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Termination risk and managerial risk taking

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Abstract

We test the hypothesis that managers who face a high termination risk make less risky investments than the managers who face a low termination risk. A 10% increase in our measure of termination risk is associated with a 5%–23% decline in stock returns volatility for the median firm in our sample. We also find that for CEOs who are more likely to be fired in the event of investment failure, the inhibiting effect of termination risk appears to offset the positive effect of convexity of managerial compensation on managerial risk taking. These results are robust to alternative definitions of forced turnover and various measures of firm performances.

JEL classification: G30; J33
Keywords: Executive compensation; Management turnover; Incentive contacts; Volatility

1. Introduction

Being a CEO is becoming an increasingly risky business in the wake of emerging shareholder activism. More and more boards are terminating their CEOs for poor financial performance. A 2002 study by Booz, Allen and Hamilton reported that average CEO career declined by 23% from 1995 to 2001. During the same period the forced turnover of CEOs due to poor performance increased by 130%. This increasing threat of termination may have implications for managerial investment decisions. However, the current literature is primarily concentrated on the effect of compensation on managerial investment decisions and ignores the impact of increasing termination risk. Previous studies find that compensation convexity is related to (i) reduced

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hedging (Rogers, 2002), (ii) riskier investment choices (Coles et al., 2006), and (iii) increased stock return volatility (Guay, 1999; Cohen et al., 2000). In this paper, we document how termination risk affects managerial investment decisions. We argue that managerial investment decisions depend not only on how a manager's compensation changes with firm risk but also on how his/her job is affected if the project fails.

Prior work indicates that increases in risk taking are associated with an increased probability of poor firm performance (Bloom and Milkovich, 1998). Numerous other studies also find that poor performance is one of the most important predictors of forced turnover.[1] When a manager makes an investment decision, the ex ante risk that she will be forced out due to the failure of the project depends on the termination risk conditional on investment failure and the probability that the project will fail. Given that higher firm risk increases the probability of project failure, managers will take termination risk into account in determining the risk level that they will accept in making risky investments. More specifically, a higher probability of being fired due to poor performance (higher termination risk) would induce the manager to reduce firm risk. Moreover, when managers are faced with high termination risk, they will be less motivated to take on higher risk projects in response to increased convexity of their compensation structures. In other words, the negative impact of increased termination risk would partially offset the positive impact of convexity on managerial risk taking.

To test our hypotheses, we extracted executive compensation information from the ExecuComp databases, and hand collected data on the reasons for CEO turnover for the years 1993–2000. With this information, we estimate the probability of forced termination for each poorly performing CEO, and then use the estimated coefficients to predict a termination propensity for all CEOs. This estimated conditional termination propensity (CTP) is our measure of termination risk. We find two interesting results: First the CEOs who face high termination risk make less risky investments. Second, for the CEOs who are more likely to be fired in the event of investment failure, the inhibiting effect of termination risk appears to offset the positive effect of convexity on managerial risk taking.

In our empirical work we are cognizant of the fact that compensation, risk taking and termination may be jointly determined. We have used lagged compensation in all our empirical specifications to reduce the impact of simultaneity. We have also addressed this issue more directly by using a simultaneous equations framework to test the robustness of our results. Specifically, we estimate the impact of termination risk on managerial risk taking in a setting where components of the compensation contract and firm risk are jointly determined. Our primary findings remain unchanged in this joint specification.

The remainder of the paper is organized as follows. Section 2 presents a brief survey of the literature. Section 3 develops the motivation and hypotheses. Section 4 describes the data and the measures of compensation sensitivity to performance. Section 5 presents a discussion of results, and Section 6 concludes with a summary of the main results. Appendix A presents a reduced-form model that describes the relation between managerial risk taking and expected termination risk.

2. Motivation and related literature

Our empirical investigation is motivated by the role of termination risk in managerial risk taking. Recent research indicates that there has been a dramatic increase in the sensitivity of CEO

[1] See for example, Coughlan et al. (1985), Warner et al. (1988), Weisbach (1988), Gilson (1989), Morck et al. (1988), and Murphy and Zimmerman (1993).

compensation to stock prices (Hall and Leibman, 1998). Firms link managerial pay to performance to reduce the agency cost arising from the separation of ownership and control. However, an increase in such sensitivity – delta – also increases the managers' exposure to risk. At certain (low) levels of wealth diversification, the manager may prefer not to increase the risk associated with his/her large investment in human capital, and this would induce him/her to forego risky but positive-NPV investments. The use of options, rather than stocks, in compensation packages can offset some of the disincentives to invest in risky projects since option value is positively related to stock price volatility.

There is empirical work that finds evidence that increased convexity in compensation contract is related to increased managerial risk taking. Tufano (1996) studies managers in the North American gold industry by comparing managers who hold more stock to those who hold more options. He finds that managers who hold more options take smaller hedging positions to manage their firms' gold price risk. Similarly, Schrand and Unal (1998) analyze managers' behavior following the conversion of thrifts to public stock companies. They find that managers who are granted options at the time of conversion increase their firms' total risk significantly more than the managers who are not granted options. Using data from the oil and gas industries, Rajgopal and Shevlin (2002) find that stock option ownership by managers is related to increased firm risk.

Several other studies use methodologies that are closely related to ours. Guay (1999) finds that an increase in convexity is associated with greater stock returns volatility. Cohen et al. (2000) find, in addition to this result, that the compensation convexity associated with managers' options has a positive relation with returns volatility. More recently, Coles et al. (2006) find that increased convexity is related to increased stock price volatility, to increased firm focus and to higher leverage.

We argue that managerial incentives to undertake risky projects depend not only on how the manager's compensation changes with firm risk, but also on whether keeping his/her current job depends on the success of his/her investments. Job loss due to poor performance results in significant costs, including reputation costs and the loss of future job opportunities. A significant body of empirical research indicates that poor performance is the most important determinant of involuntary turnover (Coughlan et al., 1985; Gilson, 1989; Murphy and Zimmerman, 1993). Unfortunately, a direct measure of the *ex ante* threat of termination is not available because employment contracts do not specify performance thresholds for termination. However, a measure of expected termination risk for underperforming CEOs can be estimated, based on the historical probability of forced termination among poorly performing firms. We call this measure the conditional terminal propensity (CTP).

Intuitively, CTP measures the manager's risk of termination due to poor performance, prior to making risky decisions. In different firms, the same performance may lead to opposite outcomes for the manager; the manager of a high CTP firm may be fired, whereas the manager of a low CTP firm may not be. Although the manager has no control over the CTP, she does control the risk that she will perform poorly. The *ex ante* probability that the manager will be fired as a consequence of accepting a project is the product of the CTP and the probability that the investment will fail.

