, we first derive the optimal contract for period two. At the beginning of period two, the firm employs either a rookie or an incumbent CEO. If the incumbent is fired in period one (*F=1*), the firm has a simple one-period problem with no learning possibilities with respect to the new CEO's talent. Thus, the firm solves:

$$\max_{a_2, b_2, e_2} : E[y_2 - w_2]$$

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[11] The standard CARA utility function is problematic here due to possible discontinuity at the end of period one.
[12] This is in contrast to the LEN framework many researchers use in the dynamic setup. Under LEN, only aggregate compensation matters, while per-period compensation does not. The LEN framework is equivalent to the assumption that the CEO has perfect access to the capital market for borrowing and lending.

*s.t.* $$e_2 = \arg\max\{E[w_2] - \frac{1}{2}\gamma Var(w_2) - \frac{1}{2}e_2^2\} \quad (3)$$

$$E[w_2] - \frac{1}{2}\gamma Var(w_2) - \frac{1}{2}e_2^2 \geq \bar{u}, \quad (4)$$

where the period effort cost function is $c(e_t) = \frac{1}{2}e_t^2$ and $\bar{u}$ is period reservation utility. Using standard solution techniques, the optimal solution to the above program is given by:

$$e_2^*(F=1) = \frac{1}{1+\gamma(\sigma_0^2+\sigma^2)} \quad (5)$$

$$b_2^*(F=1) = \frac{1}{1+\gamma(\sigma_0^2+\sigma^2)} \quad (6)$$

$$a_2^*(F=1) = \bar{u} + \frac{1}{2}[\gamma(\sigma_0^2+\sigma^2)-1][\frac{1}{1+\gamma(\sigma_0^2+\sigma^2)}]^2 - \frac{\theta_0}{1+\gamma(\sigma_0^2+\sigma^2)}. \quad (7)$$

These are standard results from a single-period principal-agent model.[13]

On the other hand, when the incumbent CEO is retained (*F*=0), the firm incorporates learning about CEO talent from period one output, and solves the problem:

$$\max_{a_2, b_2 e_2} : E[y_2 - w_2 \mid y_1]$$

*s.t.* $$e_2 = \arg\max\{E[w_2 \mid y_1] - \frac{1}{2}\gamma Var(w_2 \mid y_1) - \frac{1}{2}e_2^2\} \quad (8)$$

$$E[w_2 \mid y_1] - \frac{1}{2}\gamma Var(w_2 \mid y_1) - \frac{1}{2}e_2^2 \geq \bar{u}. \quad (9)$$

[13] Optimal effort equates with the optimal incentive parameter ($e_2 = b_2$), and the base salary ($a_2$) is set such that the participation constraint (4) holds with equality. The incentive parameter, $b_2^*(F=1)$, is decreasing in the output variance $\sigma^2$, the variance over talent $\sigma_0^2$, and risk aversion parameter $\gamma$. This simply reflects the optimal trade-off between incentives and risk.

Note that $\bar{u}$, the period two reservation utility, is assumed to be identical for both the incumbent and the rookie CEO, despite the fact that the incumbent's assessed talent would be updated based on observing $y_1$. We want to emphasize that this assumption is made strictly for tractability purposes. A CEO's outside opportunity wage would almost surely adjust up or down on the arrival of new information about general managerial talent that is transferable across companies, but may not adjust to information about firm-specific talent that is valuable only within the organization.[14] To create scope for firing, it is necessary that the reservation wage not decrease so much in response to poor performance that the principal is always indifferent to talent because revised pay levels could completely offset any talent differentials.[15] Rather than complicate the model with issues of general versus specific talent, or other potential frictions in the adjustment of outside opportunity wages, we make the simplifying assumption that reservation wage is downward rigid. The assumption of no upward adjustment is not crucial. While addressing this in the model is beyond the scope of this paper, we think this is an important issue that needs to be at least addressed from an empirical standpoint. In section 6 of the paper, we empirically explore the possibility that the board could lower a CEO's pay following poor performance rather than firing him.

Returning again to the analysis of the period 2 contract with the incumbent CEO still in place, the CEO and the firm update priors over ability after $y_1$ is realized (i.e., symmetric learning). The updated mean and variance from the firm's perspective are:

$$\theta_1 \equiv E[\theta \mid y_1] = \frac{\sigma^2 \theta_0 + \sigma_0^2 (y_1 - \hat{e}_1)}{\sigma_0^2 + \sigma^2} \qquad (10)$$

[14]Murphy and Zabojink (2007) argue that there has been a recent increase in the importance of "managerial ability" (CEO skills transferable across companies) relative to "firm-specific human capital" (valuable only within the organization). Of course the relative importance of general versus firm-specific aspects is also likely to vary significantly in the cross-section.

[15] To clearly understand our downward rigidity assumption, contrast it with the assumption made in Gibbons and Murphy (1992) and Holmstrom (1999). These papers assume that the manager receives the entire surplus while the principal earns zero profits. In this case, the principal is indifferent to updated talent assessments and has no incentive to fire the manager. Downward rigidity creates a wedge where under some circumstances the pay necessary to retain a manager after poor period one performance is too high relative to his assessed talent level, and so firing results.

$$\sigma_1^2 \equiv Var(\theta \mid y_1) = \frac{\sigma^2 \sigma_0^2}{\sigma_0^2 + \sigma^2}, \tag{11}$$

where $\hat{e}_1$ is the firm's conjecture about CEO's first period effort.[16] Solving the principal's period two problem for an incumbent CEO, we get:

$$e_2^*(F=0) = \frac{1}{1+\gamma(\sigma_1^2 + \sigma^2)} \tag{12}$$

$$b_2^*(F=0) = \frac{1}{1+\gamma(\sigma_1^2 + \sigma^2)} \tag{13}$$

$$a_2^*(F=0) = \bar{u} + \frac{1}{2}[\gamma(\sigma_1^2 + \sigma^2) - 1][\frac{1}{1+\gamma(\sigma_1^2 + \sigma^2)}]^2 - \frac{\theta_1}{1+\gamma(\sigma_1^2 + \sigma^2)}. \tag{14}$$

Given the optimal period two contracts for an incumbent or rookie CEO, we solve for the cutoff that triggers the firing option. First, we substitute the optimal solutions for the rookie from equations (5), (6), and (7) into the principal's objective function yielding expected period two profit given a rookie CEO of

$$\pi(F=1) = \theta_0 + \frac{1}{2}[\frac{1}{1+\gamma(\sigma_0^2 + \sigma^2)}] - \bar{u} - S. \tag{15}$$

We assume that $S$ is smaller than $\bar{u}$.[17] Similarly, using equations (12), (13), and (14), the expected period two profit when the incumbent CEO is retained is given by:

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[16] Since the CEO knows his effort level, he uses the true $e_1$ to update. The firm, on the other hand, has to conjecture effort. In equilibrium, the conjectured effort will equal the true effort level. For the CEO's perspective, just replace $\hat{e}_1$ with $e_1$.

[17] We also need to assume that $\theta_0$ is sufficiently large that $\pi(F=1)$ is positive. Otherwise, the firm will shut down. Also, while we call $S$ severance, it is important to note that there would likely be other costs associated with CEO turnover. These include the costs of finding a new CEO, costs due to disruption of business, etc. (see e.g., Hermalin, 2005). For purposes of drawing empirical implications for the current study, it is not important to distinguish between these costs. It would matter however in deriving period one compensation contracts, as severance payments go directly to a fired CEO, while the other costs are born by the principal directly. That the firing threshold is adjusted for direct costs of firing the CEO has been noted in previous studies. See, for example, Hirshleifer and Thakor (1998), Hermalin and Weisbach (1998, 2008), Warther (1998), Adams and Ferreira (2007), and Hermalin (2005).

$$\pi(F=0)=\theta_1+\frac{1}{2}[\frac{1}{1+\gamma(\sigma_1^2+\sigma^2)}]-\bar{u}\,. \tag{16}$$

The updated talent assessment that triggers firing, $\theta_1^*$, is derived by equating expected period two profits across the two scenarios. Equating (15) and (16) and solving yield the optimal cutoff point, $\theta_1^*=\theta_0-x$, where

$$x=S+\frac{1}{2}[\frac{1}{1+\gamma(\sigma_1^2+\sigma^2)}-\frac{1}{1+\gamma(\sigma_0^2+\sigma^2)}]>0\,. \tag{17}$$

That is, the optimal firing rule can be stated as:

$$F=\begin{cases}1 & \textit{if } \theta_1<\theta_1^* \\ 0 & \textit{otherwise}\end{cases}$$

This leads to proposition one.[18]

**Proposition 1** *There exists a unique cutoff point ($\theta_1^*$) for a CEO's assessed talent at the end of period one such that if $\theta_1 \geq \theta_1^*$, the CEO is retained. Otherwise, he is fired. $\theta_1^*$ is defined as in equation (17).*

***Proof***: It is straightforward to show the intersection between the two profit lines is unique.

From the expression for *x* in equation (17), we see that it is costly to fire the incumbent CEO due to severance pay, *S*, so the cutoff decreases in *S*. The cutoff is also affected by the posterior variance of incumbent CEO talent ($\sigma_1^2$) relative to the variance of a potential rookie's talent ($\sigma_0^2$). In essence, learning lowers the posterior variance over talent for an incumbent relative to an outside rookie. This mitigates a source of risk in the performance measure, allowing the principal to increase incentive intensity in period two for the incumbent due to the reduced demands on the risk premium needed to compensate the manager for risk. Thus, the term *x* in expression (17) is the cost

[18] If the reservation wage of the incumbent in period two were allowed to vary with posterior assessed talent, the cutoff would be given by $\theta_1^*+u(\theta_1)-u(\theta_0)$, where $u(\theta_i)$ is the reservation utility given $\theta_i$. Note that without our assumption of downward rigidity, $u(\theta_1)$ could be small enough to preclude firing.

of firing an incumbent CEO, consisting of the severance payment and the higher risk premium that must be paid to a replacement CEO relative to the incumbent due to higher uncertainty about the replacement's talent (i.e., $\sigma_0^2 > \sigma_1^2$).[19]

We next develop intuition of the model further, and derive the empirical implications of the model for the relation between CEO turnover and risk.

**2.3 Empirical Implications of the Model for Relations between Turnover and Risk**

We derive three empirical implications in this section. The key construct underlying these implications is the *ex ante* probability of firing the CEO. This can be written using the optimal cutoff point derived above (equation 17) as:

$$\Pr(F=1) = \Pr(\theta_1 < \theta_1^*) = \Phi[\frac{\theta_1^* - \theta_0}{\sigma_{\theta_1}}] = \Phi[-x\frac{\sqrt{\sigma_0^2 + \sigma^2}}{\sigma_0^2}],$$

where $\sigma_{\theta_1}$ is the standard deviation of posterior mean talent, $\theta_1$, and $\Phi(\cdot)$ is the cumulative distribution function for the standard normal distribution.

To understand the intuition underpinning the model's empirical implications, recall that the posterior distribution over talent given $y_1$ is characterized by

$$\theta_1 \equiv E[\theta \mid y_1] = \frac{\sigma^2\theta_0 + \sigma_0^2(y_1 - \hat{e}_1)}{\sigma_0^2 + \sigma^2} = \frac{\theta_0 + \frac{\sigma_0^2}{\sigma^2}(y_1 - \hat{e}_1)}{\frac{\sigma_0^2}{\sigma^2} + 1}, \qquad (10)$$

[19] To see this, suppose that updated ability, $\theta_1$, were equal to that of a potential rookie, $\theta_0$. Now, if the firm fires the CEO, it would hire a new CEO with the same expected talent, but with a variance over talent ($\sigma_0^2$) larger than that for the incumbent CEO ($\sigma_1^2$). This would increase the risk premium necessary to compensate the CEO for bearing risk without increasing the expected payoff to talent. This risk premium, while subtle and interesting, is likely to be a second order effect relative to severance and the posterior volatility over the incumbents talent ($\sigma_{\theta_1}$), so we do not emphasize it in what follows.

$$\sigma_1^2 \equiv Var(\theta \mid y_1) = \frac{\sigma^2 \sigma_0^2}{\sigma_0^2 + \sigma^2}. \tag{11}$$

From (10), we see that as $\sigma_0 / \sigma$, the ratio of talent risk relative to production risk (signal to noise ratio), gets small, the posterior assessment of talent, $\theta_1$, becomes insensitive to performance, implying that the board learns little about the CEO's talent from realized performance. In this case, the posterior is close to the prior, $\theta_0$ (the opportunity talent level of a rookie), and the firing probability is low.[20] However, when the posterior is sensitive to the performance signal, a negative signal causes the posterior to be low, potentially triggering a firing event. In the next proposition, we establish sufficient conditions for $\frac{\partial \Phi[\cdot]}{\partial \sigma_0^2}$>0 and $\frac{\partial \Phi[\cdot]}{\partial \sigma^2}$<0.

