An Empirical Investigation of the Characteristics of Firms Adopting Enterprise Risk Management

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Abstract

This paper uses a hazard model approach to examine the factors that influence firm level adoption of enterprise risk management (ERM). Enterprise risk management provides a process by which a firm integrates all of its risk management functions. We proxy the decision to implement ERM with the decision to hire a Chief Risk Officer (CRO) or similar senior level executive. We find that firms that are more levered, have more volatile earnings and have exhibited poorer stock market performance are more likely to initiate an ERM program. When the value of the CEO's option and stock portfolio is increasing in stock volatility, the firm is also more likely to appoint a CRO. This latter finding is consistent with the Board implementing ERM to offset the risk taking incentives being granted to the CEO.

JEL Classification Codes: G32.

Key Words: Enterprise Risk Management, Chief Risk Officer, Hazard Model

1 Introduction

The growing implementation of Enterprise Risk Management (ERM) programs has received increasing attention in the literature. In a recent paper, Nocco and Stulz (2006) argue that the pure efficient capital market view that a firm should not expend resources on managing idiosyncratic risk is not reasonable in a world with market frictions. They argue that an integrated, holistic, approach to risk management can create shareholder value. These authors are not the first to argue for managing risk at the enterprise level, and to date there have been numerous papers that discuss the broad concept of Enterprise Risk Management (see for example Beasley et. al., 2005).

In this paper we examine factors that have been hypothesized to be drivers of ERM implementation. Our goal is to shed light on whether firms are engaging in ERM with the goal of value maximization or whether other incentives are driving the implementation decision. Two recent papers; Liebenberg and Hoyt (2003) and Beasley, Pagach and Warr (2007), examine the impact of ERM implementation on short-term stock returns and find that firm specific characteristics are important determinants of the stock market reaction to ERM adoption. Our paper takes a different approach and seeks to examine directly the characteristics of firms that adopt ERM. As ERM adoption is largely unobservable, we use CRO hirings as a proxy for the initiation of enterprise risk management. In order to empirically determine the factors that influence the risk officer hiring decision, we model the decision using a hazard model. The hazard model allows us to examine a large sample of companies, of which only a proportion choose to adopt ERM.

The existing literature suggests a range of factors that might influence the decision to implement ERM. This leads us to examine a broad range of firm variables that measure financial, asset, market and managerial characteristics. Financial characteristics represent indirect measures of the likelihood of financial distress. Firms that face greater risk of financial distress and the implicit and explicit costs contained therein may benefit from ERM where ERM reduces the chance of costly lower tail earnings and cash flow outcomes. Asset characteristics measure the potential costs of financial distress. For example, firms with growth options will benefit from ERM if it reduces the probability that they may be unable to pursue these currently profitable future projects because of financial distress. Market characteristics measure the potential costs associated with volatile security performance. Firms will benefit from ERM if it reduces the volatility of stock returns and the firm's cost of capital. Finally managerial characteristics measure the degree to which the CEO's stock and option based compensation encourages risk taking or risk avoiding behavior. Firms whose CEOs have high levels of option based compensation will benefit from ERM if it reduces manager's incentives to take on excessively risky projects.

As a preview of our results we find that firms that have greater risk of financial distress, i.e. those with more leverage, less financial slack and more volatile earnings are more likely to hire a CRO. We find that firms with more opaque assets and more growth options are less likely to hire a CRO, a result that is counter to our hypothesis, but may reflect a preoccupation with risk management in firms that have lower quality growth options and are trying to create wealth by focusing more attention on the day-to-day business. Firms that have volatile stock prices and have seen recent poor stock price performance are more likely to hire CROs. Finally, we find that firms with CEOs that have incentives to take risk, based on option compensation, are also more likely to hire a CRO. This result appears counterintuitive, but is consistent with boards making the CRO appointment to provide a control against the CEO's risk taking incentives.

Our paper proceeds as follows; Section 2 presents a literature review and develops our hypothesis. Section 3 presents the data. Section 4 presents the univariate results and Section 5 presents the multivariate hazard model results. Section 6 concludes.

2 Literature Review and hypothesis development

Risk management has evolved from a narrow, insurance based view to a holistic; all risk encompassing view, commonly termed Enterprise Risk Management (ERM).[1] The benefits or costs of ERM are subject to debate[2], although recent work by Nocco and Stultz (2006) argues that ERM is beneficial to most firms because it allows the firm to manage risks in a manner that avoids costly left tale outcomes.[3] These authors argue that the frictionless capital market notion that any expense incurred to reduce idiosyncratic risk must be a negative NPV project is inconsistent with a world in which numerous market frictions and imperfections exist. Stulz (1996, 2003) and Nocco and Stultz (2006) then present arguments under which risk management activities could be value increasing for shareholders when agency costs and market imperfections interfere with the operation of perfect capital markets.

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[1] See Tufano, (1996); Liebenberg and Hoyt, (2003); Beasley et. al. (2005); and Slywotzky and Dzik (2005) for discussions of the development and adoption of ERM.
[2] Beasley, Pagach and Warr (2007) find no significant stock price reaction (positive or negative) to ERM adoption.
[3] Lin, Pantzalis and Park (2007) find that corporate use of derivates reduces asymmetric information

ERM can be value creating if at the most basic level, the goal of ERM is to reduce the probability of large negative cash flows through the coordination of offsetting risks across the enterprise and to ensure that no single project risk will have an adverse effect on the overall firm. ERM will have its greatest effect on earnings by reducing their variability through controls on the risk of cost centers and revenue sources. In reality, it is downside risk that the firm most seeks to avoid, and a goal of ERM is to reduce the likelihood that multiple negative events will occur simultaneously. Stulz (1996, 2003) recognizes this issue and argues that any potential value creation role for risk management is in the reduction or elimination of "costly lower-tail outcomes." He defines lower tail outcomes as the negative consequences that result from severe declines in cash flows. A risk management program that reduces the likelihood of lower tail outcomes could have a positive net present value. But, as Stulz (1996, 2003) points out, it is only firms that face these lower tail outcomes that will benefit from ERM, while other firms will see no benefit and could destroy value by spending corporate resources on risk management.