Given that increasing firm risk increases the probability of poor performance (Bloom and Milkovich, 1998), we expect that a manager in a higher CTP firm will be less likely to make risky investments, *ceteris paribus*; that is, we predict a negative relation between conditional termination propensity (CTP) and managerial risk taking.

Hypothesis 1. Managers at high CTP firms are less likely to choose risky investments than managers at low CTP firms.

Moreover, we expect that the CTP will also have an effect on the relation between compensation convexity and managerial risk taking. As discussed above, empirical studies have documented that increased convexity is positively associated with managerial risk taking. However, one would expect that managers facing high CTP will be less inclined to take on higher risk projects, for the same level of compensation convexity. We predict that the marginal effect of convexity on managerial risk-taking is weaker when the termination threat is higher.

Hypothesis 2. The impact of increased convexity is weaker for CEOs of high CTP firms and stronger for CEOs of low CTP firms.

In Appendix A, we present a reduced-form model that describes the relation between managerial risk taking and expected termination risk. We show that both of our hypotheses can be derived from this model.

3. Data and sample construction

We obtain a sample of CEOs from the 1992–2000 ExecuComp databases.[2] We exclude firms that are subject to regulation and those in the financial sector by dropping all firms in SIC codes 4910–4949 and 6000–6999. After these deletions, we have a sample of 10,441 firm-year observations from 1993 to 2000.

We define turnover as a change in the CEO from 1 year to the next. After deleting departing CEOs who have less than 2 years of data, our sample contains 7417 firm-year observations: 116 forced turnover observations, 704 voluntary turnover observations and 6597 no-change observations. We omit all non-forced turnover observations, and observations that do not have the compensation details required for calculating delta and convexity (vega). This leaves us with 5800 firm-year observations. We lose 1949 observations due to missing data; a majority of these (1445) are due to missing institutional holding data. Because we are interested in poor performers, we compute three relative performance measures for each firm-year observation. Our remaining samples of poor performers include (a) 2277 firm-year observations for firms with negative 1-year industry-adjusted returns, (b) 1905 firm-year observations for firms with negative 3-year industry-adjusted returns and (c) 1449 firm-year observations for firms with negative 1-year industry-adjusted return on equity (ROE). We use this data to estimate CTP.

We use the annualized standard deviation of daily stock returns over the past fiscal year as our measure of firm risk. Since stock price volatility reflects the market's assessment of both the net effect of all CEO risky investments and market risk, and since the CEO's compensation depends on both types of risk, it is an appropriate proxy for the risk that is relevant to his/her decisions.

3.1. Definition of forced turnover

The ExecuComp databases provide four reasons for CEO turnover: resignation, retirement, death and unknown. To estimate the termination propensity conditional on poor performance we need to distinguish between forced and non-forced turnover. For this purpose, we search business news and wire service items in the Lexis–Nexis Academic Universe database. In order to correctly identify the reason for the CEO change, we review multiple news items for each termination. We are able to identify reasons for all 820 CEO changes that survive our screening.

[2] Since we require that each CEO have at least 2 years of data, to obtain lagged values for compensation, the sample is for the period 1993–2000.

Table 1
Details of the sample frequencies of reasons for CEO turnover for the period 1993–2000

Reason	Frequency of turnover
Mandatory retirement	197
Retired – but stayed with the company	299
Forced resignation/conflict	47
Mergers/Acquisitions/Takeover attempt	42
Poor performance mentioned	40
Moved to another prestigious position	36
Death/Illness	29
No reason identified	26
Personal reasons/pursue other interests	26
Other	25
Interim CEO	14
Co-CEO	13
Went to another subsidiary/spin off	10
Restructuring/New leadership	6
No news found	7
The executive is not CEO	3
Total	820

An executive is classified as a CEO if she is coded in the ExecuComp data set as CEO and this information is subsequently verified in the news item search. A CEO change is defined as a change in the identity of the CEO in the ExecuComp data set from one year to the next. The reason for the change was identified through a comprehensive search of the Lexis–Nexis Academic Universe database.

We classify a CEO change as forced if the news item or article (1) specifically says that it is forced, (2) mentions poor performance or dissatisfaction with financial results, (3) mentions restructuring or new leadership, or (4) gives no reason and the CEO is less than 60 years old. Using these criteria, we classify 116 of our 820 CEO changes (14.2%) as forced turnover. Table 1 shows the numbers of observations classified under each category. Retirement, both mandatory and voluntary, is the most common reason for CEO turnover.

Our method of identifying forced turnover is similar to the methods used by Weisbach (1988), Hadlock and Lumer (1997), Huson et al. (2001), and Fee and Hadlock (2004), among others. As Fee and Hadlock (2004) point out, many researchers exclude turnovers due to changes in control.[3] However, we include in our forced turnover category those observations for which a news item mentions restructuring or new leadership as a reason for CEO change.

Our overall turnover rate of 9.87% is consistent with turnover rates reported by other researchers, which range from 8.8% to 12.2% (Weisbach, 1988; Parrino, 1997, respectively). In our study, forced turnovers are 14.2% of all turnovers, which is comparable to the 16.2% reported by Huson et al. (2001) and the 17.1% reported by Hartzell (2001). We are more conservative than these researchers in classifying a change as a forced termination. They consider all retirements as forced turnover if the CEO is less than 60 years old and the retirement is not announced at least six months in advance, whereas we do not include any retirements in the forced termination category. We find that when we substitute the less conservative definition used by Huson et al. (2001) and

[3] CEO departures following mergers and acquisitions (M&As) are often a side effect of the M&A decision. This is especially true for the period of our analysis (the 1990s), during which there were, compared to the 1980s, a relatively large number of consolidating mergers relative to hostile takeovers. In "friendly" M&As, the CEO of the acquired firm either voluntarily resigns, in order to avoid personality clashes with the CEO of the acquiring firm, or she takes a subsidiary role such as President or Chief Operating Officer (COO). For this reason, we do not include M&A related CEO turnover in our forced turnover category.

Hartzell (2001), our results are unchanged. We also test the robustness of our results to two other definitions of the forced-turnover category: first, we add M&A related turnovers to our conservative definition, and second, we add retirements of CEOs who are less than 60 years old. Our results remain unchanged with both of these broader definitions.

3.2. Measuring the delta and convexity of the compensation contract

We define delta as the dollar change in the CEO's portfolio of stocks and options in response to a 1% change in stock price. We define convexity as the dollar change in the CEO's portfolio of options in response to a 1% change in stock price volatility (the portfolio's vega). We use the Core and Guay (2002) methodology for estimating delta and convexity, and for valuing stock option portfolios. This method is easy and involves low computational costs, as it requires information from only the most recent proxy statement.