**Proposition 2**

(i). *There exists a function* $K(\sigma_0^2, \sigma^2, \gamma)$ *(defined in the Appendix) such that, if* $S > K(\sigma_0^2, \sigma^2, \gamma)$, *then* $\frac{\partial \Phi[\cdot]}{\partial \sigma_0^2}$ *>0.*

(ii) *There exists a function* $G(\sigma_0^2, \sigma^2, \gamma)$ *(defined in the appendix) such that, if* $S > G(\sigma_0^2, \sigma^2, \gamma)$, *then* $\frac{\partial \Phi[\cdot]}{\partial \sigma^2}$ *<0. It is the case that* $\frac{\partial G}{\partial \sigma^2}$ *<0, where the* $\lim_{\sigma^2 \to \infty} G = 0$ *and* $\lim_{\sigma^2 \to 0} G = \frac{\gamma \sigma_0^2 (1 + 7\gamma \sigma_0^2 + 4\gamma^2 \sigma_0^4)}{2(1 + \gamma^2 \sigma_0^2)^2}$. *It is the case that* $G(\sigma_0^2, \sigma^2, \gamma) \geq K(\sigma_0^2, \sigma^2, \gamma)$ *for all values of* $\sigma^2{}_0$, $\sigma^2$ *and* $\gamma$, *implying that if the conditions of this proposition are met,* $S > K(\sigma_0^2, \sigma^2, \gamma)$ *and so proposition 2 also holds.*

***Proof:*** See Appendix.

[20] In the limit, if the cost of firing *S*>0, the firm would not pay *S* to buy a rookie with the same talent distribution as the incumbent, implying that the probability of firing is 0. However, if *S*=0, firing the manager is free, and since the talent distribution is identical for incumbent and rookie, the firm is indifferent between retaining implying a firing probability of one half (i.e., a coin toss).

This leads to the following two empirical implications.

***Empirical Implication 1***: *The probability of CEO turnover is increasing in the variance over CEO talent, holding firm performance and variance unrelated to CEO talent constant.*

***Empirical Implication 2***: *The probability of CEO turnover is decreasing in the variance unrelated to CEO talent, holding firm performance and variance over CEO talent constant.*

Next, we consider how the sensitivity of turnover to observed performance is influenced by both $\sigma_0^2$ and $\sigma^2$. In our simple two period model, the firing cutoff value, $\theta_1^*$, does not depend on the realization of the signal, but only on the variance-covariance matrix. The realization of performance only determines whether the board's posterior assessment of talent is above or below the pre-determined cutoff. Thus, the derivatives $\frac{\partial \Phi[\cdot]}{\partial y_1}$, $\frac{\partial^2 \Phi[\cdot]}{\partial y_1 \partial \sigma_0}$, and $\frac{\partial^2 \Phi[\cdot]}{\partial y_1 \partial \sigma}$ do not have any content. However, the probability of turnover is increasing in $\sigma_0^2$ implying that the performance threshold for firing moves closer to the mean of performance in standard deviation terms as $\sigma_0^2$ increases, increasing the range of outcomes over which turnover occurs. On the other hand, CEO turnover is less responsive to performance when $\sigma^2$ is higher, moving the threshold further below the mean in standard deviations terms, decreasing the range of outcomes over which turnover will occur. Figure 2 illustrates the intuition, leading to the third empirical implication of the model.

***Empirical Implication 3:*** *CEO turnover will be less sensitive to observed performance as $\sigma^2$ increases, and more sensitive to observed performance as $\sigma_0^2$ increases.*

It is informative to note that our model can be intuitively interpreted from the perspective of real options. That is, the firm can view the possibility of firing of the CEO as an (abandonment) option where the strike price is given by the severance package (and the period two risk premium differential discussed in the previous section).[21] The option will be "in the money" when the

[21] We thank an anonymous referee for pointing this out.

underlying asset value, here the assessed talent of the incumbent CEO, is sufficiently low relative to that of a replacement. As is well known from option pricing theory, the value of this option is increasing in the volatility of the underlying assessed talent, $\sigma_{\theta_1}$. Intuitively, high volatility, $\sigma_{\theta_1}$, implies that the board's assessment of talent is very sensitive to the signal, which occurs when the signal is informative about the CEO's talent. The informativeness of the signal and the volatility of the underlying asset value are increasing in the idiosyncratic risk of talent of the incumbent CEO ($\sigma_0^2$, measured in our empirical tests by the idiosyncratic risk of the past firm performance), and decreasing in risk unrelated to CEO talent ($\sigma^2$, measured by the systematic risk of firm performance).[22] In essence, higher idiosyncratic risk increases the signal's informativeness and the volatility of assessed talent, thus increasing the probability of the CEO being fired and equivalently, the value of the firing option. Higher systematic risk does just the opposite.

In a related model, Hermalin and Weisbach (2008) focus on benefits and costs of changing the quality of performance measures in corporate governance settings, including CEO turnover decisions.[23] They show that by increasing the quality of the performance measure relative to assessed CEO talent, the value of the firing option to the principal increases. Hermalin and Weisbach (2008) are concerned with understanding the determinants of optimal performance measure quality. In contrast, we take the quality of the information system as fixed and exogenous, and focus on the determinants of the probability of firing. While the models share some commonalities, the objectives of the two papers differ significantly.

We examine empirical implications 1 and 2 in section 4, and implication 3 in section 5.

### 2.4 Empirical Implications for Relations between the Firing Option and CEO Compensation

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[22] This can be seen by observing that $\sigma_{\theta_1}^2 = 1/(\frac{1}{\sigma_0^2} + \frac{\sigma^2}{\sigma_0^4})$.

[23] Other models of turnover include Hirshleifer and Thakor (1998), Hermalin and Weisbach (1998), Warther (1998), Spear and Wang (2005), Adams and Ferreira (2007), Hermalin (2005), Eisfeldt and Rampini (2008), among others.

Finally, we consider the impact of the firing option on the first period wage contract. The following proposition characterizes the first period contract.

**Proposition 3**

*Optimal first period effort,* $e_1^*$*, and pay-performance-sensitivity,* $b_1^*$*, are characterized as follows:*

$$e_1^* = \frac{1}{1+\gamma(\sigma_0^2+\sigma^2)} + \frac{\phi(.)\gamma(\sigma_0^2+\sigma^2)}{[1+\gamma(\sigma_0^2+\sigma^2)]\sqrt{\sigma_0^2+\sigma^2}}\{(\overline{u_1}-S)+\frac{1}{2}\gamma(\overline{u_1}-S)^2[1-2\Phi(.)]\} \qquad (18)$$

$$b_1^* = \frac{1}{1+\gamma(\sigma_0^2+\sigma^2)} - \frac{\phi(.)}{[1+\gamma(\sigma_0^2+\sigma^2)]\sqrt{\sigma_0^2+\sigma^2}}\{(\overline{u_1}-S)+\frac{1}{2}\gamma(\overline{u_1}-S)^2[1-2\Phi(.)]\}, \qquad (19)$$

*Where* $\phi(\cdot)=\phi[-\frac{x\sqrt{\sigma_0^2+\sigma^2}}{\sigma_0^2}]$ *and* $\Phi(\cdot)=\Phi[-\frac{x\sqrt{\sigma_0^2+\sigma^2}}{\sigma_0^2}]<\frac{1}{2}$ *are, respectively, the density function and cumulative distribution function of the standard normal distribution.*

***Proof:*** See Appendix for a sketch of the proof.

Note that pay-performance-sensitivity, $b_1^*$, consists of two terms, where the second term depends on the firing option both through the function, $\phi(\cdot)$, and the CDF, $\Phi(\cdot)$. As $\Phi(\cdot) <$ ½, and taking $\overline{u_1} > S$, this second term will be non-negative (it will be zero if there is no probability of firing). That is, the existence of a non-trivial firing option results in a decrease in first period pay-performance-sensitivity relative to a setting without such an option. In essence, the firing option creates implicit incentives, analogous to career concerns (Gibbons and Murphy, 1992), allowing the principal to back off on explicit incentives. These implicit incentives are evident in the term for period one effort, $e_1^*$, where we see that the firing option increases effort through the second term in (18). This leads to our fourth empirical implication.

***Empirical Implication 4:*** The existence of a non-trivial firing option creates implicit incentives that serve to decrease period one pay-performance-sensitivity.

We investigate empirical implication 4 in section 6 below. We turn now to our empirical analysis.

## 3. CEO Turnover: Data and Descriptive Statistics

### 3.1 Data and Construction of the Forced Turnover Sample

Identifying whether a CEO turnover event is forced is not straightforward as involuntary turnovers are often presented as retirement. Classification thus requires hand-collection of data from multiple sources, in particular press releases. We follow the classification scheme devised by Parrino (1997) to classify turnovers into forced and routine.[24]

CEO turnovers are identified using the Standard & Poors ExecuComp database for the time period 1992 to 2005. We isolate a CEO turnover for each year in which the CEO identified in ExecuComp changes (2,281 events). We then search the *Factiva* news database for details about the turnover and classify each CEO turnover as forced or routine. All turnovers for which press articles report that the CEO is fired, demoted, or retires or resigns under questionable circumstances (e.g., policy differences, pressure, lawsuits or suspected earnings management), are classified as forced (500 events). We further investigate turnovers when the CEO retires at age below 60 and classify them as forced if the article does not report the reason as death, poor health, or the acceptance of another position (294 events). Finally, we exclude CEO turnovers due to death, interim, mergers or spin-offs from the analysis (238 events),[25] and we lose 220 turnover events due to missing financial data. Given our model implication, all our empirical analysis is based on forced CEO turnovers.

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[24] We have taken great care in classifying our turnover sample, but acknowledge the possibility that we have incorrectly classified some voluntary turnovers as forced. We have verified that our results are robust to alternative classification schemes, such as using the announcements only without reclassification of retirements, or using retirement age of 61 or 62. As argued in Hermalin and Weisbach (2003), voluntary turnovers are unlikely to be related to performance and so the difficulty in distinguishing the two types of turnovers simply adds noise to the *dependent* variable.

[25] We do not distinguish turnovers by whether the replacement CEO was hired from inside or outside the firm. Important papers examining the decision to hire an insider versus an outsider include Cremers and Grinstein (2008), Murphy and Zabojnik (2007), Parrino (1997) and Chan (1996), among others.

This process results in 794 forced turnovers, with the remaining 1,029 turnovers classified as routine turnovers. The control sample consists of firm-years in the ExecuComp where no turnovers occurred. Accordingly, we have the following 3 samples: a routine turnover sample (N=1,029), a forced turnover sample (N=794), and a control sample (N=15,965). Table 1 provides summary statistics for the 3 samples.

We merge this data set with firms' financial data from Compustat and CRSP.

### 3.2 Variable Definition and Measurement

We estimate empirical proxies for the model constructs talent risk ($\sigma_0$) and unrelated risk ($\sigma$) by decomposing total return volatility into its idiosyncratic and systematic return volatility components. We posit that information about CEO talent will be reflected in the firm-specific component of stock return performance, while the systematic component represents noise with respect to learning about CEO talent.[26]

Our proxy for talent risk ($\sigma_0$), denoted *Risk_ Idiosyncratic*, is constructed as the standard deviation of the idiosyncratic portion of stock returns after removing industry returns, while our proxy for production risk ($\sigma$), denoted *Risk_ Peer*, is the standard deviation of a firm's stock returns due to industry effects.[27] We use daily returns over the prior year to construct *Risk_ Peer* and *Risk_ Idiosyncratic*. Specifically, we run the following firm-specific regressions using daily stock returns:

$$r_{i,t-1} = \beta_0 + \beta_I r_{industry,t-1} + \varepsilon_{i,t-1},$$

[26] It is difficult to empirically separate variability in idiosyncratic performance specifically due to CEO talent from other stochastic variation unrelated to industry or market shocks. As result, our measure of idiosyncratic return volatility captures a mix of the effect of talent and other aspects of firm-specific performance, some of which may be outside the CEO's control. See also a related discussion in Jenter and Kanaan (2008).

