The Determinants of CEO risk-taking incentives and how CEOs respond to these incentives

Abstract

This paper explores the determinants of CEO risk-taking incentives and how CEOs respond to these incentives. I find that firms that are characterised by growth options (i.e. high R&D and low CAPEX) provide more risk-taking incentives to their CEO. CEOs respond to these incentives by increasing the stock return volatility of the firm they manage. I measure risk-taking incentives as the sensitivity of the CEO's option portfolio to stock return volatility. The analysis is done on a new, manually gathered dataset, which consists of Dutch firms between 2003 and 2013.

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1 Introduction

Incentive misalignment between CEO and shareholders can create an agency problem (Jensen and Meckling, 1976). CEO actions might deviate from the ones preferred by shareholders as unlike shareholder wealth, CEO wealth is not only dependent on firm value, but also dependent on other factors such as personal wealth and managerial power. As a result, the perceived expected value an action creates can substantially differ between the two parties. Equity-based components in the executive compensation scheme, like common stock or stock options, can help relieve the agency problem. They establish a situation in which CEO and shareholders share the same benefits and costs, which aligns the incentives of the two, and helps ensure that the CEO implements actions that are line with shareholder interests. Stock options create two types of incentives for a CEO. They incentivize the CEO to manage the firm in a way that maximizes firm value, since the value of an option increases in stock price. Besides, options create an incentive to increase the riskiness of the firm. The asymmetric payoff structure of an option causes its value to increase when expected stock return volatility increases, and return volatility increases as the firm becomes riskier.

Since the 1990s, stock options have grown to a significant component in CEO compensation schemes (Cohen, Hall and Viceira, 2000), which led to an increase in academic literature on incentive alignment through equity-based compensation. Initially, most of this literature focusses on the CEO incentive to increase firm value (e.g. Jensen and Murphy, 1990; Hall and Liebman, 1998). These studies indicate that the link between CEO pay and firm performance grew over time, together with the fraction of equity-based components in the executive compensation scheme. However, as Guay (1999) argues, encouraging the CEO to increase firm value is not sufficient to induce the CEO to make decisions according to shareholder interest. Encouraging the CEO to take adequate risk should not be ignored, since a difference in risk-appetite between CEO and shareholders can lead to risk-related agency problems. As shareholders hold well diversified portfolios, they would like the CEO to pursue all actions that are expected to increase firm value, irrespective of the associated risks. Risk-averse CEOs, who are expected to have higher fraction of their personal wealth connected to the firm compared to shareholders, are likely to take fewer risk than optimal.

Risk-related agency problems are supposed to be most severe for firms that are characterized by growth opportunities. These firms incur the highest opportunity costs when valuable growth opportunities are not exploited due to CEO risk aversion. This theory implies that firms that are characterized by growth opportunities should provide more risk-taking incentives to their CEO. I use the following hypothesis to test this relationship:

Hypothesis 1: convexity in the executive compensation scheme is positively related to the proportion of firm assets that are growth options.

If CEOs include the risk-taking incentives provided to them in their decision making, they should increase the riskiness of their actions when risk-taking incentives increase, as long as the increase in personal wealth offsets their risk-aversion. I use the following hypothesis to test this relationship:

Hypothesis 2: firm risk increases as convexity in the executive compensation scheme increases.

I use the variables vega and delta to measure the two types of incentives that are provided to CEOs through stock options. Vega captures the CEO incentive to increase the riskiness of the firm, measured as the sensitivity of CEO wealth to stock return volatility. Delta captures the CEO incentive to increase the value of the firm, measured as the sensitivity of CEO wealth to stock price. I use the Black and Scholes (1973) option pricing model to calculate these sensitivities. Descriptive statistics indicate that on average the value of a CEO's option portfolio increases with €22,320 for an increase in volatility of stock returns of 0.01, and with €32,520 for a 1 percent increase in stock price. Dutch listed firms provide less risk-taking incentives to their CEO than US listed firms. Guay (1999), Coles, Daniel and Naveen (2006), and Armstrong and Vashishtha (2012) report a mean vega of $45,970, $80,000, $100,000 respectively. The main driver for this difference in vega seems to be that the average time-to-maturity of the CEO option portfolio is smaller in Dutch firms. The option grants happened relatively further in the past, which is an indication that options are becoming a less significant component in executive compensation schemes in the Netherlands.