4. Estimation and methodology

To estimate the impact of compensation and termination risk on managerial risk taking, we first estimate the probability of forced turnover and predict the conditional termination propensity (CTP) for all CEOs. Then we estimate the impact of termination risk (the predicted CTP) on managerial risk taking. We use three industry-adjusted returns to identify poor performers. The first two measures are industry-adjusted 1- and 3-year holding period stock returns, where the industry average is the mean for firms with the same 2-digit SIC code. The third measure is the 1-year industry-adjusted return on equity (ROE), which is computed with the same method.

4.1. Estimating conditional termination propensity (CTP)

To estimate CTP, we first run logit regressions in which the dependent variable is a binary variable that equals one if the firm-year includes a forced CEO termination, and zero otherwise. Specifically, we estimate the following equation:

$$\begin{aligned}&\text{Probability}\ (\text{Termination}|\text{Poor Performance})_t\\&\quad = F(\text{CEO, Compensation, Firm, and Governance characteristics}).\end{aligned} \tag{1}$$

We then use the coefficients from this regression to estimate the probability of termination for all CEOs. This estimated probability is referred to as the conditional terminal propensity (CTP) and is our proxy for termination risk in our main regressions.

We include in our regressions several CEO characteristics that may potentially affect the probability of forced turnover. First, previous research has found that large CEO stock holdings are related to a lower probability of termination. Based on previous research findings, we assume that CEOs who own more than 5% of their firm's stock may have enough power to protect themselves from being terminated for poor performance.[4] Therefore, we include a dummy variable that equals one if the CEO has stock holdings of at least 5%; we expect a negative coefficient on this variable.

Similarly, CEOs who are members of the firm's founding family are likely to enjoy considerable influence and power. Previous studies have found that founding family CEOs have large stockholdings (Parrino, 1997), and that they appear to be removed less frequently (Morck et

[4] Salnacik and Pfeffer (1980) categorize firms with CEO ownership of 4% or more as owner managed firms.

al., 1988). We include a founding family dummy variable that equals one if the CEO is a member of the founding family; we expect a negative coefficient on this variable. We also include the level of CEO total compensation and CEO tenure as CEO characteristic variables. Highly paid CEOs are usually powerful enough to make it difficult to remove them for poor performance. Longer tenure may allow CEOs to build powerful relationships with their board members, which they can use to affect turnover decisions (Goyal and Park, 2002). We predict a negative sign on the CEO total compensation and tenure coefficients.

We include two governance structure variables: one to capture the relation between effective governance and the probability of terminating an underperforming CEO, and one to capture the influence of the board of director's monitoring of the CEO. Firms with weak governance provisions (weak shareholder rights), are less likely to fire a CEO for poor firms with strong shareholder rights. We use Gompers et al. (2003) G-Index as our corporate governance measure and expect a negative sign on the G-Index variable.

It is commonly accepted that large institutional stockholders act as outside monitors because their large positions give them both the motivation and the ability to monitor firms in which they hold stock. Denis et al. (1997) find that the presence of outside block holders significantly increases the probability of forced termination due to poor performance, although this relation is not statistically significant. We include a dummy variable that equals one if the firm has institutional holdings of 5% or more and expect a positive coefficient on this variable.

Firm size is another variable that may impact the probability of terminating poorly performing CEOs (Parrino, 1997; Warner et al., 1988). Several size related characteristics may be relevant. For example, larger firms have a bigger talent pool, which may make it easier to replace CEOs. Further, analysts and the financial press follow large firms closely, making it difficult to hide bad news. We include the natural log of sales to control for firm size. We expect a positive sign on this variable.

Firms with greater growth opportunities are characterized by greater information asymmetry between management and shareholders compared to firms with fewer growth opportunities, and increased information asymmetry makes monitoring of CEOs more difficult. Following Smith and Watts (1992), we use the market-to-book ratio as a proxy for growth opportunities. We expect to find a positive sign on this variable.

Our compensation control variables are delta, the sensitivity of CEO compensation to stock price, and convexity, the sensitivity of CEO compensation to volatility (vega). Delta and the threat of termination may be substitute mechanisms for discouraging CEO risk taking. (Hartzell, 2001). Convexity, on the other hand, encourages risk taking and may be positively related to termination. In all regressions for estimating the CTP, we also include an industry-adjusted lagged performance variable to capture performance level effects.

4.2. Estimating termination risk, compensation and firm risk

As mentioned earlier, our measure of firm risk is the annualized standard deviation of daily stock returns over the past fiscal year. We use the conditional termination propensity (CTP) as a proxy for termination risk in the following equation:

$$\begin{aligned}\text{Volatility}_t = F(&\text{Termination risk}, \quad \text{Compensation components}_{t-1}, \text{ CEO},\\ &\times \text{Firm and} \quad \text{Industry controls}).\end{aligned} \tag{2}$$

The variables of interest in this equation are the CTP, which is estimated in Eq. (1), and convexity. As noted above, we expect to find a negative relation between CTP and firm risk.

Table 2
Summary statistics

Variable	Forced turnover [median (S.D.)]	Non-forced turnover [median (S.D.)]	No turnover [median (S.D.)]
Sales ($ millions)	1126.72 (8525.95)	1242.97 (12 872.71)	1069.71 (10 854.65)
Market-to-book	1.48 (1.01)	1.55 (1.61)	1.66 (2.36)
Institutional holdings (%)	19.67 (16.38)	13.95 (15.76)	15.10 (15.89)
Leverage	0.70 (9.97)	0.52 (26.76)	0.47 (5.53)
G-Index (0–24)	9.00 (2.61)	9.00 (2.86)	9.00 (2.76)
1-year stock returns (%)	−36.32 (64.12)	−15.13 (273.99)	−8.83 (761.96)
3-year stock returns (%)	−20.83 (22.65)	−5.54 (24.73)	−1.35 (28.45)
Return on equity (%)	−4.24 (454.01)	2.62 (186.56)	3.77 (345.50)
Stock return volatility (%)	49.06 (21.23)	36.89 (20.82)	37.04 (20.26)
Tenure as CEO (years)	3.00 (4.22)	8.00 (8.20)	6.00 (7.22)
Shares owned (%)	0.19 (2.56)	0.47 (6.39)	0.52 (7.68)
Delta ($ $\times 10^3$)	117.32 (395.05)	167.50 (2382.64)	176.39 (4033.97)
Convexity ($ $\times 10^3$)	48.86 (101.90)	30.52 (108.44)	32.39 (165.40)
Cash compensation ($ $\times 10^3$)	681.02 (785.61)	823.24 (907.13)	800.00 (1001.32)
Total compensation ($ $\times 10^3$)	1552.02 (15 009.61)	1488.52 (3873.64)	1868.00 (15 397.30)
No. of firm-years	116	704	6597

Comparison between firm-years with and without forced CEO turnover in the following fiscal year. Size is measured by natural log of sales. Market-to-book is [Book value of debt + Market value of equity]/[Book value of assets]. Institutional holdings are institutional block holdings of 5% or more. Leverage is [Book value of debt]/[Market value of equity]. G-Index is the governance index of Gompers et al. (2003). 1-year and 3-year stock returns and 1-year ROE are net of two-digit SIC industry averages. Stock return volatility is the annualized standard deviation of daily stock returns over the last 120 trading days of the fiscal year. Tenure is the number of years the CEO has been in office. Shares owned are CEO's stock holdings as a percent of total equity. Delta and Convexity are the changes in CEO portfolio wealth for a 1% change in stock price and for a 1% change in volatility, respectively. Cash compensation includes salary and bonus. Total compensation includes salary, bonus, other annual compensation, restricted stock and stock options granted during the year and long-term incentive payouts. All variables are measured at fiscal year end. Standard deviation is in parenthesis.