[27] In our main analyses, we use industry returns as benchmark performance in our first stage regressions to decompose performance (risk) into the systematic component and the idiosyncratic component. Alternatively, we have also used the following two as peer groups: (1) both industry and market returns; (2) market returns only. We find qualitatively similar results as those presented in the paper.

where $r_{industry,t-1}$ is industry median daily returns. We run individual firm regressions using daily returns in fiscal year *t-1*, provided that there are at least 100 of the 256 daily returns available for each firm-year. The standard deviation of the predicted values from this regression, $\hat{\beta}_0 + \hat{\beta}_1 r_{industry,t-1}$, is our proxy for *Risk_ Peer*, and the standard deviation of the residual returns, $\hat{\varepsilon}_{i,t-1}$, is our proxy for *Risk_ Idiosyncratic*.

We include two aspects of a firm's stock return performance, an idiosyncratic component conjectured to capture effects of CEO talent (*Ret_ Idiosyncratic*), and a systematic component due to industry returns (*Ret_ Peer*). We include the decomposed performance measures to avoid model misspecification in light of the results documented in Jenter and Kannan (2008) and Kaplan and Minton (2006) that CEO turnover is sensitive to both aspects of performance. Specifically, we run the following first-stage cross-sectional regressions using one year lagged annual returns:[28]

$$r_{i,t-1} = \beta_0 + \beta_1 r_{industry,t-1} + \varepsilon_{i,t-1},$$

where $r_{i,t-1}$ is firm specific return and $r_{industry,t-1}$ is industry-median return. The predicted value from the regression, $\hat{\beta}_0 + \hat{\beta}_1 r_{industry,t-1}$, is our proxy for *Ret_ Peer*, and the residual return, $\varepsilon_{i,t-1}$, is our proxy for *Ret_ Idiosyncratic*.[29]

Finally, we construct an accounting-based risk measure denoted *Risk_ ROA*, measured as the standard deviation of quarterly industry median adjusted earnings growth over the past 4 years. We require that data from at least 8 of the 16 quarters are available.[30, 31] Due to data limitation, we do not decompose this risk further. We also include return on assets (*ROA*) as an accounting

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[28] The performance effect on turnover could potentially extend beyond one lag (e.g., Kim, 1996; Jenter and Kanaan, 2008; and Kaplan and Minton, 2006). For robustness, we run the analyses including lagged 2 year performance measures and risk measures estimated over the past two years. All of our results are robust to this specification.

[29] While the regression specifications are the same for both risk and performance decompositions, the data frequency differs. For robustness, we use daily returns to estimate firm-specific industry betas for each firm year, and then construct annualized *Ret_Idiosyncratic* and *Ret_Peer*. Our results are robust to this alternative estimation.

[30] Earnings growth rates (not earnings itself) are used to remove seasonality, similar to Berger, Chen and Li (2006).

[31] We also try the standard deviation of ($Earn_t$ - $Earn_{t-4}$) / $Assets_{t-4}$ and find qualitatively similar results.

performance measure. Following prior literature, we use lagged one year median industry adjusted *ROA*, deducting the industry median *ROA* from the firm's *ROA*. We define industry based on two-digit SIC industry codes, and use Compustat /CRSP firms as our industry comparison group.

**3.3 Summary Statistics**

Summary statistics for all variables used in turnover analyses are presented in Table 1 for the routine turnover sample, the forced turnover sample, and the control sample separately. Across all performance measures, the forced turnover sample has the lowest mean/median, and the control sample has the highest mean/median. The mean (median) *Ret Idiosyncratic* is -13.5% (-19.5%) for the forced turnover sample, and 4.1% (-6.5%) for the control sample, while *ROA* is 0.6% (1.1%) for the forced turnover sample, and 4.3% (2.6%) for the control sample. The same pattern holds for *Ret_Peer,* but with a less pronounced difference (13.5% vs. 18.9%) between the forced turnover sample and the control sample.[32]

Turning to our risk measures, we find that on average, the forced turnover sample has the highest risk and the control sample has the lowest risk. Mean (median) *Risk_ Idiosyncratic* is 0.46 (0.40) for the forced turnover sample and 0.38 (0.33) for the control sample. The same ordering holds for *Risk_Peer* but with smaller differences across samples. Finally, we note that the forced turnover sample has the highest value of *Risk_ROA* (1.88/ 1.78), and the control sample has the lowest value of *Risk_ROA* (1.52/1.29).

With regard to control variables, we note that, relative to routine CEO turnovers, CEOs who are forced out tend to be younger (53.7 vs. 61.7 years old), have shorter tenure (7.5 vs. 12.1 years), and less likely to be the company founder (0.099 vs. 0.178).[33] We also note that firms with forced turnovers are more likely to be smaller (7.30 vs. 7.58 of log assets) and younger (22.92 vs. 27.42

[32] We note that the industry-adjusted ROA is fairly high in our sample. Since we use CRSP firms as our industry comparison group, this is a likely result due to the sample selection induced by ExecuComp firms.
[33] Younger CEOs in the forced sample could be partially attributed to the fact that we reclassify some of the retirements into forced sample based on the age they "retired".

years), and face more competition (429 vs. 391 firms in the same industry), compared to firms associated with routine turnovers. For corporate governance measures, forced turnover firms have slightly lower G-index (9.2 vs. 9.5) and higher board independence (0.65 vs. 0.63) relative to routine turnover firms though the institution ownership is similar (0.58 vs. 0.59).

## 4. Empirical Analysis of CEO Turnover and the Decomposition of Risk

In section 4.1, we present in table 2 our main analysis of our predictions that CEO turnover probability is increasing in *Risk_ Idiosyncratic* (due to enhanced learning potential) and decreasing in *Risk_ Peer* (due to reduced learning potential), after controlling for firm performance. In table 3 we examine whether the impact of the two components of risk on turnover varies with two CEO characteristics: CEO tenure and company founder status. In section 4.2, we extend the analysis to include three governance metrics: institutional ownership percentage, board independence, and the Gompers, Ishii and Metrick (2003) G-index. In all specifications, we include a number of key control variables and year dummies (all variables are defined in detail in table 1). We compute robust standard errors clustered at the firm level in all regressions.

### 4.1 Empirical Relations between CEO Turnover and Risk, Controlling for Performance

Table 2 presents the results of our Probit analysis of the relation between forced CEO turnover and two risk constructs, *Risk_ Idiosyncratic* and *Risk_ Peer*. The dependent variable is forced turnover, defined as one if there is a forced turnover in a given firm/year, and zero otherwise. We report results estimating the systematic component of returns against three different benchmark returns. Column (1) estimates the systematic component of returns relative to industry median returns, column (2) uses value-weighted market returns only, and column (3) uses both value-weighted market returns and industry median returns. For each analysis, we report both the Probit coefficient estimate and an estimate of the economic significance for each variable. Economic significance is computed as the product of three terms: the coefficient estimate times mean turnover density (this product is the marginal effect of the variable), times the standard deviation of the variable (e.g., Greene, 1997).

Consistent with our hypothesis that the two distinct aspects of risk will have opposite effects on CEO turnover, table 2 documents that in all three specifications, *Risk_ Idiosyncratic* is positively and significantly associated with the probability of forced turnover, and *Risk_ Peer* is negatively and significantly associated with turnover. That is, higher levels of *Risk_ Idiosyncratic* are consistent with performance being more diagnostic about CEO talent, and higher levels of *Risk_ Peer* with performance being less diagnostic. Turning to economic significance, a one standard deviation increase in *Risk_ Idiosyncratic* is associated with a greater than 1.4% increase in the probability of forced turnover across specifications, while a one standard deviation increase in *Risk_ Peer* is associated with a greater than 0.4% decrease in forced turnover probability.

With respect to the relation between realized performance and forced turnovers, we find that, consistent with prior research, *Ret_ Idiosyncratic* is negatively and significantly associated with turnover. In terms of economic significance, a one standard deviation increase in *Ret_ Idiosyncratic* is associated with a greater than 2% increase in the probability of forced turnover across specifications. It is interesting to note that while *Ret_ Idiosyncratic* has the largest economic significance of any variable in the analysis, *Risk_ Idiosyncratic* has the second largest effect and the effects are of comparable magnitudes.

For *Ret_ Peer*, we replicate the basic findings of Jenter and Kanaan (2008) and Kaplan and Minton (2006). In columns (1) and (3), *Ret_ Peer* is negatively and significantly associated with turnover, with a one standard deviation increase in *Ret_ Peer* associated with a greater than .94% decrease in the probability of forced turnover. However, in column (2), where we estimate the systematic component of returns relative to value-weighted market returns only, *Ret_ Peer* is not significantly related to CEO turnover. Jenter and Kanaan (2008, tables 6 and 7) find a similar result and conjecture that corporate boards take value-weighted market indexes (such as the S&P 500) into account when assessing the performance of their CEOs, while ignoring less directly visible outside influences on firm performance. While these results on *Ret_ Peer* represent a conundrum with respect to relative performance evaluation, it is beyond the scope of our paper to investigate this further. We refer the reader to Jenter and Kanaan (2008), who put forth a number of proposed explanations for these findings, although their tests do not provide convincing support for any of the proposed explanations for the industry effect on CEO turnover. From this point forth, we only report results using industry median returns to decompose returns and return volatility into idiosyncratic and systematic components. Our results with respect to risk and turnover are robust to all three specifications.

We next investigate whether the results on *Risk_ Idiosyncratic* and *Risk_ Peer* documented in table 2 vary with two characteristics of the CEO: CEO tenure and founder status. The length of a CEO's tenure with a firm may have implications for the board's learning process with respect to talent, as there is likely to be more uncertainty about the talent of newer CEOs given that the board has only a short time in which to assess talent. If true, this would imply that learning is relatively more important for younger CEOs, and consequently we would expect both *Risk_ Idiosyncratic* and *Risk_ Peer* to have more pronounced effects on turnover as CEO tenure gets shorter. Column (1) of table 3 reports the results of interacting CEO tenure with both *Risk_ Idiosyncratic* and *Risk_ Peer*.

In table 3 we report both the Probit coefficients and the marginal effects of all variables.[34] Focusing on marginal effects, we find that the positive relation between forced turnover and *Risk_*

[34] Because of the non-linearity of the Probit function, the introduction of interaction terms makes Probit coefficients difficult to interpret directly. Thus, we report marginal effects, where the marginal effect of a variable is the partial derivative of the Probit function with respect to that variable, and the marginal effects for an interaction term is the cross-partial derivative with respect to the two interacted variables. These partial derivatives are evaluated at the mean values of all variables. To assess statistical significance, we calculate the standard errors of marginal effects using the delta method (see Ai and Norton, 2003 and Powers, 2004).

*Idiosyncratic* is reduced as CEO tenure increases (interaction marginal effect is negative (-.002) and marginally significant using a two-tailed test), while the negative relation between forced turnover and *Risk_ Peer* is also mitigated as CEO tenure increases (interaction marginal effect is positive (.004) and marginally significant using a two-tailed test). Of course, these results are also consistent with longer tenure capturing CEO entrenchment. To further assess the entrenchment story, we interact our risk variables with a CEO's founder status, under the premise that firm founders are more likely to be entrenched than non-founders, all else equal. However, as shown in column (2) of table 3, while the main effect of *Founder* is negative and significant (founders have a lower probability of being fired), the interaction of *Founder* with neither *Risk_ Idiosyncratic* nor *Risk_Peer* is significantly different from zero.

To summarize, this section documents evidence consistent with our hypothesis that *Risk_ Idiosyncratic* is positively associated with the probability of forced turnover, while *Risk_ Peer* is negatively associated with turnover.