Lower tail outcomes have direct and indirect costs. For example, events such as bankruptcy and financial distress involve direct outlays to lawyers and courts. Indirect costs include the inability to pursue growth options, the loss of customer confidence, and the inability to realize the full value of intangible assets upon liquidation. A decline in debt ratings and the resulting increase in borrowing costs can also be costly for shareholders.

Managers who own stock in their company will have an undiversified equity portfolio and will bear a greater proportion of the cost of a lower tail event than a fully diversified shareholder. In an efficient labor market, these managers will demand higher compensation for bearing this idiosyncratic risk. Other stakeholders, such as suppliers, may be reluctant to enter into long term contracts with the firm if the potential for future payment is uncertain. All of these problems can result from the possibility of costly lower tail outcomes and represent value creating opportunities for a risk management program that can minimize such outcomes.

In this study we aim to conduct a wide ranging examination of the determinants of implementing an ERM program as proxied by Chief Risk Officer hiring. Because corporations disclose only minimal details of their risk management programs (Tufano, 1996), our focus on hiring announcements of senior risk officers measure the characteristics of firm's signaling an enterprise risk management process. There is good reason to believe that CRO hiring coincides with the decision to follow an ERM program. For example, The Economist Intelligence Unit, (2005) reports that many organizations appoint a member of the senior executive team, often referred to as the chief risk officer or CRO, to oversee the enterprise's risk management process. Walker, ET. al. (2002) notes that because of its scope and impact, ERM requires strong support from senior management. Beasley et al. (2005) show that the presence of a CRO is associated with a greater stage of ERM adoption.

We examine firm-specific variables that reflect the likelihood and cost of a firm experiencing a lower-tailed event either through increasing the chance of financial distress or increasing the costs associated with such distress. We also attempt to shed light on the impact of managerial incentives on ERM implementation.

The variables we examine are grouped in four broad categories. The first; financial characteristics, represent indirect measures of the likelihood of financial distress. Firms that face greater risk of financial distress and the implicit and explicit costs contained therein may benefit from ERM. These variables include leverage, financial slack (measured as cash as a percentage of assets) and earnings volatility. We hypothesize that firms with more leverage and less financial slack will be more likely to implement ERM. Firms with greater earnings volatility are more likely to experience lower tail earnings outcomes.

The second category measures asset characteristics and proxies for the potential costs of financial distress - for example the inability to pursue risky but profitable future projects. These variables include, asset opacity, Research and Development intensity and growth options. We hypothesize that firms with more opaque assets, greater R&D expense and more growth options are more likely to benefit from ERM.

The third category measures market performance and the volatility of the firm's stock returns. We hypothesize that firms with more volatile stock prices are more likely to benefit from ERM. Furthermore, firms that have seen poor stock performance in recent periods may implement ERM as a means to convince investors that they are addressing operational issues in order to avoid future poor performance.

The final category measures managerial incentives to protect their own undiversified investment portfolios, or the degree to which their incentives are aligned with those of investors. We compute the partial derivatives of the CEO's stock and option holdings with respect to the stock volatility and the stock price (as in Rogers, 2002). The ratio of these measures captures the risk taking incentives of the CEO. We hypothesize that those CEOs who have compensation portfolios that are more sensitive to volatility (such as close to the money options) will avoid ERM and programs that might try to reduce risk.

Our remaining variables control for industry membership, operating segments and institutional ownership.

3 Data

Our study starts with 138 announcements of senior risk officer appointments made from 1992-2005 for which we are able to obtain all the necessary data for our tests. Announcements are obtained by searching the business library of LEXIS-NEXIS for announcements containing the words "announced", "named", or "appointed", in conjunction with position descriptions of "chief risk officer" or "risk management". Only announcements for publicly traded companies were retained and in the case of multiple announcements for the same company we selected only the first announcement on the assumption that this represented the initiation of the risk management program.

By starting our search in 1992, we hope to capture the first appointment of a Chief Risk Officer; however, it is possible that some appointments, although being the first announcements, are not actually the first appointments. These announcements will add noise to our sample and reduce the power of our tests.

We collect data for all firms listed in Compustat from 1992 to 2005. We supplement the data with stock price data from CRSP and 13-F ownership data. In a subset of tests we include a variable to measure the sensitivity of the CEO's compensation to the volatility of the stock price. The data for these variables comes from

ExecuComp, but is only available for the S&P 1500 firms, and reduces the number of CRO hire firms in our sub sample to 69. The full data set is an unbalanced panel in which CRO hirings are indicated by a dummy variable that takes the value 1 in the year that they are made, and zero otherwise.

Table 1 presents the distribution of the announcements through time as well as the distribution across industries. Most CRO hires tend to be in the later part of the sample period, clustered around 1999 through 2002. A substantial portion of the appointments are located in the financial and utility industries. These are defined in our sample as having SIC codes in the 6000s for financial firms and in the 4900s for utilities.