We use lagged values of delta and convexity in order to avoid any concerns for simultaneity of risk and compensation.[5] An increase in delta increases the CEOs exposure to firm risk, and consequently discourages him/her from taking risks. On the other hand, higher convexity increases his/her incentive to accept risk, since the value of his/her option portfolio increases with firm risk. We expect a negative coefficient on delta and a positive coefficient on convexity.

Tenure with the firm is one of our CEO variables. Following May (1995), we assume that CEOs who have longer tenure have more human capital invested in their firms. CEOs with longer tenure have less diversified human asset portfolios, and therefore have less motivation to accept high risk projects. We also include cash compensation as a proxy for CEO's outside wealth following Guay (1999). Cash compensation, as opposed to compensation in stock and options, reduces the manager's exposure to firm performance risk, since it does not depend on stock price or volatility. This encourages him/her to increase firm risk. We therefore predict a positive relation between cash compensation and managerial risk taking.

Among firm variables, we control for the growth potential of the investment opportunities available to the firm and the firm's level of financial leverage, both of which affect firm risk. We measure the growth potential of a firm's investment opportunities with the market-to-book ratio,

[5] We run an AR (1) fixed effects regression of volatility on lagged convexity, lagged delta and other control variables, as a preliminary check of endogeneity. The correlation between ui and the explanatory variables is less than 4%.

and leverage with the debt-to-equity ratio. We also include a proxy for size, the natural log of sales. Finally, we include industry dummy variables to control for industry differences.

4.3. Summary statistics

Table 2 presents summary statistics for sub samples of forced turnover, non-forced and no-turnover firms. Firms that experience forced turnover have a median industry-adjusted stock return in the previous year of −36.32% and a median industry-adjusted annualized stock return in the previous 3 years of −20.83%. In contrast, no-turnover firms have a median industry-adjusted stock return in the previous year of −8.83% and in the previous 3 years of −1.35%. *T*-tests indicate that the returns of the forced turnover firms are significantly less than zero, while returns of the no turnover firms are not. Thus, the forced turnover firms perform significantly worse than the no-turnover firms. The results for return on equity are similar.[6]

Among the CEO characteristics, the median cash compensation (salary and bonus) for CEOs at forced turnover firms is $681,000 whereas it is $800,000 at no-turnover firms. Similarly, CEOs who are forced to resign get less total compensation (including salary, bonus, other annual compensation, restricted stock and stock options granted during the year and long-term incentive payouts) compared to CEOs who are not terminated. The median total compensation is $1,552,000 for CEOs at forced turnover firms and $1,868,000 for CEOs at no-turnover firms. Note also that the compensation contract of forced out CEOs has a lower median delta and a higher median convexity compared to CEOs at no-turnover firms. Finally, CEOs at forced turnover firms have a median tenure that is half that of CEOs at no-turnover firms.

5. Results

5.1. Conditional termination propensity (CTP)

Table 3 presents the estimated coefficients of the logit regression, Eq. (1). The coefficients are used to estimate the probability of termination conditional on poor performance (CTP) for all firms. The CEO years included in the sub sample for Model (1) have negative 1-year industry-adjusted returns; their mean (median) estimated CTP is 0.0376 (0.0217), with a standard deviation of 0.0474. The Model (2) CEO years have negative 3-year industry-adjusted stock returns; their mean (median) CTP is 0.0403 (0.0205), with a standard deviation of 0.0562. And the CEO years included in Model (3) have negative 1-year industry-adjusted ROEs; their mean (median) CTP is 0.0482 (0.0287), with a standard deviation of 0.0646.

Among the coefficients of interest in Table 3, the coefficient of lagged convexity is positive and significant in all three specifications, which implies that higher convexity is associated with an increased CTP. However, the coefficient of lagged delta is negative and statistically significant only in two specifications. This suggests that delta and termination risk may be substitutes; that is, the managers whose compensation is more sensitive to stock price are less likely to be fired for poor performance, as mentioned by Hartzell (2001).

Among the control variables, only a few are significant at the 5% level or higher. CEO tenure is negative and significant in all specifications. This is consistent with the idea that CEOs with longer tenure are more difficult to terminate because they often have friendly relationships with

[6] Only two forced turnover firms have one or more positive industry-adjusted returns. In contrast, over 70% of the firms with non-forced turnover had one positive industry-adjusted return.

Table 3
Estimating the conditional termination propensity

Variables	1-year industry-adjusted returns	3-year industry-adjusted returns	Industry-adjusted return on equity
	(1)	(2)	(3)
Convexity$_{-1}$ ($\times 10^{-3}$)	2.5983*** (0.006)	3.4238*** (0.004)	1.7324** (0.030)
Delta$_{-1}$ ($\times 10^{-3}$)	−1.0717** (0.040)	−2.0021** (0.044)	−0.3565 (0.369)
Total compensation$_{-1}$ ($\times 10^{-6}$)	−0.0619 (0.181)	−0.0387 (0.411)	−0.0173 (0.584)
Tenure	−0.0988*** (0.009)	−0.1312*** (0.003)	−0.1051** (0.015)
Stock ownership (<5%)	0.7476 (0.302)	1.1992 (0.258)	1.3656 (0.188)
Founding family	−0.8953 (0.270)	−0.8008 (0.330)	−1.3648 (0.212)
Size	0.0731 (0.429)	0.0965 (0.357)	0.0471 (0.608)
Market-to-book	−0.1785 (0.244)	−0.4337* (0.071)	−0.2136 (0.120)
5% Institutional holdings	0.0016 (0.826)	0.0024 (0.765)	0.0126 (0.123)
G-Index	−0.1143** (0.013)	−0.1167** (0.011)	−0.0659 (0.252)
1-year stock returns$_{-1}$	−0.0004 (0.756)		
3-year stock returns$_{-1}$		0.0005 (0.949)	
Industry-adjusted ROE$_{-1}$			−0.0009 (0.537)
Observations	2199	1829	1298
Pseudo R^2	13.8%	16.4%	15.6%