**4.2 Risk and CEO Turnover: Governance Metrics**

Thus far, the analysis basically assumes that the firm is well governed, and that boards optimally fire CEOs when appropriate. However, the strength of a firm's corporate governance may also play a role in CEO turnover decisions. While we explore CEO tenure and founder status in the previous section, we now extend our analysis to incorporate three aspects of a firm's governance structure: the percentage of stock held by institutional investors (*Institutional Own %*), the percentage of outside directors on the board (*Board Ind*), and the Gompers, Ishii and Metrick (2003) G-Index (typically posited to measure CEO entrenchment due to strong anti-takeover provisions).

Table 4 includes the three governance metrics as main effects. None of the three governance variables loads significantly in table 4, while our main results with respect to *Risk_ Idiosyncratic* and *Risk_Peer* are robust to the inclusion of the three governance metrics. The coefficient on *Risk_ Idiosyncratic* remains positive and significant (at the 1% level, two-tailed) across all specifications. The coefficient on *Risk_Peer* remains negative and significant when institutional ownership (5% level two-tailed), board independence (10% level two-tailed), and G-index (10% level one-tailed) are included.

We complete the analysis in this section by exploring the impact of interacting *Risk_ Idiosyncratic* and *Risk_Peer* with the three aspects of a firm's governance structure. Table 5 documents that the only interaction term with a statistically significant marginal effect is the percentage of outside directors (*Board Ind.*) interacted with *Risk_Idiosyncratic* (marginal effect of .155, significant at the 5% level using a two-tailed test). That is, turnover becomes more sensitive to *Risk_Idiosyncratic* as the percentage of outside directors increases, consistent with outside directors being more reliant on the information content of realized performance to learn about CEO talent than are inside directors. Although not statistically significant, the negative sign on the interaction of *Board Ind.* with *Risk_Peer* is also consistent with this story (outside directors are more impacted by noise in performance than insiders). These results complement Weisbach (1988) who documents that CEO turnover is more sensitive to firm performance for outsider-dominated boards than for insider-dominated boards. We find related results with respect to institutional ownership (*Institution Own%*). While not statistically significant, the marginal effect of the interaction of *Institution Own%* with *Risk_Idiosyncratic* is positive, and its interaction with *Risk_Peer* is negative, again consistent with outsiders (in this case institutional investors) being more reliant on the information content of realized performance to learn about CEO talent. We do not find any results with respect to the interaction of the *G-Index* with the two components of risk.

Overall, tables 4 and 5 show that our fundamental result, that the probability of turnover is increasing in *Risk_ Idiosyncratic* and decreasing in *Risk_Peer*, is robust to the inclusion of a range of CEO characteristics and firm governance characteristics. We turn next to an analysis of the relation being risk components and the sensitivity of turnover to performance.

## 5. The Empirical Relation between Performance Risk and Turnover-Performance-Sensitivity

In this section, we investigate the prediction (empirical implication 3 in section 2) that the sensitivity of turnover to performance is increasing in idiosyncratic risk, consistent with higher levels of idiosyncratic risk implying higher information content of performance with respect to talent, and decreasing in systematic risk, consistent with higher levels of systematic risk implying lower information content. The results of our analyses are documented in tables 6 and 7.

Table 6 presents the main results of this section. We estimate interactions between firm-specific returns, *Ret_ Idiosyncratic*, and both *Risk_ Idiosyncratic* and *Risk_Peer*. We report both Probit coefficients and marginal effects. Consistent with our predictions, table 6 documents that the marginal effect of the interaction between *Ret_ Idiosyncratic* and *Risk_ Idiosyncratic* is negative and significant (marginal effect of -.038, significant at the 1% level two-tailed), and the marginal effect of the interaction between *Ret_ Idiosyncratic* and *Risk_Peer* is positive and significant (marginal effect of 0.062, significant at the 5% level two-tailed).[35] This result, based on our theory of learning about CEO talent, stands in stark contrast to the extant executive compensation literature where higher performance risk generally puts downward pressure on pay-performance-sensitivity due to risk aversion considerations. In fact, we find the sensitivity of turnover to performance is increasing in idiosyncratic risk!

Beyond the interaction analysis of table 6, it is also informative to consider the economic significance of the effects of *Risk_ Idiosyncratic* and *Risk_Peer* on the sensitivity of turnover to

[35] Note that the marginal effect for the interaction term (*Ret_Idio * Risk_Idio*) has opposite sign from its coefficient estimate. This highlights the potential danger when only the coefficient estimate is used to interpret the interaction term in Probit model (Powers, 2004).

performance. Given the difficulty in assessing the economic significance of the marginal effects of the interaction terms in table 6, we conduct an additional partition analysis. In table 7, panel A, we first rank all firms based on *Risk_ Idiosyncratic* and then partition the entire sample into three equal sub-samples. Column (1) is the low *Risk_ Idiosyncratic* sub-sample, Column (2) the medium *Risk_ Idiosyncratic* sub-sample, and Column (3) the high *Risk_ Idiosyncratic* sub-sample. We report Probit coefficients and economic effects. We see that the economic effect of a one standard deviation increase in *Ret_ Idiosyncratic* changes monotonically as we move from the low *Risk_ Idiosyncratic* partition to the high *Risk_ Idiosyncratic* partition. Specifically, the economic effect of *Ret_ Idiosyncratic* for the low *Risk_ Idiosyncratic* sub-sample is -0.93%, compared to -2.53% for the medium *Risk_ Idiosyncratic* sub-sample, and -3.04 % for the high *Risk_ Idiosyncratic* sub-sample.

In table 7, panel B, we similarly partition the sample into three equal sub-samples by ranking all firms based on *Risk_Peer*, after orthogonalizing *Risk_Peer* to *Risk_Idiosyncratic*. We do this to deal with the significant correlation between *Risk_Peer* and *Risk_Idiosyncratic* (Pearson correlation = .5).[36] We document that the economic effect of *Ret_ Idiosyncratic* for the low *Risk_Peer* sub-sample is -3.1% compared to only -1.9% for the high *Risk_Peer* sub-sample.

Overall, tables 6 and 7 provide evidence that the sensitivity of CEO turnover to *firm-specific* performance is increasing in *Risk_ Idiosyncratic* and decreasing in *Risk_Peer*. These findings are consistent with the main argument of the paper, that the informativeness of firm-specific performance with respect to CEO talent is increasing in *Risk_ Idiosyncratic* and decreasing in *Risk_Peer*.

## 6. Implications of CEO Turnover Decisions on CEO Compensation Contracts

[36] Substantial correlation between *Risk_Peer* and *Risk_Idiosyncratic* is not unexpected. For example, Fu (2009) documents a cross-sectional Pearson correlation between Beta and idiosyncratic volatility of .34.

The model in section 2 simultaneously solves for the optimal firing rule and the optimal CEO compensation contract. In this final empirical section, we study interrelations between the firing option and CEO compensation. First, we explore the extent to which the threat of turnover creates implicit incentives which reduce the explicit pay-performance-sensitivity in CEOs' compensation contracts. Second, we explore how the probability of turnover impacts the future pay levels of CEOs who are not fired in the current period.

### 6.1 Data, Measurement and Descriptive Statistics

In building our sample for these analyses, we exclude both the first and the last year of a CEO's tenure to mitigate confounding effects from one-time payments such as a first-year signing bonus or last-year severance pay. This implies that we only examine the compensation contracts for those CEOs who are retained in the year subsequent to when we estimate the probability of turnover. We employ ExecuComp database to obtain CEO compensation data, and use Compustat and CRSP for financial data.

Recall that in our two-period model, we show that higher turnover pressure is associated with lower pay-performance-sensitivity (see section 2.4). This prediction is similar in spirit to the idea that explicit incentives from optimal compensation contracts should be weaker when implicit career concerns are stronger in Gibbons and Murphy (1992). We use predicted turnover probability to capture implicit incentives.

To proxy for pay-performance-sensitivity (PPS), we use the dollar holding measure from Core and Guay (1999) and estimate the change in the dollar value of a CEO's restricted stock grants and option grants in year t for 1% change in the stock price. In particular, for restricted stock grants, we calculate 1% of the value of the grants, and for stock option grants, we sum the option deltas from each option grant and multiply by 1% of the stock price. Note that, in constructing the PPS measure, we consider only incentives embedded in equity grants from the current year, not the overall incentives implied by the CEO's entire firm-specific equity portfolio. This approach allows us to measure the compensation components over which the board of directors currently has control, where the overall CEO equity portfolio is the result of wealth accumulation from prior periods, which is outside the control of board of directors' compensation decision for the current period (see also Hartzell and Starks (2003) for additional discussion). We use the logarithmic transformation of 1 + PPS (Core and Guay, 1999 and Himmelberg, Hubbard and Palia, 1999 use a similar variable construction).

To explore how turnover pressure affects PPS, we regress PPS (measured in year t) on the predicted turnover probability (measured in year t-1). Conjecturing that the implicit incentives for the CEO are increasing in the predicted probability of turnover, we predict the coefficient on turnover probability to be negative . We include standard determinants of PPS in the regressions (e.g., Core and Guay, 1999 and Hartzell and Starks, 2003). We control for firm size (logarithm of total assets), book-to-market ratio (*BTM*), *Firm Age*, *Risk_Idiosyncratic,* and *Risk_Peer*, all of which are measured in year t – 1. We also include firm stock returns at both year t – 1 and year t and control for *CEO Age, CEO Tenure*, and *CEO Equity Holdings,* which is the CEO's equity ownership of the firm at year-end t – 1 (measured as the number of shares the CEO owns divided by total shares outstanding for the firm). Finally, we include industry fixed effects (defined at SIC 2-digit levels) and year dummies, and compute robust standard errors clustered at firm level.

While our model in section 2 makes the simplifying assumption that period 2 opportunity utility of retained incumbents does not change with updated talent assessments (in particular that it is downward rigid), it is of course possible that reductions in pay are an alternative to firing the CEO. We explore this possibility next. In our final analysis, we investigate whether the pay-level of a retained CEO decreases as the probability of him being fired increases. We examine both cash compensation (defined as salary plus bonus) and total compensation (defined as the sum of salary, bonus, other cash compensation, the value of stock options and restricted stock grants, long-term incentive plans, and all other compensation). Control variables include firm size, book-to-market ratio, *Firm Age*, *Risk_Idiosyncratic, Risk_Peer*, stock returns, and CEO age and tenure (Hartzell and Starks, 2003). All of the firm level control variables are measured at year t – 1, except that we include stock returns at both year t – 1 and year t. Finally, we include industry fixed effects (defined at SIC 2-digit levels) and year dummies, and report robust standard errors clustered at firm level.

Table 8 presents summary statistics used in the compensation analyses. As can be seen from the table, the mean (median) predicted CEO turnover probability is 4.7% (4%). The average PPS from CEO equity compensation is $64 thousand, and the average changes in cash and total compensation are $136 thousand and $292 thousand, respectively.

**6.2 Regression Results**

Table 9 displays the regression results for the relation between the CEO's probability of turnover and PPS, while table 10 presents the empirical results for regressions of changes in compensation level on the probability of turnover. In Column (1) of table 9, we estimate the specification that includes control variables except *Risk_Idiosyncratic, Risk_Peer*, and stock returns at year t – 1. The coefficient on the predicted turnover probability is negative and statistically significant, supporting the model prediction that turnover pressure provides implicit incentives and is negatively associated with pay-performance-sensitivity. We then include *Risk_Idiosyncratic* and *Risk_Peer* in Column (2), and additionally add stock returns at year t – 1 in Column (3). While the inclusion of stock returns at year t – 1 lowers the statistical significance on the coefficient of the predicted turnover probability in Column (3), it remains negative and statistically significant in both columns. The results also suggest that PPS is significantly greater for larger (*Size*) and more established (*BTM*) firms.

Table 10 column (1) presents the specification where the dependent variable is the change in cash compensation, where in column (2) the dependent variable is the change in total compensation. While the coefficient on predicted turnover probability is not statistically significant when the dependent variable is the change in cash compensation, it is negative and statistically significant when the dependent variable is the change in total compensation. This latter result is consistent with Gao, Harford and Li (2008), who show that pay cuts can be a short-term substitute for dismissal. They find that after a pay cut, a CEO with continued poor performance is just as likely to be fired as a CEO with similar performance whose pay was not cut. That is, while firms do indeed at times keep on a poorly performing CEO at reduced pay, based on Gao, Harford and Li (2008), such forbearance only offers a temporary respite from termination in the face of continued poor performance. This implies that at some point, the firm finds it economically appropriate to fire the CEO rather than lower pay further (i.e., assessed talent below the cutoff). While our modeling assumption of complete downward (and upward) rigidity is strong, all we really need is the existence of some friction in the downward adjustment of reservation utility to allow scope for firing. The empirical evidence is consistent with the existence of such friction.