The variables being examined are those that appear later in out multivariate analysis. These variables are either hypothesized determinants of the CRO hire decision or they represent control variables. In detail, these variables are grouped together and defined as follows:[4]

3.1 Liquidity and Firm Characteristics

3.1.1 Leverage

Firms with greater leverage are more likely to suffer from financial distress than firms with low leverage. Liebenberg and Hoyt (2003) find that in a small sample of firms appointing CROs matched with firms not appointing CROs; those appointing chief risk officers have greater financial leverage.

Leverage= Total liabilities/Total Assets = (data6 – data60)/data6 (1)

[4] Where applicable, the Compustat data items used to compute the variables are shown.

3.1.2 Cash ratio

Cash Ratio measures the amount of highly liquid assets that the firm has on hand that could be used to make up a short fall in operating cash flows.

Cash Ratio = Cash and marketable securities/Total Assets = data1/data6 (2)

3.1.3 Earnings volatility

Firms with more volatile earnings are more likely to benefit from ERM if the goal of ERM is to smooth earnings. Smooth earnings reduce the probability of experiencing a lower tail earnings outcome and the costs associated with missing earnings targets and violating debt covenants. SDNI is the standard deviation of the error term from a regression of the firm's quarterly earnings on the prior quarter's earnings. This regression is run for eight quarters.

3.2 Asset Characteristics

Asset characteristics measure the potential costs of financial distress, and proxy for the potential unrecoverable losses that may be incurred in financial distress.

3.2.1 Opacity

Firms that have opaque assets may have difficulty selling these assets at purchase cost to avert financial distress, as opaque assets are associated with more information asymmetry thus and thus are more likely to be undervalued. Opacity is computed as:

Opacity = Intangibles/ Total Assets = data33/data6 (3)

3.2.2 Growth options

Firms with growth options have much of the firm's value tied to future, and as yet, unrealized cash flows. Because of the uncertain nature of the payoff from such expenditures, the value of these investments are unlikely to be fully realized in bankruptcy, thus ERM may be favored by firms with higher growth options. We proxy for growth options using market-to-book and Research and Development expense. These variables are computed as:

MB = Market Value of Equity/ Book Value of Equity = (data199*data25)/data60 (4)

RD = Research and Development Expense / Total Assets = data46/data6 (5)

3.3 Market Characteristics

Market characteristics measure the volatility of the firm and the stock price performance. SDRET is the standard deviation of the firm's daily returns over the year prior to the hiring of the CRO.

Firms that have had dramatic changes in shareholder value, in particular, declines in value, may feel pressure to convey to shareholders through ERM initiation that they are doing something to prevent future occurrences. We compute the value change (Value

Change) as the change in market value of the firm over the year prior to the hiring of the CRO.

3.4 Managerial incentives

Executive share and option based compensation can affect the incentives of executives in terms of their risk preferences. CEOs that have a large proportion of option based compensation are more likely to prefer strategies that increase the volatility of the firm's stock – thus increasing the value of their option holdings. Alternatively, CEOs with larger stock holdings hold undiversified portfolios which are overweighted in their company's stock. These CEOs may prefer strategies that reduce overall stock idiosyncratic risk. The distinction between option and stock compensation is further complicated by the degree to which the option portfolio is in the money. Very in the money options provide much more stock like incentives compared to at the money or underwater options. Therefore, measuring option and stock based compensation requires more than just summing the value of the CEO's holdings. We therefore use the approach of Rogers (2002) who builds upon Core and Guay (2002). Rogers computes a proxy that incorporates CEO incentives to increase risk relative to incentives to increase stock price. This proxy combines the partial derivative of the dividend adjusted Black-Scholes equation with respect to the standard deviation of stock returns and the partial derivative of the Black Scholes equation with respect to the level of the stock price. The first measure, Vega, measures the incentive to take risk and the second measure, Delta, measures the incentive to increase stock price.

We compute Vega and Delta for each CEO's stock and option portfolio and use the ratio (as in Rogers, 2002) of the two variables – Vega to Delta as our proxy for the

CEO's risk taking incentives. The full details of the computation of Vega and Delta are contained in the appendix.

3.5 Controls

Firms with more operating segments (Numseg) are likely to be able to diversify operating and financial risks within the firm. Firm's with greater institutional ownership may have greater pressure to install controls associated with ERM. We measure institutional ownership as the percentage of the firm's stock held by institutional investors as recorded in 13-F filings. This variable is designated as PINST. The number of institutional investors is designated as NINST. Finally, we control for industry membership – specifically whether the firm is a financial firm or a utility and firm size.

4 Univariate Results

Table 2 presents summary statistics for the main variables. In addition to providing means and medians of the CRO sample and the sample as a whole, the table presents results of tests of the means (t-tests) and medians (sign-rank tests). Note that CRO firms are in the main sample until the year in which they hire a CRO.

The CRO hiring firms tend to have more volatile earnings and tend to be larger, more levered and have lower cash ratios than the non-hiring firms. These results are to be expected in that CRO hires tend to be more prevalent among financial firms. CRO hiring firms tend to be less opaque than non-hiring firms in that they have lower Opacity, Market-to-Book and Research and Development expenses. These findings are counter to our hypothesis that firms with more opaque assets and more growth options will tend to try and protect those future revenue sources through risk management. These results are most likely being heavily influenced by large number of financial firms in the hiring sample. The multivariate results will allow us to separate out these affects after controlling for industry.

CRO hiring firms tend to have less volatile stock prices. The hiring firms have also seen poorer stock performance in the period before the hiring announcement.