The dependent variable equals 1 if the current CEO is forced out during the following fiscal year. Only forced turnover firm-years are included. The three sub-samples of underperformers, shown in columns (1), (2) and (3), are selected based on three industry-adjusted (two-digit SIC code) returns: 1-year stock returns, 3-year stock returns and 1-year ROE, respectively. Delta and Convexity are the changes in CEO portfolio wealth for a 1% change in stock price and for a 1% change in volatility, respectively. Total compensation includes salary, bonus, other annual compensation, restricted stock and stock options granted during the year and long-term incentive payouts. Tenure is the number of years the CEO has been in office. Stock ownership is a dummy variable that equals 1 if the CEO stock holdings are less than 5%. Founding family is a dummy variable that equals 1 if the CEO is from the founding family. Size is measured by natural log of sales. Market-to-book is [Book value of debt+Market value of equity]/[Book value of assets]. Institutional holdings are institutional block holdings of 5% or more. G-Index is the governance index of Gompers et al. (2003). The industry and year dummy variable coefficients are not reported.
p-values are in parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

board members. The G-Index (governance index) coefficient is negative and significant in two of the specifications, which provides some indication that firms with weak shareholder rights (strong managerial powers) are less likely to fire their CEOs for poor performance. Interestingly, the performance variables are not significant in any of the specifications, which may indicate that below a certain threshold, the actual level of performance does not have an impact on the probability of termination.

5.2. Impact of termination risk on firm risk

Table 4 documents results from robust least squares regressions that test the relation between firm risk and both CTP and compensation risk (Eq. (2)). The standard errors of the estimations that include CTP have been corrected for the forecasting error associated with the CTP estimates. We correct the standard errors by means of a bootstrapping procedure with 500 repetitions.

The first column in Table 4 presents the results of our benchmark regression, which is similar to those used by Coles et al. (2006). The estimates of CTP used in Models (1), (2) and (3) are computed using sub samples of firms with negative industry-adjusted returns, identified using three measures: 1-year stock returns, 3-year stock returns and 1-year ROE, respectively.

Table 4
Termination risk and managerial risk taking

Variables		(1)	(2)	(3)
CTP		−0.3495*** (0.004)	−0.2852** (0.013)	−0.5001*** (0.000)
Convexity$_{-1}$ ($\times 10^{-3}$)	0.0949*** (0.000)	0.1046*** (0.000)	0.1006*** (0.000)	0.1088*** (0.000)
Delta$_{-1}$ ($\times 10^{-6}$)	0.3111 (0.675)	0.0372 (0.970)	0.1346 (0.900)	−0.1847 (0.863)
Cash compensation$_{-1}$ ($\times 10^{-6}$)	4.8751 (0.240)	3.6883 (0.403)	3.8504 (0.385)	4.8425 (0.264)
Tenure ($\times 10^{-3}$)	−0.5543 (0.173)	−1.3164*** (0.004)	−1.3127*** (0.006)	−1.9668*** (0.000)
Size	−0.0582*** (0.000)	−0.0586*** (0.000)	−0.0583*** (0.000)	−0.0597*** (0.000)
Market-to-book	0.0086*** (0.000)	0.0068*** (0.006)	0.0066*** (0.007)	0.0043* (0.038)
Leverage	0.0013*** (0.010)	0.0013 (0.891)	0.0014 (0.875)	0.0013 (0.897)
Constant	0.7251*** (0.000)	0.7374*** (0.000)	0.7349*** (0.000)	0.7569*** (0.000)
Observations	2842	2842	2842	2812
R^2	35.2%	35.5%	35.5%	36.4%

The dependent variable is the annualized standard deviation of daily stock returns over the last 120 trading days of the fiscal year. CTP stands for conditional termination propensity and is the predicted probability of the CEO being terminated. The three sub samples of underperformers, shown in columns (1), (2) and (3), are selected based on three industry-adjusted (two-digit SIC code) returns: 1-year stock returns, 3-year stock returns and 1-year ROE, respectively. Delta and Convexity are the changes in CEO portfolio wealth for a 1% change in stock price and for a 1% change in volatility, respectively. Cash compensation includes salary and bonus. Tenure is the number of years the CEO has been in office. Size is measured by natural log of sales. Market-to-book is [Book value of debt+Market value of equity]/[Book value of assets]. Leverage is [Book value of debt]/[Market value of equity]. The industry dummy variable coefficients are not reported.
The *p*-values are based on standard errors estimated using a bootstrapping procedure with 500 repetitions. *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

The coefficients on the variable of interest, CTP are negative and strongly significant in all three specifications that include CTP. This outcome supports our hypothesis that increased termination risk is associated with less CEO risk taking. For example, the Model (1) results indicate that a 10% increase in the conditional termination propensity is related to a decline in volatility of 9.20% for the median firm in the sample. The comparable declines are approximately 7.51% and 13.16% for Models (2) and (3), respectively.

As expected, the coefficients on lagged convexity are positive and significant. However, the magnitude of convexity's impact on firm risk is much smaller than that of termination risk. The number of observations is greater in Table 4, in which we use the full sample of firms, than in Table 3, in which we use only a sub sample of firms.

Although we expected delta to be negatively related to volatility, it is negative only in one specification and is statistically insignificant in all three specifications. Among the firm characteristic control variables, the coefficient on the market-to-book ratio, our proxy for growth opportunities, is positive and significant in all specifications. Since higher market-to-book ratios are assumed to imply higher growth opportunities, and hence more information asymmetry between management and investors, this result is consistent with our expectation that firms with higher market-to-book ratios have greater returns volatility. Leverage, on the other hand, is positively related to volatility, as anticipated, but is insignificant in all specifications. The relation between firm size and volatility is negative, as expected, and strongly significant, which is consistent with previous research findings.