The sample is based on Dutch listed firms between 2003 and 2013. It contains 281 firm year observations, distributed over 46 firms that traded on the Euronext Amsterdam stock exchange, and for which all required information is publicly available. Analysis is done on a unique, manually constructed dataset, that contains precise details on CEO option holdings in Dutch firms. These are not covered in any online database. To my knowledge, there is only one other dataset that covers CEO option holdings for Dutch firms, while most studies based on US firms lack detail. The samples of Coles, Daniel and Naveen (2006) and Armstrong and Vashishtha (2012) are constructed with the help of the ExecuComp. This is a dataset that contains proxy statements for US listed firms. A disadvantage of using this dataset is that it excludes options that are “out-of-the-money”, which makes it impossible to estimate the sensitivities of CEO wealth to changes in stock price and stock return volatility with true accuracy

I use a rich set of control variables in all model specifications to avoid omitted variable bias. The effects of all other variables that influence the dependent variable need to be captured in the model, to be able to estimate accurate regression coefficients for the explanatory variables of interest. As an addition, I include industry fixed effects and year fixed effects to control for unobserved changes in the industry and macroeconomic environment, which simultaneously affect the dependent and independent variables. In the regressions that are reported in the appendix, I replace industry fixed effects by firm fixed effects. Firm fixed effects are not my primary focus, since Coles, Daniel and Naveen (2006) argue that they may not be suitable for my empirical context. As CEO replacements are infrequent, the level of value maximizing vega is relatively stable over time, and thus most variation in vega arises cross sectionally, rather than in the time series. Besides, when CEOs respond quickly to changes in their risk-taking incentives, the effect these changes have on the riskiness of the firm are only visible in the first one or two years after the change in CEO incentives.

T-statistics on the regression coefficients are calculated based on robust standard errors, clustered at the firm level. As Cameron and Miller (2015) point out, an essential element for accurate statistical inference is to apply a standard error calculation method that fits the empirical context. Since my analysis is based on panel data, model errors for each individual firm are likely to be correlated over time, but errors are uncorrelated across firms. Clustered standard errors control for this within-firm error correlation, which reduces the probability of misleading statistical inference. Failure to control for this correlation can lead to misleadingly small standard errors, which in turn lead to overstated t-statistics (Cameron and Miller, 2015).

My primary regression method is ordinary least squares (OLS), but the regression parameters that are estimated to test the second hypothesis are also estimated with the two-stage least squares method (2SLS). As Coles, Daniel and Naveen (2006) and Armstrong and Vashishtha (2012) point out, endogeneity could be an issue when the influence of CEO risk-taking incentives on firm risk is analysed. Risk-taking incentives could influence CEO decision making, but boards might already incorporate this effect when structuring the compensation contract. The joint determination of CEO decisions and the design of the compensation contract can cause biased regression coefficients from OLS. The fact that some papers regress firm risk on vega (e.g. Guay, 1999; Cohen, Hall and Viceira, 2000; Coles, Daniel and Naveen, 2006; Armstrong and Vashishtha, 2012), while others regress vega on firm risk (Guay, 1999; Coles, Daniel and Naveen, 2006), provides evidence that an endogeneity problem might be apparent in this empirical context. Implementation of 2SLS controls for this potential endogeneity problem. In the 2SLS regressions, vega is replaced by a predicted value, which is estimated by regressing vega on a set of instrumental variables.

These instrumental variables are CEO cash compensation and delta. There are two main requirements that must be met by the instrumental variables for them to be considered valid instruments. They need to have high correlation with vega, and they should not be correlated to firm risk. I choose these instruments since I suppose that shareholders choose a combination of cash, delta and vega to provide the optimal incentives to their CEO. In the main text I will expand on this argument, and I will report several post-estimation tests to assess the model specification and the validity of the instruments.

Test results on the first hypothesis indicate that convexity in the executive compensation scheme is positively related to the proportion of assets that are growth options. I find that vega is positively related to research and development expenditures (R&D), while vega is negatively related to capital expenditures (CAPEX). The results do not depend on the combination of fixed effects that is included in the regression model.

Test results on the second hypothesis indicate that firm risk increases as convexity in the executive compensation scheme increases. I find that stock return volatility is positively related to vega, which indicates that CEOs respond to their incentives. Industry fixed effects, as well as year fixed effects, are an essential inclusion in the model. The relationship between total risk and vega does not hold when fixed effects are removed, or when industry fixed effects are replaced with firm fixed effects. The post-estimation tests indicate that the instruments are valid, the 2SLS model is correctly specified, but results from OLS are consistent. Coefficient estimates from OLS are slightly stronger than the ones from 2SLS.