In examining compensation, Vega to Delta for the hiring firms is higher than for the non-hiring firms, which is a result that runs counter to our expectation that firms with volatility preferring CEOs will not choose ERM. Finally we find that the hiring firms have more segments and more institutional ownership than the non-hiring firms, but again these results may be picking up other effects, such as size.

In Table 3 we examine correlations between our key variables. Somewhat unsurprisingly, size is correlated with many of the other variables in manners which might be expected. For example, larger firms tend to have less earnings and stock volatility (SDNI and SDRET). Vega to Delta shows little correlation with most of the other variables of interest.

5 Multivariate determinants of CRO hiring announcements

In this section we focus on the multivariate determinants of the CRO hire decision. An important contribution of this paper is the econometric approach that we use to model the relation between the CRO appointment decision and firm characteristics. Typically, binary decisions of this type are modeled using a "static model", so called by Shumway (2001), in which a logit regression is run on a data set that is comprised of the dates on which CROs are hired. On each of these dates, a “hire” dummy variable is created and coded 1 for the firms that have hires, while the other non-hire firms are coded zero. This approach ignores information contained in the time periods on which there are no CRO hires.

An alternative approach is to use the full time series of data, including those periods during which no hiring event occurs. For the periods with no hirings, the dependent binary variable is zero for every firm in the data set. The data set is not a traditional panel data set but more correctly termed an event history data set, which reduces in observations each time a firm hires a CRO and thus exits from the data set. This approach has been used by other authors including Pagano, Panetta and Zingales (1998) to model the IPO decision and Denis, Denis and Sarin (1997) to model executive turnover.[5]

Using a logit model to estimate the parameters of an event history data set will produce incorrect test statistics because of the assumption that all the observations for a firm are independent. To see this lack of independence, consider that an event on day t=1 can only be preceded by a non event on day t=-1. A hazard model overcomes this problem, and can incorporate the impact of time on the hiring decision. Hazard models, commonly used in medical research, model an event (in this case a CRO hire) as a function of the determinants of the event. The hazard model approach takes account of the evolution of a firm’s characteristics and computes a hazard ratio of the firm hiring a CRO, whether or not the firm actually hires. The parameter estimates of the hazard

[5] In addition to those cited, several other authors use hazard models in finance research, for example Johnson (2004), Ongena and Smith (2001) , McQueen and Thorley (1994), Deshmukh (2003) and Danielsen, Van Ness and Warr (2007).

model should be similar to those of the logit model (using a full event history data set), but the hazard model produces superior test statistics.

We use a Cox proportional hazard function to estimate equation 6. The Cox model is a semi parametric model in which the likelihood of failure is not related to elapsed time. The hazard model takes into account the evolution of the firm's characteristics and computes a hazard (or likelihood) ratio of the firm hiring a CRO, whether or not the firm actually announces a hire.

We estimate the following hazard model:

$$CROHIRE_{it} = f(\text{Financial Characteristics}_{it}, \text{Asset Characteristics}_{it}, \text{Market Characteristics}_{it}, \text{Managerial Characteristics}_{it}, \text{Controls}) + e_{it} \qquad (6)$$

The subscript i represents each firm in the data set that could have a CRO hiring announcement, but has not yet had one. The subscript t represents every year from 1992 to 2005. The dependent variable, CROHIRE is a binary variable that takes the value of 1 if the firm announces the appointment of a CRO, and zero otherwise. For the years prior to a CRO hiring, CROHIRE=1. Once a CRO is hired, the observation drops out of the data set. Therefore, a firm can have a maximum of one observation with CROHIRE=1.

The independent variables are estimated as of the beginning of the fiscal year in which the CRO is hired.

5.1 Hazard Model Results

Table 4 presents the results of our basic hazard model estimation. Interpreting the economic significance of the coefficients requires estimating the increase in the likelihood of the event, in this case a CRO hire, given a change in the independent variable of interest. Commonly, standardized hazard ratios are computed by calculating the effect of a one standard deviation shift for each independent variable. However, several of the variables in our study are right-tail skewed, and consequently have large standard deviations, which may make cross-sectional comparisons misleading. We therefore closely follow the approach of Danielsen, Van Ness and Warr (2007) and consider a change in each right-hand-side variable equal to 10% of the variable's mean value. This measure is referred to as a 10%-of-mean-standardized hazard ratio to avoid confusion with a ratio based on standard deviations. Because hazard ratios are easier to interpret when the coefficient estimates are positive, we use the absolute value of each coefficient to estimate our 10%-of-mean-standardized hazard ratio. The 10%-of-mean-standardized hazard ratio (Std HR) is computed as:

$$Std\ HR = e^{|coef| \times 0.1 \times mean} \tag{7}$$

Table 4 presents our base model for the full sample. The first column "HR" is the hazard ratio, the second "Coef" is the coefficient and the third column "Std HR" is the "10%-of-mean-standardized hazard ratio". The last column of the table labeled "mean" is the mean of the variable and is used in the computation of the "Std HR" column.

We find that leverage and size are positively related to the likelihood of hiring a CRO. A 10% increase in leverage will result in a 7.8% increase in the likelihood of a hire.[6] This result is consistent with firms that are more levered are at a greater risk of financial distress. The economic significance of the size variable is particularly large, indicating a 10% increase in size will increase the likelihood of a hire by 27%. Furthermore, for the standard deviation of earnings, SDNI, a 10% increase will result in a 4.7% increase in the likelihood of a hire. We find no relation for the Cash Ratio variable.