5.3. Robustness checks

We check for the robust of our results in several ways in Table 5. Panel A reports results when we add firm specific fixed effects to control for firm heterogeneity. Again the coefficients on CTP

Table 5
Termination risk and managerial risk-taking – robustness tests

Variables	Panel A			Panel B		
	Firm fixed effects			Least absolute deviation		
	(1)	(2)	(3)	(1)	(2)	(3)
CTP	−0.7016*** (0.000)	−0.7912*** (0.000)	−0.8888*** (0.000)	−0.3450*** (0.000)	−0.2750*** (0.000)	−0.4868*** (0.000)
Convexity$_{-1}$ ($\times 10^{-3}$)	0.1123*** (0.002)	0.1057*** (0.002)	0.1378*** (0.000)	0.1297*** (0.003)	0.1226*** (0.006)	0.1149*** (0.002)
Delta$_{-1}$ ($\times 10^{-6}$)	−1.0409 (0.414)	−0.9147 (0.503)	−1.3399 (0.502)	1.0586 (0.430)	1.1924 (0.385)	1.0795 (0.390)
Cash compensation$_{-1}$ ($\times 10^{-6}$)	17.0779*** (0.004)	14.5020*** (0.009)	14.9346** (0.017)	0.5317 (0.909)	0.7257 (0.870)	0.8769 (0.861)
Tenure ($\times 10^{-3}$)	−0.9432 (0.228)	−1.6208* (0.062)	−1.6041* (0.064)	−1.2308** (0.017)	−1.3247** (0.012)	−1.5375*** (0.004)
Size	0.0626*** (0.000)	0.0628*** (0.000)	0.0571*** (0.000)	−0.0502*** (0.000)	−0.0505*** (0.000)	−0.0504*** (0.000)
Market-to-book	−0.0017 (0.691)	−0.0022 (0.598)	−0.0033 (0.357)	0.0084*** (0.003)	0.0083*** (0.008)	0.0030 (0.350)
Leverage	0.0234** (0.018)	0.0237** (0.017)	0.0143 (0.205)	0.0009 (0.943)	0.0009 (0.945)	0.0009 (0.948)
Constant	−0.0579 (0.540)	−0.0455 (0.648)	−0.0314 (0.758)	0.6564*** (0.000)	0.6598*** (0.000)	0.6674*** (0.000)
Observations	2842	2842	2812	2842	2842	2812
R^2/Pseudo R^2	14.7%	15.9%	17.5%	21.6%	21.6%	22.3%

The dependent variable is the annualized standard deviation of daily stock returns over the last 120 trading days of the fiscal year. Panel A regressions include controls for firm-level fixed effects. Panel B contains coefficients from Least Absolute Deviation regressions. CTP stands for conditional termination propensity and is the predicted probability of the CEO being terminated. The three sub samples of underperformers, shown in columns (1), (2) and (3) of each panel, are selected based on three industry-adjusted (two-digit SIC code) returns: 1-year stock returns, 3-year stock returns and 1-year ROE, respectively. Delta and Convexity are the changes in CEO portfolio wealth for a 1% change in stock price and for a 1% change in volatility, respectively. Cash compensation includes salary and bonus. Tenure is the number of years the CEO has been in office. Size is measured by natural log of sales. Market-to-book is [Book value of debt+Market value of equity]/[Book value of assets]. Leverage is [Book value of debt]/[Market value of equity]. The industry dummy variable coefficients are not reported.
The *p*-values are based on standard errors estimated using a bootstrapping procedure with 500 repetitions. *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

are negative and strongly significant in all of the specifications, thus lending support to our hypothesis that termination risk reduces CEOs' propensity to increase firm risk. These coefficients are larger than those in the main regression tests reported in Table 4. The Panel A results also indicate that for the firms in the Model (1) each 10% increase in CTP is associated with a decline in stock price volatility of more than 18%. The relation between convexity and volatility is similar to that in the tests reported in Table 4, which do not include firm fixed effects.

Table 5, Panel B reports results from least absolute deviation (LAD) regression estimations. This methodology is intended to minimize the effect of outliers. Results are similar to those for the robust least squares estimations. The coefficients on CTP are negative and significant in all three specifications. In Model (1), a 10% increase in CTP is associated with a decline in firm risk of approximately 9%. The estimated impact of convexity on firm risk is similar to that in the robust least squares estimates. Finally, the coefficients of other control variables are similar to those in other specifications discussed above.

5.4. Impact of termination risk on firm risk: controlling for simultaneity

Although we include lagged components of compensation in all specifications, this approach may not completely control for the endogeneity of risk and compensation.[7] In order to control for endogeneity of risk and compensation, we incorporate termination risk in a system of simultaneous equations in which convexity, delta and firm risk are jointly estimated.[8] We estimate the following system of equations:

$$\text{Volatility}_t = F(\text{CTP}, \text{Convexity}_t, \text{Delta}_t, \text{Cash compensation}_t, \text{Size}, \text{Market-to-book}, \text{Leverage}, \text{CEO tenure}, \text{Industry dummies}), \quad (3)$$

$$\text{Convexity}_t = F(\text{Volatility}_t, \text{Delta}_t, \text{Cash compensation}_t, \text{Total value of options}_t, \text{Size}, \text{Market-to-book}, \text{Industry dummies}), \quad (4)$$

$$\text{Delta}_t = F(\text{Volatility}_t, \text{Convexity}_t, \text{Total wealth}_t, \text{Size}, \text{Market-to-book}, \text{CEO tenure}, \text{Industry dummies}). \quad (5)$$

The explanatory variables that are common to all three equations are the three endogenous variables (volatility, convexity and delta), firm size, the market-to-book ratio and the industry dummies. The three identifying variables in the system of simultaneous equations are the conditional termination propensity CTP in the volatility Eq. (3), the value of the CEO's option portfolio in the convexity Eq. (4), and the CEO's total portfolio wealth in the delta Eq. (5). The role of CTP in risk-taking has already been discussed extensively. The rationale for the other two identifying variables is as follows. The value of the CEO's option portfolio is the most important determinant of the CEO's compensation convexity. It affects volatility only indirectly, through its impact on convexity. It is also less correlated with the delta of CEO's contract than with its

[7] Some researchers argue that firm risk affects the pay-for-performance sensitivity. For example, see Aggarwal and Samwick (1999).

[8] Termination may also be endogenous and hence should be incorporated in the system of simultaneous equations. However, we do not know of an estimation methodology that can incorporate a binary dependent variable (termination) and three continuous variables (delta, convexity and volatility) in a system of four equations. For this reason we use the simpler, tractable, system of three equations, which we believe captures most of the endogeneity.

convexity. This is because delta is driven more by the CEO's stock holdings, which have a delta of 1, than by his/her options, which always have a delta of less than one. Similarly, the total portfolio wealth of the CEO, which includes stock and option holdings, is more closely related to the delta of the CEO's contract than to its the convexity.

Table 6 reports the results of the three-stage least squares (3SLS) estimation for Eq. (3). Although the CTPs in columns (1), (2), and (3) were estimated using the three sub samples of underperformers, all CEO years are included in these tests, regardless of performance level. The sample size is larger than in previous tables because these samples include current, rather than lagged values of delta and convexity. The standard errors have been corrected for forecasting error by means of a bootstrapping procedure with 500 repetitions.

The results confirm our main findings. The coefficient on CTP is negative and strongly significant in the estimations of all three specifications. Thus, the evidence described above generally provides support for Hypothesis 1, which proposes that an increase in termination risk is associated with less CEO risk taking.