## 7. Summary and Conclusions

In this paper, we investigate the role played by performance risk in impacting a board's ability to learn about a CEO's unknown talent. A key element in a board of director's decision to retain or dismiss an incumbent CEO is the board's assessment of the CEO's talent. The fundamental insight of our paper is that the impact of performance risk on the ability of boards to learn about CEO talent from firm performance depends crucially on the underlying sources of the risk. If volatility in performance is driven primarily by unobservable CEO talent, firm performance will be diagnostic about such talent. On the other hand, if volatility in performance is driven by factors unrelated to CEO talent (e.g., noise, economy-wide effects, etc.), then a board's ability to infer CEO talent from performance is more limited, making it difficult to cleanly distinguish an incumbent's talent level from the assessed talent of potential replacement CEOs.

We conjecture that idiosyncratic volatility reflects information arrival related to the impact of CEO talent on aspects of performance under the CEO's control, while systematic volatility captures aspects of return variability unrelated to CEO talent and beyond the CEO's control. We predict that these distinct aspects of volatility will have opposite effects on CEO turnover given their differential implications for the process of learning about CEO talent. We provide robust empirical evidence that the probability of CEO turnover is increasing in idiosyncratic, firm specific risk and decreasing in systematic risk, after controlling for firm performance.

We also predict and document that turnover-performance-sensitivity increases in idiosyncratic risk and decreases in systematic risk, consistent with the information content of performance with respect to learning about CEO's talent increasing in idiosyncratic risk and decreasing in systematic risk. This result stands in stark contrast to the extant executive compensation literature where higher performance risk from any source is generally expected to decrease pay-performance-sensitivity due to risk aversion considerations. We make a fundamental contribution to the CEO turnover literature by focusing on the learning process of boards and documenting that the ability of boards to learn about CEO talent from performance depends crucially on the underlying sources of variability in performance. The learning perspective in our paper complements the executive compensation literature by shifting the focus from the impact of performance risk on risk premium demanded by risk-averse executives, to the role played by performance risk in facilitating or impeding a board's ability to learn about CEO talent from realized performance. In our turnover setting, risk impacts the learning process, and can either increase or decrease turnover-performance-sensitivity depending on the underlying source of the volatility.

Finally, we extend the executive compensation literature by empirically exploring interrelations between a board of director's option to fire the CEO and CEO compensation. We demonstrate in our model and empirically document that for retained CEOs, pay-performance-sensitivity is decreasing in the probability of turnover, consistent with the firing option creating implicit incentives which reduce the need for explicit pay-performance-sensitivity in CEOs' compensation contracts. We also document that for CEOs who are retained, subsequent pay *levels* are a decreasing function of the probability of turnover, consistent with Gao, Harford and Li (2008), who show that pay cuts can be a short-term substitute for dismissal.

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## Appendix

### Proof of Proposition 2

(i) In equilibrium, the probability of firing is given by $\Pr(F=1)=\Phi[-\frac{x\sqrt{\sigma_0^2+\sigma^2}}{\sigma_0^2}]$. So, $\frac{\partial\Phi[\cdot]}{\partial\sigma_0}$>0 is equivalent to $\frac{\partial\left(\frac{x\sqrt{\sigma_0^2+\sigma^2}}{\sigma_0^2}\right)}{\partial\sigma_0}<0$. Taking this derivative and tedious algebra yields the condition that the derivative is negative when *S*>*K*, where *K* is given by

$$K=-\frac{\gamma\sigma_0^4(-2\gamma^2\sigma^6-\sigma_0^4+\gamma\sigma_0^6-\gamma\sigma^6(4+3\gamma\sigma_0^2)+\sigma^4(-2-6\gamma\sigma_0^2+\gamma^2\sigma_0^4)+\sigma^2\sigma_0^2(-3-2\gamma\sigma_0^2+2\gamma^2\sigma_0^4))}{2(2\sigma^2+\sigma_0^2)(\gamma^2\sigma^6+\sigma_0^2+\gamma\sigma_0^4+\gamma\sigma^4(2+3\gamma\sigma_0^2)+\sigma^2(1+4\gamma\sigma_0^2+2\gamma^2\sigma_0^4))^2}. \quad \text{(A1)}$$

■

(ii) In equilibrium, the probability of firing is given by $\Pr(F=1)=\Phi[-\frac{x\sqrt{\sigma_0^2+\sigma^2}}{\sigma_0^2}]$. So, $\frac{\partial\Phi[\cdot]}{\partial\sigma^2}$<0 is equivalent to $\frac{\partial\left(\frac{x\sqrt{\sigma_0^2+\sigma^2}}{\sigma_0^2}\right)}{\partial\sigma}>0$. Taking this derivative and manipulating the algebra yields the condition the derivative is positive when *S*>*G*, where *G* is given by

$$G=\frac{\gamma\sigma_0^4(5\gamma^2\sigma^6+\sigma_0^2+7\gamma\sigma_0^4+4\gamma^2\sigma_0^6+3\gamma\sigma^4(2+5\gamma\sigma_0^2)+\sigma^2(1+12\gamma\sigma_0^2+14\gamma^2\sigma_0^4))}{2(\gamma^2\sigma^6+\sigma_0^2+\gamma\sigma_0^4+\gamma\sigma^4(2+3\gamma\sigma_0^2)+\sigma^2(1+4\gamma\sigma_0^2+2\gamma^2\sigma_0^4))^2}. \quad \text{(A2)}$$

It is straightforward to show that $\frac{\partial G}{\partial\sigma}<0$. Substituting $\sigma=0$ into (A1) yields the result that $\lim_{\sigma^2\to 0}G=\frac{\gamma\sigma_0^2(1+7\gamma\sigma_0^2+4\gamma^2\sigma_0^4)}{2(1+\gamma^2\sigma_0^2)^2}$. To see that $\lim_{\sigma^2\to\infty}G=0$, expand the numerator and denominator in (A1) and note that the highest power of $\sigma$ in the numerator is 6, while in the denominator it is 12.

Finally, taking the expression for *K* in equation (A1), it is straightforward to show that *G-K>0*.■

**Proof sketch of Proposition 3: Period 1 Contract Given a Firing Option**

We solve the maximization problem faced by the firm at the beginning of period 1, written as

$$\max_{a_1, b_1, e_1} : E_1\{(y_1 - w_1) + \Pr(F=0)E_2(y_2 - w_2 \mid y_1, F=0) + \Pr(F=1)E_2(y_2 - w_2 - S)\}$$

*s.t.*

$$e_1 = \arg\max E_1\{[E_1(w_1) - \frac{1}{2}\gamma V_1(w_1) - \frac{1}{2}e_1^2] + [\Pr(F=0)(E_2(w_2 \mid y_1) - \frac{1}{2}\gamma V_2(w_2 \mid y_1) + \Pr(F=1)S] - \frac{1}{2}\gamma \Pr(F=1)\Pr(F=0)[T-S]^2 \quad \text{(A3)}$$

$$RHS \geq \bar{u} \quad \text{(A4)}$$

RHS refers to the right-hand side of incentive comparability constraint. The last term in the incentive comparability constraint represents the risk premium associated with firing.[37] $T$ represents the outcome when the CEO is retained and equals to

$$E_2[w_2 \mid y_1] - \frac{1}{2}\gamma V_2(w_2 \mid y_1) - \frac{1}{2}e_2^2$$

the mean-variance utility the CEO expects to receive if he is retained. Now, if we substitute the optimal solutions from period 2 into the above expression, we have $T = \overline{u_1}$, which is his reservation utility.

Taking the derivative with respect to $e_1$ and imposing the equilibrium condition that $\hat{e}_1 = e_1$, the solution to the above optimization problem is

$$e_1^* = \frac{1}{1+\gamma(\sigma_0^2+\sigma^2)} + \frac{\phi(.)\gamma(\sigma_0^2+\sigma^2)}{[1+\gamma(\sigma_0^2+\sigma^2)]\sqrt{\sigma_0^2+\sigma^2}}\{(\overline{u_1}-S) + \frac{1}{2}\gamma(\overline{u_1}-S)^2[1-2\Phi(.)]\} \quad \text{(A5)}$$

$$b_1^* = \frac{1}{1+\gamma(\sigma_0^2+\sigma^2)} - \frac{\phi(.)}{[1+\gamma(\sigma_0^2+\sigma^2)]\sqrt{\sigma_0^2+\sigma^2}}\{(\overline{u_1}-S) + \frac{1}{2}\gamma(\overline{u_1}-S)^2[1-2\Phi(.)]\}, \quad \text{(A6)}$$

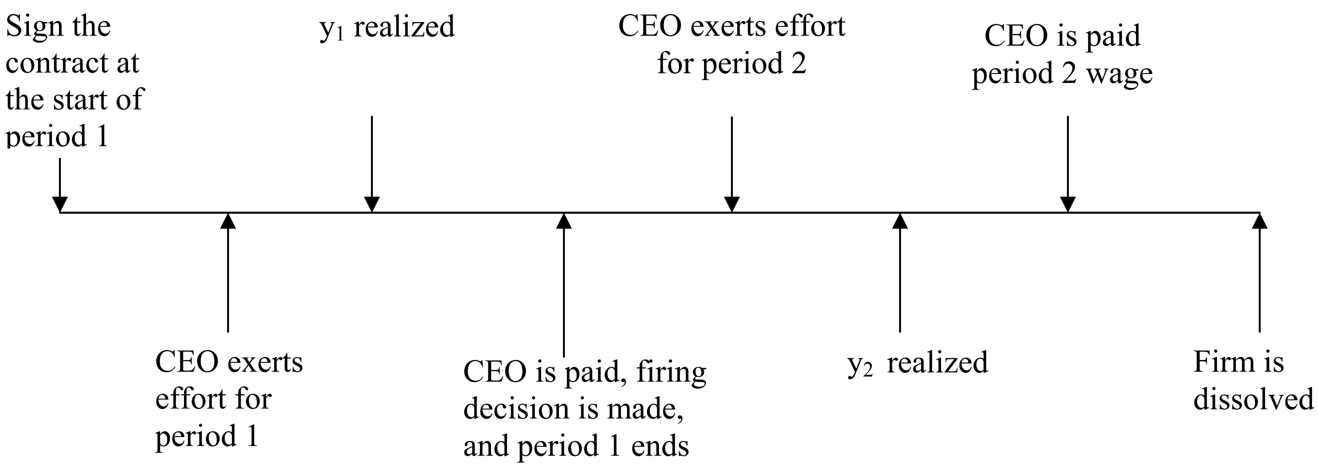
where

[37] Since to fire or not to fire is a binary choice, it is straightforward to show that the variance equals the product of the probabilities associated with each outcome and the squared difference between the two outcomes.