Of the variables that proxy for the asset characteristics, RD and MB are both significant and negative (the HR is less than 1, resulting in a negative coefficient which is the log of HR). This result is counter to our hypothesis that firms with more growth options and RD investments will seek to protect these through ERM. It is possible that higher growth firms are less concerned with ERM because they are focusing on growth opportunities. Stable and mature growth firms are forced to look to improvements (through ERM) in their day to day management of operations.

The market variables, volatility of returns and Value Change are both significant. First SDRET, the volatility of returns in the year prior to ERM implementation, has a Std HR of 1.143 indicating that a 10% increase in volatility will result in a 14% increase in the likelihood of a CRO hire. This result is consistent with the hypothesis that firms implement ERM to control stock volatility. The Value Change variable is negative and the significant, indicating that the probability of a hire is negatively related to recent price performance of the firm. We interpret this result as evidence of that firms try to make amends after a period of poor performance by implementing ERM to try and avoid repeating the poor performance in the future.

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[6] This magnitude is obtained from the Std HR value of 1.078 which implies that an increase of the mean of the independent variable by 10% will increase the hazard likelihood l.078 times or 7.8%.

We find that the number of segments is positively related to the likelihood of a CRO hire. But both the institutional ownership variables are insignificant. Finally, both the financial firm and utility firm dummy variables are positive and highly significant consistent with a preference among these firms for implementing ERM.

5.2 CEO incentives

In Table 5 we explore the effect of CEO compensation on the CRO hire decision. As we stated earlier, data on CEO compensation is only available for a sub set of our firms, and hence we have a reduced sample size. We measure CEO incentives using the ratio of Vega to Delta, as in Rogers (2002). A higher value of this ratio indicates that the value of the manager's compensation is more sensitive to stock volatility. In Table 5, the coefficient on Vega to Delta is positive and significant indicating that as CEOs compensation packages become more sensitive to stock volatility, the likelihood of hiring a CRO increases. This result appears to be at odds with the incentives of a CEO to maximize his own personal wealth, as one would expect a rational CEO who has much of his/her compensation in the form of at the money options to prefer that the firm be more risky. However, it is generally not the CEO that makes the decision to implement ERM; indeed it is the board of directors that usually leads this initiative (Lam, 2001). Thus a possible explanation for this result is that the board recognizes that the CEO has an incentive to increase risk and therefore is implementing a risk management program to control the risk that is expected to be taken on by the CEO. From the board's point of view this is a rational strategy – to effectively encourage risk taking by the CEO and at the same time implement a program to actively manage, coordinate and understand these risks.

5.3 Industry sub samples

Table 6 repeats the analysis from Table 5 for the two main industry sub samples. The first model examines the financial firms. Earnings volatility, size, number of institutions and vega to delta are positive and significant, consistent with the main results from Table 4 and 5. However for the utility industry only size and earnings volatility remain significant.

6 Conclusion

Using a hazard model we examine the impact of various factors on the decision of firms to hire a Chief Risk Officer (CRO). We assume that hiring a CRO signals an increased corporate emphasis on risk management and enterprise risk management in particular. Our results indicate that firms appear to be implementing ERM when they are more volatile, have greater earnings volatility and greater leverage. We also find some evidence that firms that have seen recent poor stock performance are also likely to hire CROs.

Counter to our initial thinking we find that firms that hire CROs tend to be less opaque and have fewer growth options. We suspect that this result may be due to ERM being favored by more stable firms, that in the absence of a portfolio of high growth projects, they focus attention on the day to day running of the business.

When we include the sensitivity of the CEOs compensation portfolio to the volatility of the firm's stock we find that CEOs with more sensitive holdings are in firms that are more likely to hire CROs. A possible explanation for this result is that boards are implementing ERM to offset the risk taking incentives that they have granted to the CEO.

Appendix: Computing Vega and Delta for the CEO option portfolio

We follow Rogers (2002), who in turn follows Core and Guay (2002) in computing the option sensitivities to volatility and price. Delta measures the option value's sensitivity with respect to a 1% change in stock price and Vega measures the option value's sensitivity to a 0.01 change in standard deviation. These values are computed as:

$$\text{Delta: } \frac{\partial Value}{\partial S}\frac{S}{100} = \exp\{-dT\}N(Z)\frac{S}{100} \qquad \text{(A.1)}$$

$$\text{Vega: } \frac{\partial Value}{\partial \sigma}\times 0.01 = 0.01\left[\exp\{-dT\}N'(Z)S\sqrt{T}\right] \qquad \text{(A.2)}$$

where:

$$Z = \frac{\ln(S/X) + T(r - d + \sigma^2/2)}{\sigma\sqrt{T}}$$

$N(\cdot)$ is the cumulative probability function for the normal distribution, $N'(\cdot)$ is the normal probability density function, S is the share price of the stock at the fiscal year-end, d is the dividend yield as of fiscal year-end, X is the exercise price of the option, r is the risk free rate. We use the risk free rate provided in ExecuComp. σ is the annualized standard derivation of daily stock returns measured over 120 days prior to fiscal year-end and T is remaining years to maturity of option.