5.5. Termination risk, convexity and risk taking

In this section, we present tests of Hypothesis 2, which proposes that the impact of convexity on managerial risk taking is less for CEOs in high termination risk firms than for CEOs in low termination risk firms.

Here we divide the sample into high and low CTP firms, run a separate regression for each group, and then test whether the two convexity coefficients are significantly different. The high (low) termination risk group consists of firms that have a CTP greater than (less than or equal to)

Table 6
Termination risk and managerial risk-taking – three-stage least squares regressions

Variables		(1)	(2)	(3)
CTP		−0.2822*** (0.007)	−0.2534***	−0.3803*** (0.000)
Convexity ($\times 10^{-3}$)	0.2369*** (0.000)	0.2508*** (0.000)	0.2519*** (0.000)	0.2605*** (0.001)
Delta ($\times 10^{-6}$)	−4.5465** (0.020)	−7.0744** (0.013)	−8.1371*** (0.009)	−7.4475*** (0.008)
Cash compensation ($\times 10^{-6}$)	−5.4404* (0.051)	−7.1421 (0.188)	−7.0686 (0.150)	−7.6840 (0.212)
Tenure ($\times 10^{-3}$)	−0.3374 (0.421)	−0.7192 (0.140)	−0.7029 (0.170)	−1.1061** (0.040)
Size	−0.0589*** (0.000)	−0.0574*** (0.000)	−0.0564*** (0.000)	−0.0584*** (0.000)
Market-to-book	0.0114*** (0.000)	0.0132*** (0.005)	0.0142*** (0.006)	0.0082*** (0.045)
Leverage	0.0012*** (0.000)	0.0012 (0.916)	0.0011 (0.935)	0.0013 (0.916)
Constant	0.7158*** (0.000)	0.7064*** (0.000)	0.6970*** (0.000)	0.7265*** (0.000)
Observations	3071	3071	3071	3035
R^2	31.6%	25.2%	21.4%	24.4%

The dependent variables in the system of three equations are the volatility of the firm's stock, and the delta and convexity of the CEO's compensation contract. Only the coefficients in the volatility equation are reported. Volatility is the annualized standard deviation of daily stock returns over the last 120 trading days of the fiscal year. CTP stands for conditional termination propensity and is the predicted probability of the CEO being terminated. The three sub samples of underperformers, shown in columns (1), (2) and (3), are selected based on three industry-adjusted (two-digit SIC code) returns: 1-year stock returns, 3-year stock returns and 1-year ROE, respectively. Delta and Convexity are the changes in CEO portfolio wealth for a 1% change in stock price and for a 1% change in volatility, respectively. Cash compensation includes salary and bonus. Tenure is the number of years the CEO has been in office. Size is measured by natural log of sales. Market-to-book is [Book value of debt+Market value of equity]/[Book value of assets]. Leverage is [Book value of debt]/[Market value of equity]. The industry dummy variable coefficients are not reported.

The *p*-values are based on standard errors estimated using a bootstrapping procedure with 500 repetitions. *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

Table 7
Effect of convexity on volatility, by conditional termination propensity level

	(1)		(2)		(3)	
	High CTP	Low CTP	High CTP	Low CTP	High CTP	Low CTP
Convexity$_{-1}$ ($\times 10^{-3}$)	0.0120 (0.782)	0.1048*** (0.001)	0.0621 (0.202)	0.0997*** (0.000)	0.0410 (0.206)	0.1300*** (0.000)
Delta$_{-1}$ ($\times 10^{-6}$)	46.4705* (0.074)	0.1711 (0.815)	32.1571 (0.306)	0.1252 (0.842)	11.5421 (0.552)	−0.3956 (0.567)
Cash compensation$_{-1}$ ($\times 10^{-6}$)	6.5109 (0.409)	2.7651 (0.552)	5.4313 (0.513)	2.4618 (0.616)	14.3939* (0.056)	1.0706 (0.839)
Tenure	−4.1902*** (0.001)	−1.5492*** (0.002)	−4.6499*** (0.002)	−2.3497*** (0.000)	−4.9804*** (0.000)	−2.5273*** (0.000)
Size	−0.0641*** (0.000)	−0.0570*** (0.000)	−0.0585*** (0.000)	−0.0580*** (0.000)	−0.0621*** (0.000)	−0.0577*** (0.000)
Market-to-book	−0.0073 (0.201)	0.0072*** (0.003)	−0.0345*** (0.000)	0.0089*** (0.000)	−0.0159*** (0.003)	0.0057*** (0.009)
Leverage	0.0013*** (0.005)	0.0236*** (0.005)	0.0012*** (0.004)	0.0263** (0.012)	0.0012*** (0.001)	0.0335*** (0.005)
Constant	0.9625*** (0.000)	0.7004*** (0.000)	0.8251*** (0.000)	0.7106*** (0.000)	0.8437*** (0.000)	0.7059*** (0.000)
Observations	1475	1517	1394	1448	1387	1425
R^2	36.9%	38.8%	37.7%	38.2%	38.5%	40.3%

The dependent variable is the annualized standard deviation of daily stock returns over the last 120 trading days of the fiscal year. CTP stands for conditional termination propensity and is the predicted probability of the CEO being terminated. The three sub samples of underperformers, shown in columns (1), (2) and (3), are selected on the basis of three industry-adjusted (two-digit SIC code) returns: 1-year stock returns, 3-year stock returns and 1-year ROE, respectively. Delta and Convexity are the changes in CEO portfolio wealth for a 1% change in stock price and for a 1% change in stock returns volatility, respectively. Cash compensation includes salary and bonus. Tenure is the number of years the CEO has been in office. Size is measured by natural log of sales. Market-to-book is [Book value of debt+Market value of equity]/[Book value of assets]. Leverage is [Book value of debt]/[Market value of equity]. The industry dummy variable coefficients are not reported.
The *p*-values are based on standard errors estimated using a bootstrapping procedure with 500 repetitions. *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

the median CTP of our sample. We performed Wald's test to determine whether the same structural model can be used to capture the impact of convexity in both groups. The null hypothesis is rejected, indicating that the high and low CTP firms are quite distinct.

Table 7 reports the results of our benchmark estimations of Eq. (2) for the two groups. The results lend support to Hypothesis 2 which says that the risk-taking incentive associated with high convexity is less effective in the presence of high termination risk. For high CTP firms, the in all three specifications, which indicates that the incentives associated with convexity have no impact on these CEO risk taking. On the other hand, for low CTP firms, the impact of convexity on firm risk is positive and statistically significant; these CEOs respond to increased convexity by taking on more risk.