$$\phi(.) = \phi[-\frac{x\sqrt{\sigma_0^2 + \sigma^2}}{\sigma_0^2}]$$

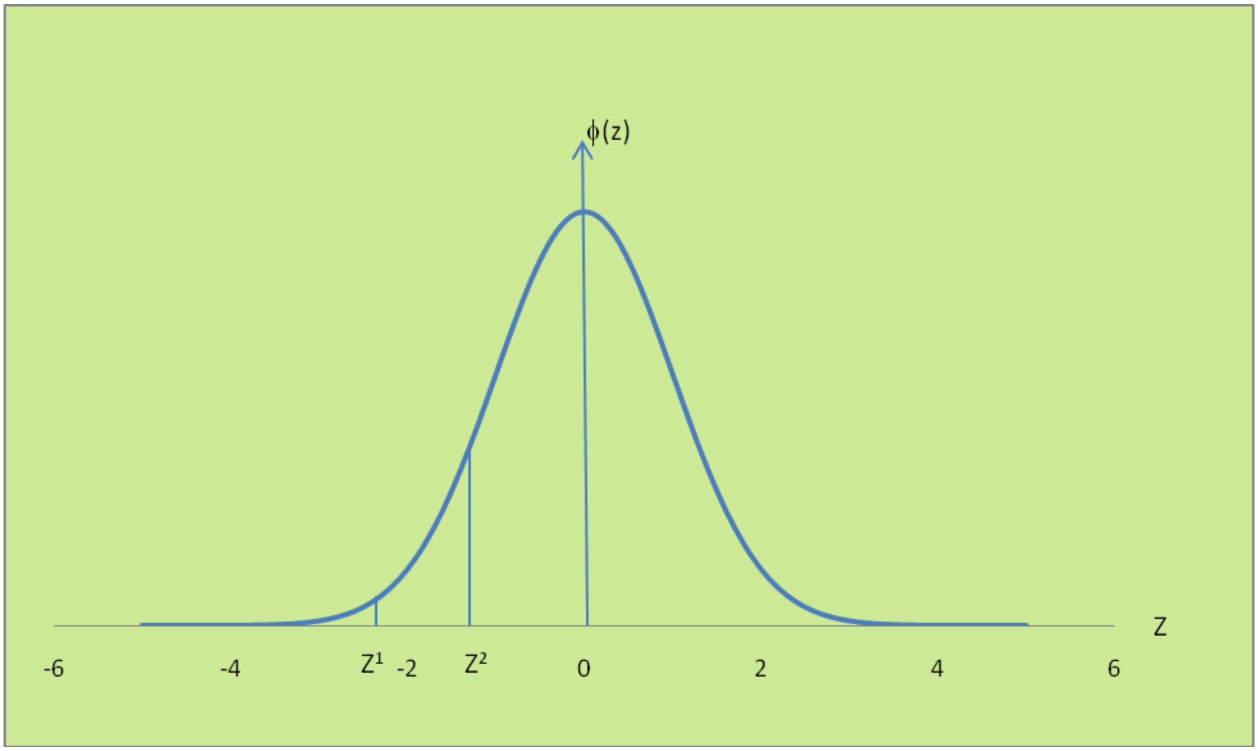
$$\Phi(.) = \Phi[-\frac{x\sqrt{\sigma_0^2 + \sigma^2}}{\sigma_0^2}] < \frac{1}{2} \ .$$

**Figure 1 Time Line for the Two-Period Model**




**Note:** This figure demonstrates the time line for the two-period model. $y_1$ and $y_2$ are first and second period firm performance, respectively.

**Figure 2 Model Implications for Risk and Turnover-Performance-Sensitivity**




**Note:** $Z$ is the Z-statistic calculated by standardizing the cutoff threshold for firing the CEO under a standard normal distribution. With the cutoff threshold given by $\theta_1^*$, expected CEO talent assessment by $\theta_0$, and the standard deviation of assessed talent by $\sigma_{\theta_1}$, we have $Z = \frac{\theta_1^* - \theta_0}{\sigma_{\theta_1}}$. The probability of being fired is given by $\Phi(Z)$, where $\Phi$ is the cumulative distribution function for a standard normal and $\phi$ is the standard normal density. Let $Z^1$ and $Z^2$ be the standardized cutoff thresholds for firm 1 and firm 2, respectively, where for example firm 2 has higher idiosyncratic risk than firm 1 implying $Z^1 < Z^2$ (see proposition 2). This figure shows that firm 2 has larger firing interval than firm 1 has.

## Analysis of Risk and CEO Turnover

Table 1 Risk and CEO Turnover: Descriptive Statistics

| | Routine turnovers (N=1,029) | | | Forced turnovers (N=794) | | | Control sample (N=15,965) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Median | Std Dev | Mean | Median | Std Dev | Mean | Median | Std Dev |
| Ret_Idiosyncratic | -0.021 | -0.092 | 0.472 | -0.135 | -0.195 | 0.515 | 0.041 | -0.065 | 0.653 |
| Ret_Peer | 0.172 | 0.163 | 0.287 | 0.135 | 0.116 | 0.312 | 0.189 | 0.176 | 0.295 |
| Risk_Idiosyncratic | 0.363 | 0.315 | 0.191 | 0.459 | 0.399 | 0.252 | 0.380 | 0.330 | 0.202 |
| Risk_Peer | 0.152 | 0.124 | 0.117 | 0.183 | 0.150 | 0.133 | 0.155 | 0.125 | 0.121 |
| ROA | 0.037 | 0.025 | 0.195 | 0.006 | 0.011 | 0.228 | 0.043 | 0.026 | 0.150 |
| Risk_ROA | 1.546 | 1.268 | 1.267 | 1.878 | 1.784 | 1.220 | 1.522 | 1.292 | 1.220 |
| Size | 7.581 | 7.483 | 1.681 | 7.303 | 7.104 | 1.866 | 7.369 | 7.184 | 1.764 |
| CEO age | 61.652 | 63.000 | 7.209 | 53.686 | 54.000 | 6.133 | 54.429 | 55.000 | 7.401 |
| CEO tenure | 12.071 | 9.000 | 8.776 | 7.500 | 6.000 | 5.694 | 8.505 | 6.000 | 7.460 |
| Founder | 0.178 | 0.000 | 0.383 | 0.099 | 0.000 | 0.300 | 0.139 | 0.000 | 0.346 |
| Competition | 390.930 | 298.000 | 350.049 | 429.411 | 367.000 | 376.257 | 383.377 | 298.000 | 334.662 |
| Firm age | 27.424 | 24.000 | 20.357 | 22.923 | 17.000 | 18.137 | 24.285 | 21.000 | 18.603 |
| InstitutionHolding | 0.592 | 0.606 | 0.200 | 0.581 | 0.600 | 0.216 | 0.587 | 0.602 | 0.202 |
| Board Indep% | 0.631 | 0.667 | 0.175 | 0.651 | 0.667 | 0.170 | 0.643 | 0.667 | 0.179 |
| G-index | 9.489 | 10.000 | 2.664 | 9.207 | 9.000 | 2.692 | 9.289 | 9.000 | 2.713 |

**Note:** Routine turnover sample includes firm-years when a company experienced a routine turnover. Forced turnover sample includes firm-years when a company experienced a forced turnover. See Section 3 of the paper for detailed definition of routine turnover and forced turnover. Control sample includes all firm-years when there was no turnover event. *ROA* (return on assets) are industry median adjusted annual returns; *Ret_ Idiosyncratic* is calculated as the residuals from the first stage cross sectional regressions (annual returns) that use industry median returns to predict firm stock returns; *Ret_ Peer* is calculated as the predicted values from the first stage corss sectional regressions (annual return) that use industry median returns to predict firm stock returns; *Risk_ Idiosyncratic* is calculated as the standard deviation of residuals from regression of daily stock returns on daily industry median returns; *Risk_ peer* is calculated as the standard deviation of the predicted values from regression of daily stock returns on daily industry median returns from year t-1; *Risk_ ROA*: standard deviation using 16 quarterly earnings growth rates after removing 2 digit SIC industry median; *Size:* log of assets (in millions); *CEO age*: age measured in years; *Tenure*: years being on the current CEO position; *Founder*: founder of the current company the CEO serves and defined as one if yes, zero if no; *Competition*: the number of potential CEO candidates measured as number of firms in the same 2-digit SIC code; *Firm age*: the age of the firm the CEO serves measured in years (using CRSP monthly return data). All the variables are measured at the year before the turnover event. The last 3 variables have 16,456(*InstitutionHolding*), 9,782 (*BoardIndependence*), and 13,392 (*G-index*) observations. *InstitutionHolding* is percentage of shares held by institutional investors in decimal; *BoardIndependence* is percentage of independent board members in decimal; *G-index* is Gompers-Ishii-Metrick corporate governance measure.

Table 2 Relation between Risk and CEO Turnover

| | (1) | | (2) | | (3) | |
|---|---|---|---|---|---|---|
| | Peer=Industry Return | | Peer =Market Return | | Peer=Industry + Market | |
| | Coefficient | Economic | Coefficient | Economic | Coefficient | Economic |
| Ret_ Idiosyncratic | -0.339*** | -2.065 | -0.342*** | -2.156 | -0.337*** | -2.051 |
| | (5.83) | | (5.97) | | (5.82) | |
| Ret_Peer | -0.341*** | -0.949 | -0.095 | -0.149 | -0.336*** | -0.940 |
| | (3.68) | | (0.32) | | (3.55) | |
| **Risk_Idiosyncratic** | **0.744*** ** | **1.435** | **0.727*** ** | **1.427** | **0.760*** ** | **1.463** |
| | **(6.45)** | | **(6.26)** | | **(6.40)** | |
| **Risk_Peer** | **-0.407** ** | **-0.464** | **-0.398** ** | **-0.402** | **-0.385** ** | **-0.433** |
| | **(2.19)** | | **(1.96)** | | **(2.04)** | |
| ROA | -0.178 | -0.259 | -0.160 | -0.233 | -0.170 | -0.248 |
| | (1.64) | | (1.51) | | (1.58) | |
| Risk_ROA | 0.073*** | 0.839 | 0.070*** | 0.805 | 0.072*** | 0.827 |
| | (5.12) | | (4.91) | | (5.04) | |
| Size | 0.019 | 0.316 | 0.020 | 0.333 | 0.021* | 0.349 |
| | (1.53) | | (1.60) | | (1.70) | |
| CEO age | 0.001 | 0.069 | 0.001 | 0.069 | 0.001 | 0.069 |
| | (0.31) | | (0.33) | | (0.31) | |
| CEO tenure | -0.003 | -0.208 | -0.004 | -0.278 | -0.003 | -0.208 |
| | (1.15) | | (1.21) | | (1.15) | |
| Founder | -0.215*** | -0.695 | -0.213*** | -0.689 | -0.215*** | -0.695 |
| | (3.47) | | (3.43) | | (3.46) | |
| Competition | 0.000* | 0.000 | 0.000** | 0.000 | 0.000* | 0.000 |
| | (1.76) | | (2.19) | | (1.82) | |
| Firm age | -0.001 | -0.175 | -0.001 | -0.175 | -0.001 | -0.175 |
| | (1.00) | | (1.10) | | (1.00) | |
| Pseudo $R^2$ | 0.054 | | 0.053 | | 0.054 | |
| Observations | 16,759 | | 16,759 | | 16,759 | |
| N (Forced) | 794 | | 794 | | 794 | |
| N (Control) | 15,965 | | 15,965 | | 15,965 | |

Note: The dependent variable is forced turnover, defined as one if there is a forced turnover, zero otherwise. All other variables are as defined in Table 1. Z-statistics are reported below each coefficient estimate using robust standard errors controlling for firm level clustering. Column (1) considers both value-weighted market and industry median returns as peer performance, column (2) considers only industry median return as peer performance, and column (3) considers only value-weighted market returns as peer performance. Year dummies are included in all specifications. Economic effects are calculated as the product of three terms: the coefficient estimate times mean turnover density (i.e., this product is the marginal effect), times the standard deviation of the variable. For *Founder* the economic effect is the product of the coefficient estimate and mean turnover density (See Greene, 1997). ***, **, * denote significance at the 1%, 5% and 10% levels (two-tailed), respectively.