The data for estimation is from ExecuComp (and originally from the proxy statements), however, the exercise price and maturity are only available for current years option grants. Therefore to estimate prior years exercise prices and maturities we follow the Core and Guay (2002) algorithm, which is detailed on page 617 of their paper. The proxy statement provides realizable values of options grants (i.e. the excess of the stock price over the exercise price). Because X and T are computed separately for new options, the number and fiscal year-end realizable value of new options must be deducted from the number and realizable value of unexercisable options. Dividing unexercisable (excluding new grants) and exercisable realized values by the number of unexercisable and exercisable options held by the executive, respectively, yields estimates of, on average, how far each of the groups of options are in the money. Subtracting this number from the stock price yields the average exercise price. The exercise price is computed for exercisable and unexercisable options. The time to maturity for the exercisable options is the maturity of the new grants less one year (or nine years if no new grant is made). For the unexercisable options, the time to maturity is the maturity of the new grants less three years (or six years if no grant is made).

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Table 1. CRO appointments by year

This table presents CRO appointments by year. The totals are broken out by financial firms (6000<= SICC<=6999) and utilities (4900 <= SICC<=4999).

Year	Number of CRO Appointments	Banks	Utilities
1990	0	0	0
1991	7	4	0
1992	9	2	0
1993	8	3	1
1994	9	3	1
1995	11	6	3
1996	5	4	1
1997	6	4	0
1998	9	5	1
1999	13	8	1
2000	23	14	5
2001	14	6	4
2002	12	8	1
2003	9	7	0
2004	3	3	0
	138	77	18

Table 2. Summary Statistics and Sample Comparisons

Leverage = Total liabilities/Total Assets = (data6 – data60)/data6, Cash Ratio = Cash and marketable securities/Total Assets = data1/data6, SDNI is the standard deviation of the error term from a regression of the firm's quarterly earnings on the prior quarter's earnings. This regression is run for eight quarters. Size is the market value of equity. Opacity = Intangibles/ Total Assets = data33/data6, MB = Market Value of Equity/ Book Value of Equity = (data199*data25)/data60, RD = Research and Development Expense / Total Assets = data46/data6, SDRET is the standard deviation of the firm's daily returns over the year prior to the hiring of the CRO, Value Change is the change in market value of the firm over the prior year. Vega/Delta is the ratio of Vega, the partial derivative of the CEOs option and stock portfolio to stock volatility and delta is the partial derivative with respect to the stock price as in Rogers (2002). Numseg is the number of operating segments of the firm. PINST is institutional ownership as the percentage of the firm's stock. The number of institutional investors is designated as NINST. The means test is a two sided t-test. The medians test is a Wilcoxon Sign Rank test.

	CRO Hire firms			Non CRO Hire firms			Means		Medians	
	Mean	Median	SD	Mean	Median	SD	Difference	T- Test	Difference	Rank Sum
Financial Characteristics										
Leverage	0.744	0.812	0.217	0.530	0.538	0.260	-0.214	-11.548***	-0.274	-9.772***
Cash Ratio	0.088	0.052	0.110	0.170	0.072	0.218	0.082	8.798***	0.020	3.437***
SDNI	0.876	0.351	1.841	0.564	0.170	12.196	-0.312	-1.921*	-0.181	-6.428***
Asset Characteristics										
Opacity	0.054	0.013	0.105	0.074	0.003	0.138	0.019	2.148**	-0.010	-0.435
MB	2.447	1.820	3.064	4.844	1.849	79.482	2.396	6.349***	0.029	0.556
RD	0.005	0.000	0.017	0.045	0.000	0.135	0.040	26.870***	0.000	5.828***
Market Characteristics										
SDRET	0.026	0.021	0.017	0.040	0.033	0.028	0.015	10.133***	0.012	8.239***
Value Change	0.657	0.083	2.219	1.644	0.190	3.482	0.987	5.213***	0.107	2.086**
Managerial Characteristics										
Vega/Delta	0.503	0.405	0.529	0.358	0.244	0.519	-0.145	-2.583**	-0.160	-2.752***
Controls										
Numseg	4.957	3	5.083	3.086	2	3.464	-1.871	-4.321***	-1.000	-3.478***
NINST	196.507	148	175.678	61.240	23	104.929	-135.267	-9.043***	-125.000	-11.037***
PINST	0.454	0.476	0.250	0.308	0.242	0.264	-0.145	-6.828***	-0.234	-6.531***
Size	7.521	7.742	2.117	5.068	4.916	2.111	-2.453	-13.604***	-2.826	-11.973***

***, **, *: Significant at the 1%, 5%, 10% level respectively

Table 3. Correlations

Leverage = Total liabilities/Total Assets = (data6 – data60)/data6, Cash Ratio = Cash and marketable securities/Total Assets = data1/data6, SDNI is the standard deviation of the error term from a regression of the firm's quarterly earnings on the prior quarter's earnings. This regression is run for eight quarters. Size is the market value of equity. Opacity = Intangibles/ Total Assets = data33/data6, MB = Market Value of Equity/ Book Value of Equity = (data199*data25)/data60, RD = Research and Development Expense / Total Assets = data46/data6, SDRET is the standard deviation of the firm's daily returns over the year prior to the hiring of the CRO, Value Change is the change in market value of the firm over the prior year. Vega/Delta is the ratio of Vega, the partial derivative of the CEOs option and stock portfolio to stock volatility and delta is the partial derivative with respect to the stock price as in Rogers (2002). Numseg is the number of operating segments of the firm. PINST is institutional ownership as the percentage of the firm's stock. The number of institutional investors is designated as NINST. P values for significance level of each pair-wise correlation are in parenthesis.