6. Conclusion

This paper examines the impact of termination risk on managerial risk taking. Although previous research has documented the effect of compensation risk on managerial risk taking, this analysis is the first to document the effect of termination risk on managerial investment decisions. We find that CEOs who face high termination risk make less risky investments. A 10% increase in termination propensity reduces firm risk by 5% to 23% in our sample. We also find that termination risk reduces the impact of convexity of compensation on managerial risk taking. The expected positive relation between convexity and managerial risk taking is significant only in firms where managers face low termination risk – CEOs who face high termination risk, the inhibiting effect of termination risk appears to offset the risk-taking incentive of increased convexity of compensation. While it may be possible to encourage managerial risk taking by increasing managers' compensation convexity, our findings indicate that increased convexity will be less effective in stimulating higher risk investment choices in high CTP firms than in low CTP firms.

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Appendix A. Termination propensity and risk-taking: a simple model

We use a simple reduced-form model to illustrate how managerial risk-taking might be affected by termination risk, and to motivate our two main hypotheses. We show that:

(i) The appropriate measure of termination risk is the conditional termination propensity (CTP);
(ii) The relation between CTP and risk-taking is negative; and
(iii) The relation between convexity and risk-taking is weaker when CTP is higher.

There are N firms in an economy, each run by a manager. The manager's role is to select the risk-return combination of his/her firm's investments. There is a range of projects available for investment and each manager chooses one. The expected profits of project i, y_i, are distributed according to the probability distribution function $F(\cdot)$, with mean μ_i and variance σ_i^2. The firm

cannot control the manager's choice of project directly, but it can influence the manager's decision through his/her compensation contract.

The manager's expected compensation, based on his/her contract is as follows

$$E(C) = S + b_1\mu + b_2\sigma^2 - D\Pr\ (\text{Poor Performance})\ \text{CTP},$$

where $E(\ )$ is the expectation operator, C is total expected compensation, S is a fixed salary \$, b_1 is an incentive indexed to average performance, b_2 is "convexity," an incentive indexed to risk that is intended encourage investment in higher risk-return projects, and the third term represents the CEO's expected termination cost if the firm performs poorly, which includes D, the manager's penalty costs associated with poor performance, $P(\ )$ is a probability, and CTP the conditional probability of being fired in the event of poor performance. The penalty D includes all costs related to the firing: loss of firm specific human capital, loss of reputation and loss of future opportunities due to being fired for poor performance, loss of unvested stock and options, the costs of searching for a new job, relocation, etc. It is net of the manager's severance payment.[9] We treat D as exogenous. Poor performance refers to performance in any period that is below some benchmark, such as the industry mean or median. Note that the *ex ante* probability that the manager will be fired after the outcome of a risky investment is known is P(Poor Performance)$\times$CTP. Firms set the CTP, but the probability of performing poorly depends on the manager's investment choices. The same project and performance may lead to opposite outcomes for managers at firms having different CTP levels; a high CTP may fire its manager, while a low CTP firm may not.

We are primarily interested in the relation between expected compensation and both convexity and termination risk. First, we show that an increase in CTP is associated with lower risk-taking.

The manager's first order condition for his/her risk-level decision is

$$\frac{\mathrm{d}C}{\mathrm{d}\sigma} = b_2 - D \times \text{CTP} \times \frac{\mathrm{d}P[\text{Poor Performance}]}{\mathrm{d}\sigma} = 0. \tag{A1}$$

Let x denote the performance benchmark in a given period. Then, the probability of poor performance is $P[y<x]=F(x)$, and a solution to (A1) exists as long as $\mathrm{d}F(x)/\mathrm{d}\sigma>0$.

In order to find the relation between CTP and risk-taking, we differentiate both sides of (A1) with respect to σ

$$-D \times \frac{\mathrm{d}F}{\mathrm{d}\sigma} - D \times \text{CTP} \times \frac{d^2F}{\mathrm{d}\sigma^2} \times \frac{\mathrm{d}\sigma}{\mathrm{dCTP}} = 0. \tag{A2}$$

From (2), we see that $\mathrm{d}\sigma/\mathrm{dCTP}<0$ if $\mathrm{d}^2F/\mathrm{d}\sigma^2>0$.

Since x is a benchmark for poor performance, we may assume that it lies to the left of the expected or mean level of profits. Several distribution functions, including the normal distribution satisfy both conditions; $\mathrm{d}F(x)/\mathrm{d}\sigma<0$ and $\mathrm{d}^2F/\mathrm{d}\sigma^2>0$, in the region: $x<\mu$. These two conditions imply that the probability of poor performance increases with risk at an increasing rate. Assuming that these conditions hold, we see that $\mathrm{d}\sigma/\mathrm{dCTP}<0$. This gives us our first hypothesis.

Managers at high CTP firms are more likely to select low risk investments than managers at low CTP firms.

[9] Fee and Hadlock (2004) find that severance payments are made to only 50% of executives who are forced out. Further, the mean severance pay is roughly twice the base salary in the preceding year, which is a relatively small amount considering that a large percentage of CEO pay is in the form of bonuses, stock and options.

Next, in order to see the relation between CTP and the marginal effect of convexity on risk taking, we differentiate both sides of (A1) with respect to b_2:

$$1-D \times \mathrm{CTP} \times \frac{\mathrm{d}^2F}{\mathrm{d}\sigma^2} \times \frac{\mathrm{d}\sigma}{\mathrm{d}b_2} = 0. \tag{A3}$$

Hence, $\mathrm{d}\sigma/\mathrm{d}b_2 = 1/(D \times \mathrm{CTP} \times \mathrm{d}^2F/\mathrm{d}\sigma^2)$. From this, it is easy to see that as CTP increases, $\mathrm{d}\sigma/\mathrm{d}b_2$ decreases. This gives us our second hypothesis.

The impact of higher convexity is weaker for CEOs of high CTP firms and stronger for CEOs of low CTP firms.

Our model also demonstrates that convexity is negatively related to D, the poor performance penalty. While D is unobservable, we can find some indirect evidence of this negative relation. One control variable that we use, tenure, captures some of the termination penalty. CEOs with longer tenure may have more firm-specific human capital, and thus stand to lose more if they are fired for poor performance. If this is correct, then the sensitivity of risk taking to convexity should decrease as CEO tenure increases ($\mathrm{d}^2\sigma/\mathrm{d}D\mathrm{d}\mathrm{CTP} < 0$).

While we cannot directly measure this effect with our regressions, we can determine the sign of the second derivative by looking at the relative magnitudes of the tenure coefficients for the low and high CTP firms shown in Table 7. The coefficient on tenure is a larger negative number for high CTP firms than for low CTP firms, which is consistent with $\mathrm{d}\sigma/\mathrm{d}D$ declining (becoming more negative) as CTP increases, or in other words, it is consistent with $\mathrm{d}^2\sigma/\mathrm{d}D\mathrm{d}\mathrm{CTP} < 0$. Thus, our results lend support to the model's predictions regarding the negative relation between the termination penalty and CEO risk taking.

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