Table 3 Risk and CEO Turnover: Interactions with CEO Tenure and Founder

| | (1) Tenure | | (2) Founder | |
|---|---|---|---|---|
| | Coefficient | Marginal Effect | Coefficient | Marginal Effect |
| Ret_Idiosyncratic | -0.339*** | -0.029*** | -0.339*** | -0.029*** |
| | (5.84) | (-6.22) | (5.82) | (-6.19) |
| Ret_Peer | -0.341*** | -0.029*** | -0.342*** | -0.029*** |
| | (3.68) | (-3.76) | (3.69) | (-3.77) |
| **Risk_Idiosyncratic** | **0.898*** ** | **0.061*** ** | **0.734*** ** | **0.063*** ** |
| | **(5.91)** | **(5.97)** | **(5.98)** | **(6.38)** |
| **Risk_Peer** | **-0.719*** ** | **-0.033*** ** | **-0.392* ** | **-0.035** ** |
| | **(2.74)** | **(-2.11)** | **(1.95)** | **(-2.17)** |
| **CEO tenure** | **-0.001** | **-0.000** | | |
| | **(0.23)** | **(-1.22)** | | |
| **CEO tenure * Risk_Idio** | **-0.022** | **-0.002* ** | | |
| | **(1.48)** | **(-1.75)** | | |
| **CEO tenure * Risk_Peer** | **0.039* ** | **0.004* ** | | |
| | **(1.74)** | **(1.85)** | | |
| **Founder** | | | **-0.233* ** | **-0.016*** ** |
| | | | **(1.70)** | **(-3.59)** |
| **Founder * Risk_Idio** | | | **0.066** | **-0.018** |
| | | | **(0.27)** | **(-1.23)** |
| **Founder * Risk_Peer** | | | **-0.090** | **0.006** |
| | | | **(0.24)** | **(0.25)** |
| ROA | -0.176 | -0.015 | -0.178 | -0.015 |
| | (1.61) | (-1.61) | (1.63) | (-1.63) |
| Risk_ROA | 0.072*** | 0.006*** | 0.073*** | 0.006*** |
| | (5.08) | (5.05) | (5.13) | (5.11) |
| Size | 0.019 | 0.002 | 0.019 | 0.002 |
| | (1.52) | (1.52) | (1.52) | (1.52) |
| CEO age | 0.001 | 0.000 | 0.001 | 0.000 |
| | (0.23) | (0.23) | (0.32) | (0.32) |
| Competition | 0.000* | 0.000* | 0.000* | 0.000* |
| | (1.76) | (1.76) | (1.75) | (1.75) |
| Firm age | -0.001 | -0.000 | -0.001 | -0.000 |
| | (0.97) | (-0.97) | (1.01) | (-1.01) |
| Pseudo $R^2$ | 0.054 | | 0.054 | |
| Observations | 16,759 | | 16,759 | |
| N (Forced) | 794 | | 794 | |
| N (Control) | 15,965 | | 15,965 | |

**Note:** The dependent variable is forced turnover which is defined as one if there is a forced turnover, zero otherwise. All other variables are as defined in Table 1. Z-statistics are reported below each coefficient estimate and they are based on robust standard errors controlling for firm level clustering. Year dummies are included in all specifications. Column (1) is when the interactions between tenure and risk are considered, and column (2) is when the interactions between founder and risk are considered. Year dummies are included in all specifications. Marginal effects are calculated as the change in the probability of a forced turnover for a one unit change in the explanatory variable, holding all other variables at the mean values. Z-statistics are calculated using the delta method (Ai and Norton, 2003) ). ***, **, * denote significance at the 1%, 5% and 10% levels (two-tailed), respectively.

Table 4 Risk and CEO Turnover: Controlling for Corporate Governance Measures

| | (1) | | (2) | | (3) | |
|---|---|---|---|---|---|---|
| | Coefficient | Marginal | Coefficient | Marginal | Coefficient | Marginal |
| Ret_Idiosyncratic | -0.333*** | -0.029*** | -0.417*** | -0.041*** | -0.355*** | -0.031*** |
| | (5.72) | (-6.09) | (5.70) | (-6.05) | (4.66) | (-4.90) |
| Ret_Peer | -0.335*** | -0.029*** | -0.283*** | -0.028*** | -0.338*** | -0.030*** |
| | (3.62) | (-3.70) | (2.69) | (-2.73) | (3.14) | (-3.20) |
| Risk_Idiosyncratic | 0.761*** | 0.065*** | 0.873*** | 0.085*** | 0.870*** | 0.076*** |
| | (6.55) | (6.52) | (5.66) | (5.60) | (6.65) | (6.65) |
| Risk_Peer | -0.400** | -0.034** | -0.401* | -0.039* | -0.326 | -0.029 |
| | (2.14) | (-2.15) | (1.83) | (-1.84) | (1.53) | (-1.54) |
| ROA | -0.181 | -0.016 | -0.061 | -0.006 | -0.071 | -0.006 |
| | (1.63) | (-1.63) | (0.56) | (-0.56) | (0.44) | (-0.43) |
| Risk_ROA | 0.072*** | 0.006*** | 0.064*** | 0.006*** | 0.070*** | 0.006*** |
| | (5.04) | (5.02) | (3.80) | (3.81) | (4.62) | (4.61) |
| Size | 0.021* | 0.002* | 0.023 | 0.002 | 0.015 | 0.001 |
| | (1.71) | (1.71) | (1.58) | (1.58) | (1.14) | (1.14) |
| CEO age | 0.001 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 |
| | (0.32) | (0.32) | (0.00) | (0.00) | (0.25) | (0.25) |
| CEO tenure | -0.003 | -0.000 | -0.004 | -0.000 | -0.003 | -0.000 |
| | (1.14) | (-1.14) | (1.10) | (-1.10) | (0.93) | (-0.93) |
| Founder | -0.215*** | -0.016*** | -0.181** | -0.016** | -0.218*** | -0.016*** |
| | (3.42) | (-3.96) | (2.15) | (-2.44) | (2.76) | (-3.24) |
| Competition | 0.000* | 0.000* | 0.000 | 0.000 | 0.000 | 0.000 |
| | (1.79) | (1.78) | (1.61) | (1.61) | (1.29) | (1.29) |
| Firm age | -0.001 | -0.000 | -0.001 | -0.000 | -0.001 | -0.000 |
| | (0.98) | (-0.98) | (1.13) | (-1.13) | (0.66) | (-0.66) |
| Institution Own% | -0.003 | -0.000 | | | | |
| | (0.03) | (-0.03) | | | | |
| Board Ind. | | | 0.108 | 0.011 | | |
| | | | (0.86) | (0.86) | | |
| G-index | | | | | -0.000 | -0.000 |
| | | | | | (0.05) | (-0.05) |
| Constant | -2.694*** | | -2.112*** | | -2.626*** | |
| | (12.86) | | (8.69) | | (11.17) | |
| Pseudo $R^2$ | 0.054 | | 0.050 | | 0.054 | |
| Observations | 16,456 | | 9,782 | | 13,392 | |
| N (Forced) | 786 | | 528 | | 648 | |
| N (Control) | 15,670 | | 9,254 | | 12,744 | |

**Note:** The dependent variable is forced turnover which is defined as one if there is a forced turnover, zero otherwise. All other variables are as defined in Table 1. Z-statistics are reported below each coefficient estimate and they are based on robust standard errors controlling for firm level clustering. Year dummies are included in all specifications. Column (1) is when the institution ownership is added. Column (2) is when the board independence is added and column (3) is when G-index is added. Year dummies are included in all specifications. Marginal effects are calculated as the change in the probability of a forced turnover for a one unit change in the explanatory variable, holding all other variables at the mean values. ***, **, * denote significance at the 1%, 5% and 10% levels (two-tailed), respectively.

Table 5 Risk and CEO Turnover: Interaction with Governance Measures

| | (1) Institution Own% | | (2) Board Ind. | | (3) G-Index | |
|---|---|---|---|---|---|---|
| | Coefficient | Marginal | Coefficient | Marginal | Coefficient | Marginal |
| Ret_Idiosyncratic | -0.331*** | -0.028*** | -0.417*** | -0.041*** | -0.353*** | -0.031*** |
| | (5.71) | (-6.06) | (5.70) | (-6.06) | (4.64) | (-4.87) |
| Ret_Peer | -0.329*** | -0.028*** | -0.283*** | -0.028*** | -0.334*** | -0.029*** |
| | (3.55) | (-3.62) | (2.68) | (-2.73) | (3.10) | (-3.16) |
| Risk_Idiosyncratic | 0.451** | 0.076*** | -0.056 | 0.092*** | 0.463 | 0.079*** |
| | (2.08) | (6.85) | (0.13) | (5.99) | (1.31) | (6.82) |
| Risk_Peer | 0.115 | -0.042** | 0.447 | -0.044** | -0.186 | -0.029 |
| | (0.24) | (-2.58) | (0.66) | (-2.06) | (0.29) | (-1.52) |
| **Institution Own%** | **-0.153** | **-0.003** | | | | |
| | **(0.89)** | **(-0.38)** | | | | |
| **Institution Own%*Risk_Idio** | **0.715*** | **0.057** | | | | |
| | **(1.85)** | **(1.64)** | | | | |
| **Institution Own%*Risk_Peer** | **-1.019** | **-0.086** | | | | |
| | **(1.34)** | **(-1.27)** | | | | |
| **Board Ind.** | | | **-0.291** | **0.003** | | |
| | | | **(1.01)** | **(0.22)** | | |
| **Board Ind.*Risk_Idio** | | | **1.522**** | **0.155**** | | |
| | | | **(2.35)** | **(2.47)** | | |
| **Board Ind.*Risk_Peer** | | | **-1.394** | **-0.140** | | |
| | | | **(1.35)** | **(-1.38)** | | |
| **G-Index** | | | | | **-0.016** | **-0.000** |
| | | | | | **(1.04)** | **(-0.20)** |
| **G-Index*Risk_Idio** | | | | | **0.047** | **0.004** |
| | | | | | **(1.23)** | **(1.17)** |
| **G-Index*Risk_Peer** | | | | | **-0.015** | **-0.001** |
| | | | | | **(0.22)** | **(-0.21)** |
| ROA | -0.193* | -0.017* | -0.066 | -0.006 | -0.075 | -0.007 |
| | (1.65) | (-1.65) | (0.61) | (-0.60) | (0.46) | (-0.46) |
| Risk_ROA | 0.072*** | 0.006*** | 0.064*** | 0.006*** | 0.069*** | 0.006*** |
| | (5.01) | (4.99) | (3.78) | (3.79) | (4.57) | (4.56) |
| Control Variables Included | Yes | Yes | Yes | Yes | Yes | Yes |
| Pseudo $R^2$ | 0.054 | | 0.051 | | 0.055 | |
| Observations | 16,456 | | 9,782 | | 13,392 | |
| N (Forced) | 786 | | 528 | | 648 | |
| N (Control) | 15,670 | | 9,254 | | 12,744 | |

**Note:** The dependent variable is forced turnover which is defined as one if there is a forced turnover, zero otherwise. All other variables are as defined in Table 1. Z-statistics, reported below each coefficient estimate, are based on robust standard errors controlling for firm level clustering. Control variables included, but not reported are *Size, CEO Age, CEO Tenure, Founder, Competition and Firm Age.* Year dummies are included in all specifications. Column (1) reports interactions between institutional holding (*Institution Own%*) and risk, column (2) reports interactions between the proportion of outside directors (*Board Ind.)* and risk, and column (3) reports interactions between *G-index* and risk. Marginal effects are calculated as the change in the probability of a forced turnover for a one unit change in the explanatory variable, holding all other variables at the mean values. Z-statistics are calculated using the delta method (Ai and Norton, 2003). ***, **, * denote significance at the 1%, 5% and 10% levels (two-tailed), respectively.

Table 6 Turnover-Performance-Sensitivity and Risk: Interaction Analysis

| | (1) Coefficient | (2) Marginal |
|---|---|---|
| Ret_Idiosyncratic | -0.489*** | -0.033*** |
| | (5.75) | (-6.86) |
| Ret_Peer | -0.363*** | -0.031*** |
| | (3.96) | (-4.04) |
| Risk_Idiosyncratic | 0.738*** | 0.062*** |
| | (6.33) | (6.31) |
| Risk_Peer | -0.378** | -0.031** |
| | (2.06) | (-1.98) |
| **Ret_Idio * Risk_Idio** | **0.058** | **-0.038*** ** |
| | **(0.65)** | **(-3.93)** |
| **Ret_Idio * Risk_Peer** | **0.489*** | **0.062**** |
| | **(1.82)** | **(2.53)** |
| ROA | -0.185* | -0.016* |
| | (1.78) | (-1.78) |
| Risk_ROA | 0.073*** | 0.006*** |
| | (5.15) | (5.13) |
| Size | 0.019 | 0.002 |
| | (1.51) | (1.51) |
| CEO age | 0.001 | 0.000 |
| | (0.28) | (0.28) |
| CEO tenure | -0.003 | -0.000 |
| | (1.13) | (-1.13) |
| Founder | -0.214*** | -0.016*** |
| | (3.44) | (-3.97) |
| Competition | 0.000* | 0.000* |
| | (1.67) | (1.66) |
| Firm age | -0.001 | -0.000 |
| | (1.01) | (-1.01) |
| Pseudo $R^2$ | 0.054 | |
| Observations | 16,759 | |
| N (Forced) | 794 | |
| N (Control) | 15,965 | |

**Note:** The dependent variable is forced turnover which is defined as one if there is a forced turnover, zero otherwise. All other variables are as defined in Table 1. Z-statistics, reported below each coefficient estimate, are based on robust standard errors controlling for firm level clustering. Year dummies are included in all specifications. Marginal effects are calculated as the change in the probability of a forced turnover for a one unit change in the explanatory variable, holding all other variables at the mean values. Z-statistics are calculated using the delta method (Ai and Norton, 2003). ***, **, * denote significance at the 1%, 5% and 10% levels (two-tailed) respectively.