	Leverage	Cash Ratio	SDNI	Size	Opacity	MB	RD	SDRET	Value Change	Vega/Delta	Numsegs	NINST
Cash Ratio	-0.0694											
	(0.4186)											
SDNI	0.1021	0.0020										
	(0.2334)	*(0.9812)*										
Size	0.2471	-0.1246	-0.1790									
	(0.0035)	*(0.1453)*	*(0.0357)*									
Opacity	-0.2886	-0.0515	-0.0840	-0.0737								
	(0.0006)	*(0.549)*	*(0.3275)*	*(0.3902)*								
MB	0.1521	0.0875	0.0146	0.1354	0.0698							
	(0.075)	*(0.3076)*	*(0.8649)*	*(0.1133)*	*(0.4159)*							
RD	-0.3783	0.3436	-0.0005	-0.2501	0.1357	0.0769						
	(0.000)	*(0.000)*	*(0.9952)*	*(0.0031)*	*(0.1125)*	*(0.3697)*						
SDRET	0.0345	0.1147	0.4405	-0.4478	0.0640	0.1331	0.1927					
	(0.688)	*(0.1803)*	*(0.000)*	*(0.000)*	*(0.4558)*	*(0.1195)*	*(0.0236)*					
Value Change	-0.1224	0.2925	-0.0806	-0.0463	-0.0913	0.1320	0.2289	0.0202				
	(0.1528)	*(0.0005)*	*(0.3471)*	*(0.5898)*	*(0.2871)*	*(0.1226)*	*(0.0069)*	*(0.8141)*				
Vega/Delta	0.0093	-0.1740	0.1631	0.1343	-0.0742	-0.0966	-0.1326	-0.1178	-0.1606			
	(0.9309)	*(0.1029)*	*(0.1267)*	*(0.2094)*	*(0.4898)*	*(0.3678)*	*(0.2155)*	*(0.2717)*	*(0.1328)*			
Numseg	-0.0605	-0.0904	0.0805	0.3032	0.1639	0.1717	0.0394	0.0358	0.1565	0.1772		
	(0.4807)	*(0.2919)*	*(0.3478)*	*(0.0003)*	*(0.0548)*	*(0.044)*	*(0.6465)*	*(0.6766)*	*(0.0668)*	*(0.0967)*		
NINST	0.3012	-0.1373	-0.1385	0.8046	-0.0939	0.1281	-0.1998	-0.2284	-0.1999	0.0765	0.1450	
	(0.0003)	*(0.1084)*	*(0.1053)*	*(0.000)*	*(0.2733)*	*(0.1344)*	*(0.0188)*	*(0.007)*	*(0.0187)*	*(0.4759)*	*(0.0896)*	
PINST	0.0657	-0.1758	-0.1384	0.4702	0.0638	0.0276	-0.2517	-0.1396	-0.1812	0.0239	0.1144	0.5446
	(0.4441)	*(0.0392)*	*(0.1056)*	*(0.000)*	*(0.4576)*	*(0.7475)*	*(0.0029)*	*(0.1023)*	*(0.0334)*	*(0.824)*	*(0.1814)*	*(0.000)*

Table 4 Cox proportional hazard model on the determinants of CRO hires - Full Sample

Leverage = Total liabilities/Total Assets = (data6 – data60)/data6, Cash Ratio = Cash and marketable securities/Total Assets = data1/data6, SDNI is the standard deviation of the error term from a regression of the firm's quarterly earnings on the prior quarter's earnings. This regression is run for eight quarters. Size is the market value of equity. Opacity = Intangibles/ Total Assets = data33/data6, MB = Market Value of Equity/ Book Value of Equity = (data199*data25)/data60, RD = Research and Development Expense / Total Assets = data46/data6, SDRET is the standard deviation of the firm's daily returns over the year prior to the hiring of the CRO, Value Change is the change in market value of the firm over the prior year. Numseg is the number of operating segments of the firm. PINST is institutional ownership as the percentage of the firm's stock. Financial is a dummy for (6000<=SICC<=6999) and Utility is a dummy for (4900<=SICC<=4999). Std HR is the The 10%-of-mean-standardized hazard ratio is computed as: $e^{|coef| \times 0.1 \times mean}$.Absolute value of z statistics in parentheses

	HR	Coef	Std HR	Mean
Leverage	4.116	1.415	1.078	0.531
	(2.57)**			
Cash Ratio	1.091	0.087	1.001	0.170
	(-0.11)			
ln(SDNI)	1.305	0.266	1.047	-1.738
	(3.85)***			
Size	1.607	0.474	1.272	5.072
	(6.64)***			
Opacity	0.634	-0.456	1.003	0.074
	(-0.56)			
Ln(MB)	0.764	-0.269	1.019	0.702
	(1.75)*			
RD	0.991	-0.009	1.042	45.103
	(1.92)*			
ln(SDRET)	1.481	0.393	1.143	-3.402
	(1.70)*			
Value Change	0.925	-0.078	1.013	1.643
	(1.82)*			
Numseg	0.961	-0.040	1.012	3.089
	(1.97)**			
PINST	1.733	0.550	1.017	0.309
	(-1.49)			
NINST	1.001	0.001	1.006	61.460
	(-1.55)			
Financial	4.139	1.420	1.029	0.203
	(5.52)***			
Utility	4.508	1.506	1.005	0.036
	(4.72)***			
Observations	84362			

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5. Cox proportional hazard model on the determinants of CRO hires – Including CEO incentives

Leverage = Total liabilities/Total Assets = (data6 – data60)/data6, Cash Ratio = Cash and marketable securities/Total Assets = data1/data6, SDNI is the standard deviation of the error term from a regression of the firm's quarterly earnings on the prior quarter's earnings. This regression is run for eight quarters. Size is the market value of equity. Opacity = Intangibles/ Total Assets = data33/data6, MB = Market Value of Equity/ Book Value of Equity = (data199*data25)/data60, RD = Research and Development Expense / Total Assets = data46/data6, SDRET is the standard deviation of the firm's daily returns over the year prior to the hiring of the CRO, Value Change is the change in market value of the firm over the prior year. Vega/Delta is the ratio of Vega, the partial derivative of the CEOs option and stock portfolio to stock volatility and delta is the partial derivative with respect to the stock price as in Rogers (2002). Numseg is the number of operating segments of the firm. PINST is institutional ownership as the percentage of the firm's stock. The number of institutional investors is designated as NINST. Financial is a dummy for (6000<=SICC<=6999) and Utility is a dummy for (4900<=SICC<=4999). Std HR is the The 10%-of-mean-standardized hazard ratio is computed as: $e^{|coef| \times 0.1 \times mean}$. Absolute value of z statistics in parentheses

	HR	Coef	Std HR	Mean
Leverage	4.771	1.563	1.092	0.562
	(-1.45)			
Cash Ratio	0.457	-0.783	1.010	0.128
	(-0.58)			
ln(SDNI)	1.126	0.119	1.016	-1.369
	(-0.89)			
Size	1.841	0.610	1.562	7.313
	(3.01)***			
Opacity	0.126	-2.071	1.020	0.098
	(-1.42)			
Ln(MB)	0.810	-0.211	1.020	0.941
	(-0.83)			
RD	0.967	-0.034	1.113	31.898
	(2.01)**			
ln(SDRET)	2.170	0.775	1.334	-3.716
	(1.77)*			
Value Change	0.919	-0.084	1.004	0.484
	(-0.69)			
Vega/Delta	**1.332**	**0.287**	**1.035**	**-1.190**
	(1.98)**			
Numseg	0.970	-0.030	1.014	4.665
	(-1.12)			
PINST	3.071	1.122	1.068	0.589
	(-1.59)			
NINST	1.000	0.000	1.000	182.785
	(-0.10)			
Financial	4.445	1.492	1.021	0.141
	(3.35)***			
Utility	4.824	1.574	1.009	0.056
	(3.43)***			
Observations	13966			

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6
Cox proportional hazard model on the determinants of CRO hires – Industry sub-samples

Financials are (6000<=SICC<=6999) and Utilities are (4900<=SICC<=4999). Leverage = Total liabilities/Total Assets = (data6 – data60)/data60, Cash Ratio = Cash and marketable securities/Total Assets = data1/data6, SDNI is the standard deviation of the error term from a regression of the firm's quarterly earnings on the prior quarter's earnings. This regression is run for eight quarters. Size is the market value of equity. Opacity = Intangibles/ Total Assets = data33/data6, MB = Market Value of Equity/ Book Value of Equity = (data199*data25)/data60, RD = Research and Development Expense / Total Assets = data46/data6, SDRET is the standard deviation of the firm's daily returns over the year prior to the hiring of the CRO, Value Change is the change in market value of the firm over the prior year. Vega/Delta is the ratio of Vega, the partial derivative of the CEOs option and stock portfolio to stock volatility and delta is the partial derivative with respect to the stock price as in Rogers (2002). Numseg is the number of operating segments of the firm. PINST is institutional ownership as the percentage of the firm's stock. The number of institutional investors is designated as NINST. Std HR is the The 10%-of-mean-standardized hazard ratio is computed as: $e^{|coef| \times 0.1 \times mean}$. Absolute value of z statistics in parentheses.

	Financials				Utilities			
	HR	Coef	STD HR	Mean	HR	Coef	STD HR	Mean
Leverage	2.359	0.858	1.066	0.747	126.573	4.841	1.383	0.670
	(-1.15)				(-1.39)			
Cash Ratio	1.848	0.614	1.006	0.100	111.007	4.710	1.019	0.040
	(-0.65)				(-0.98)			
ln(SDNI)	1.28	0.247	1.049	-1.953	1.809	0.593	1.069	-1.120
	(2.70)***				(1.90)*			
Size	1.576	0.455	1.262	5.124	2.322	0.842	1.686	6.198
	(4.72)***				(2.49)**			
Opacity	1.294	0.258	1.001	0.025	0.014	-4.269	1.018	0.041
	(-0.18)				(-0.93)			
Ln(MB)	0.71	-0.342	1.014	0.418	0.409	-0.894	1.045	0.487
	(-1.50)				(-1.20)			
RD	1.001	0.001	1.000	2.271	0.999	-0.001	1.000	1.471
	(-0.73)				(-0.01)			
ln(SDRET)	1.546	0.436	1.178	-3.754	0.884	-0.123	1.051	-4.006
	(-1.37)				(-0.14)			
Value Change	0.915	-0.089	1.015	1.654	0.755	-0.281	1.035	1.228
	(-1.53)				(-0.45)			
Vega/Delta	1.608	0.475	1.002	0.051	1.172	0.159	1.004	0.238
	(2.16)**				(-0.43)			
Numseg	0.929	-0.074	1.018	2.459	1.052	0.051	1.023	4.466
	(2.56)**				(-0.86)			
PINST	1.217	0.196	1.005	0.261	6.31	1.842	1.057	0.300
	(-0.36)				(-1.04)			
NINST	1.002	0.002	1.011	54.096	0.999	-0.001	1.010	97.734
	(2.19)**				(-0.22)			
Observations	16972				2952			

* significant at 10%; ** significant at 5%; *** significant at 1%