Table 7 Turnover-Performance-Sensitivity and Risk: Analysis of Economic Significance

*Panel A: Partitioned by Risk_Idiosyncratic*

| | (1) Low Risk_Idiosyncratic | | (2) Med Risk_Idiosyncratic | | (3) High Risk_Idiosyncratic | |
|---|---|---|---|---|---|---|
| | Coefficient | Economic | Coefficient | Economic | Coefficient | Economic |
| **Ret_Idiosyncratic** | **-0.472*** ** | **-0.931** | **-0.681*** ** | **-2.525** | **-0.263*** ** | **-3.040** |
| | **(2.87)** | | **(5.84)** | | **(4.52)** | |
| Ret_Peer | -0.778*** | -1.424 | -0.511*** | -1.346 | -0.197 | -0.753 |
| | (3.60) | | (3.36) | | (1.53) | |
| Risk_Idiosyncratic | 1.670** | 0.790 | 0.394 | 0.299 | 0.559*** | 1.361 |
| | (2.05) | | (0.50) | | (3.52) | |
| Risk_Peer | 0.877 | 0.477 | -0.437 | -0.368 | -0.538** | -0.976 |
| | (1.30) | | (1.04) | | (2.28) | |
| Controls Included | Yes | Yes | Yes | Yes | Yes | Yes |
| Pseudo $R^2$ | 0.042 | | 0.054 | | 0.072 | |
| Observations | 5,582 | | 5,591 | | 5,586 | |
| N (Forced) | 189 | | 250 | | 355 | |
| N (Control) | 5,393 | | 5,341 | | 5,231 | |

*Panel B: Partitioned by Residual Risk_Peer*

| | (1) Low Residual Risk_Peer | | (2) Med Residual Risk_Peer | | (3) High Residual Risk_Peer | |
|---|---|---|---|---|---|---|
| | Coefficient | Economic | Coefficient | Economic | Coefficient | Economic |
| **Ret_Idiosyncratic** | **-0.446*** ** | **-3.138** | **-0.305** ** | **-1.347** | **-0.301*** ** | **-1.939** |
| | **(6.40)** | | **(2.47)** | | **(3.21)** | |
| Ret_Peer | -0.505*** | -1.421 | -0.517*** | -1.270 | -0.130 | -0.379 |
| | (3.41) | | (3.21) | | (0.95) | |
| Risk_Idiosyncratic | 0.408* | 0.927 | 0.840 | 1.244 | 0.905*** | 1.649 |
| | (1.83) | | (1.43) | | (3.04) | |
| Risk_Peer | 1.556* | 1.023 | -0.531 | -0.370 | -0.846* | -1.137 |
| | (1.95) | | (0.30) | | (1.76) | |
| Controls Included | Yes | Yes | Yes | Yes | Yes | Ye |
| Pseudo $R^2$ | 0.077 | | 0.053 | | 0.058 | |
| Observations | 5,582 | | 5,591 | | 5,586 | |
| N (Forced) | 302 | | 248 | | 244 | |
| N (Control) | 5,280 | | 5,343 | | 5,342 | |

**Note:** Panel A is partitioned on idiosyncratic risk and panel B is partitioned on residual peer risk (residual from regression of *Risk_Peer* on *Risk_Idiosyncratic*). The dependent variable is forced turnover which is defined as one if there is a forced turnover, zero otherwise. All other variables are as defined in Table 1. Z-statistics are reported below each coefficient estimate using robust standard errors clustered at the firm level. Column (1) is the low risk group, column (2) is the medium risk group and column (3) is the high risk group. Control variables included, but not reported are *ROA, Risk_ROA, Size, CEO Age, CEO Tenure, Founder, Competition and Firm Age.* Year dummies are included in all specifications. Economic effects (Economic) are calculated as the product of three terms: the coefficient estimate times mean turnover density (i.e., this product is the marginal effect), times the standard deviation of the variable. ***, **, * denote significance at the 1%, 5% and 10% levels (two-tailed), respectively.

## Relation between Turnover Probability and Compensation

Table 8 CEO Turnover and Compensation: Summary statistics

***PPS sample***

| Variable | N | Mean | Median | Std Dev |
|---|---|---|---|---|
| PPS | 10,917 | 63.544 | 23.002 | 219.412 |
| Predicted TO Probability | 10,917 | 4.675 | 4.036 | 3.145 |
| $Size_{t-1}$ | 7991 | 7.628 | 7.465 | 1.789 |
| $BTM_{t-1}$ | 7991 | 0.481 | 0.417 | 0.382 |
| CEO Age | 7991 | 55.242 | 56 | 6.817 |
| CEO Tenure | 7991 | 8.985 | 7 | 6.317 |
| Firm Age | 7991 | 26.861 | 23 | 19.568 |
| Risk_Idio $_{t-1}$ | 7991 | 0.369 | 0.317 | 0.197 |
| Risk_Peer $_{t-1}$ | 7991 | 0.167 | 0.137 | 0.125 |
| $Ret_{t}$ | 7991 | 0.185 | 0.113 | 0.564 |
| $Ret_{t-1}$ | 7991 | 0.224 | 0.136 | 0.632 |
| CEO Equity Holding $_{t-1}$ | 7991 | 0.017 | 0.003 | 0.044 |

***Compensation sample***

| Variable | N | Mean | Median | Std Dev |
|---|---|---|---|---|
| Change in Cash Comp | 13,346 | 136.018 | 69.715 | 1,350.75 |
| Change in Total Comp | 13,196 | 292.058 | 124.702 | 10,992.81 |
| Predicted TO Probability | 13,346 | 4.750 | 4.093 | 3.036 |
| $Size_{t-1}$ | 13,346 | 7.446 | 7.262 | 1.749 |
| $BTM_{t-1}$ | 13,346 | 0.515 | 0.440 | 0.409 |
| CEO Age | 13,346 | 55.570 | 56 | 7.346 |
| CEO Tenure | 13,346 | 9.633 | 7 | 7.460 |
| Firm Age | 13,346 | 25.744 | 22 | 18.729 |
| Risk_Idio $_{t-1}$ | 13,346 | 0.374 | 0.324 | 0.199 |
| Risk_Peer $_{t-1}$ | 13,346 | 0.160 | 0.130 | 0.122 |
| $Ret_{t}$ | 13,346 | 0.182 | 0.111 | 0.554 |
| $Ret_{t-1}$ | 13,346 | 0.219 | 0.129 | 0.669 |

Notes: *PPS:* the change in the dollar value of the CEO's restricted stock grants and option grants for a 1% change in stock price in year t; *Change in Cash Comp:* the change in cash compensation, and measured as cash compensation in year t minus cash compensation in year t-1 ; *Change in Total Comp:* the change in total compensation, and measured as total compensation in year t minus total compensation in year t-1; *Predicted TO Probability:* the predicted value from the model in Column (1) of Table 2 times 100; *Size:* the logarithm of total assets (compustat data6, in millions) measured at year t-1; *BTM:* the book to market ratio, and measured as book value over market value of equity at year t-1; *CEO age*: age measured in years; *Tenure*: years being on the current CEO position; *Firm age*: the age of the firm the CEO serves measured in years (using CRSP monthly return data); *Risk_ Idio:* the standard deviation of residuals from regression of daily stock returns on daily industry median returns at year t-1; *Risk_ peer:* the standard deviation of the predicted values from regression of daily stock returns on daily industry median returns at year t-1; $Ret_{t}$: stock returns at year t; $Ret_{t-1}$: stock returns at year t-1; *CEO Equity Holding* $_{t-1}$: the percentage of shares owned by the CEO at year t-1

Table 9 Relation between Turnover Probability and Pay-Performance-Sensitivity

| | (1) | (2) | (3) |
|---|---|---|---|
| **Predicted TO Probability** | **-0.018*** ** | **-0.039*** ** | **-0.015* ** |
| | **(-3.09)** | **(-6.07)** | **(-1.81)** |
| Size $_{t-1}$ | 0.491*** | 0.512*** | 0.502*** |
| | (34.01) | (33.57) | (32.30) |
| BTM $_{t-1}$ | -0.885*** | -0.852*** | -0.838*** |
| | (-8.71) | (-8.60) | (-8.60) |
| CEO age | -0.009*** | -0.006** | -0.007** |
| | (-2.91) | (-2.11) | (-2.20) |
| CEO tenure | 0.007** | 0.005 | 0.007** |
| | (2.37) | (1.62) | (2.16) |
| Firm Age | -0.004*** | -0.002** | -0.002** |
| | (-3.30) | (-2.32) | (-2.25) |
| Ret $_t$ | 0.658*** | 0.658*** | 0.657*** |
| | (21.39) | (21.42) | (21.47) |
| CEO Equity Holding $_{t-1}$ | -0.738 | -0.828 | -0.761 |
| | (-1.27) | (-1.44) | (-1.34) |
| Risk_Idio | | 0.571*** | 0.254 |
| | | (4.24) | (1.63) |
| Risk_Peer | | 0.658*** | 0.756*** |
| | | (3.62) | (3.99) |
| Ret $_{t-1}$ | | | 0.130*** |
| | | | (4.56) |
| Constant | -0.521*** | -1.050*** | -0.956*** |
| | (-2.70) | (-4.75) | (-4.36) |
| Observations | 7991 | 7991 | 7991 |
| Adj. $R^2$ | 0.56 | 0.56 | 0.56 |

**Note:** The dependent variable is the logarithm of (1+PPS), with PPS (pay performance sensitivity) is the change in the dollar value of the CEO's restricted stock grants and option grants for a 1% change in stock price in year t defined in table 8. Predicted turnover probability is estimated using the specification in table 2, column 1. All the other variables are as defined in table 8. Industry (defined at 2-digit SIC levels) fixed effects and year dummies are included. t statistics is below each coefficient and estimated using robust standard error clustered at firm level. ***, **, * denote significance at the 1%, 5% and 10% levels (two-tailed), respectively.

Table 10 Relation between Turnover Probability and Changes in Compensation Levels

| | (1)<br>Change in Cash Comp. | (2)<br>Change in Total Comp. |
|---|---|---|
| **Predicted TO Probability** | **4.811** | **-288.905*****  |
| | **(0.84)** | **(-3.10)** |
| Size $_{t-1}$ | 48.184*** | 149.512 |
| | (5.56) | (1.49) |
| BTM $_{t-1}$ | -26.789 | 67.871 |
| | (-0.88) | (0.29) |
| CEO age | 0.757 | 2.460 |
| | (0.82) | (0.26) |
| CEO tenure | -1.792 | -4.967 |
| | (-1.40) | (-0.64) |
| Firm Age | 0.489 | 0.654 |
| | (1.17) | (0.21) |
| Risk_Idio | 58.917 | 1,900.173 |
| | (0.67) | (1.28) |
| Risk_Peer | -135.154 | -2,271.832* |
| | (-1.19) | (-1.73) |
| ret $_{t}$ | 239.509*** | 1,560.775*** |
| | (7.95) | (4.39) |
| ret $_{t-1}$ | 33.976** | -75.561 |
| | (2.05) | (-0.16) |
| Constant | -316.683*** | -1,466.910* |
| | (-3.96) | (-1.71) |
| Observations | 13346 | 13196 |
| Adj. $R^2$ | 0.02 | 0.01 |

**Note:** *Change in Cash Comp* is the change in cash compensation, measured as cash compensation in year t minus cash compensation in year t-1 ; *Change in Total Comp* is the change in total compensation, measured as total compensation in year t minus total compensation in year t-1; Predicted turnover probability is estimated using the specification in table 2, column 1. Industry (defined at 2-digit SIC levels) fixed effects and year dummies are included. t statistics are in parentheses below each coefficient and are estimated using robust standard error clustered at firm level. All other variables are as defined Table 8. ***, **, * denote significance at the 1%, 5% and 10% levels (two-tailed), respectively.