As an addition to my main research questions, I investigate whether CEOs add to the systematic risk or the idiosyncratic risk of their firm. Cohen, Hall and Viceira (2000) argue that CEOs prefer idiosyncratic risk, since an increase in systematic risk could lower firm value. Systematic risk cannot be mitigated through diversification, so investors might require a higher expected return, and thus increase the rate at which future cash flows are discounted. My results seem to confirm this statement, but the results are not as strong as the ones on the two hypotheses. I fail to find any relationship between systematic risk and vega, while I find that idiosyncratic risk is positively related to vega in some of the model specifications. More research is needed to confidently argue that CEOs prefer idiosyncratic risk over systematic risk.

As mentioned, CEO incentives to increase firm risk has received relatively little academic attention compared to CEO incentives to increase firm value. The most cited papers on the topic are the ones written by Guay (1999) and Coles, Daniel and Naveen (2006). My main contribution is that I combine certain elements from these papers and apply them on an unexplored dataset of Dutch firms. To my knowledge, no other paper has focused on CEO risk-taking incentives in Dutch firms. Compared to US firms, Dutch firms use less option-based compensation and are exposed to a different corporate governance framework., which could lead to different test results.

My analysis does not simply copy the methodology of Guay (1999) and Coles, Daniel and Naveen (2006), but I also expand on certain elements. Guay (1999) does not include fixed effects in his regression models and does not address the endogeneity problem that might be apparent in the empirical context. Coles, Daniel and Naveen (2006) do not calculate their t-statistics based on robust standard errors clustered at the firm level, which could have influenced their statistical inference. I use a different method to control for the endogeneity problem. Coles, Daniel and Naveen (2006) use simultaneous equations, while I use instrumental variable analysis. Guay (1999) and Coles, Daniel and Naveen (2006) do not address the question of whether CEOs prefer to increase idiosyncratic risk over systematic risk as vega increases.

The paper proceeds as follows: Section 2 describes the theoretical framework which leads to the hypothesis. Section 3 illustrates prior literature on CEO incentives and provides background information on the corporate governance structure in the Netherlands. Section 4 describes the sample construction process, while Section 5 describes the variable measurement process. Section 6 is the analysis section, which contains descriptive statistics on the sample, explains the methodology and describes the results. Section 7 concludes.

2 Theoretical framework

In this section I will describe how misalignment between CEO incentives and shareholders creates an agency problem. I will illustrate the CEO incentives that are provided through equity-based compensation, and how these components can help alleviate the agency problem. Next, I will build my hypothesis by describing why it is important for firms to provide risk-taking incentives to their CEO, and how CEOs are expected to act on these incentives.

2.1 The agency problem

Public firms are characterized by a separation of ownership and control. Several shareholders own the firm, but most important decisions are made by a few managers. As head of the firm, the CEO is the one with most influence on these managerial decisions. In principle, the incentives of the shareholders and the CEO are not aligned. Shareholder wealth is purely dependent on firm value. To increase their wealth, they want the CEO to pursue all actions for which the expected benefit to the firm exceeds the expected cost. On the other hand, CEO wealth is not only driven by firm value, but also dependent on other factors, such as personal wealth and managerial power. As such, the CEO might base the decision on whether or not to pursue an action on other factors, besides the expected value the action creates for firm. As a result, the perceived expected value an action creates can substantially differ between the CEO and shareholders. This situation gives rise to a principal-agent problem; the CEO (agent) is entrusted to look after the interests of the shareholders (principal), but may use this power for personal benefits, at the cost of shareholders (Jensen and Murphy, 1990).

Literature on the agency problem states multiple examples of how the incentive misalignment causes the CEO to pursue actions that destroy shareholder value. Jensen and Meckling (1976) argue that the CEO might do too many acquisitions, as this increases the resources under the CEOs control, and thereby increases managerial power. The authors describe this phenomenon as empire building. Shareholder value gets destroyed as the firm grows above its optimal size. Second, Murphy (1985) argues that the CEO might fail to distribute excess cash to shareholders, even when there are no positive net present value projects to invest in. The author argues that the CEO might rather invest the excess cash below the cost of capital, since shareholder payouts reduce the resources under control, and thus decrease managerial power. Last, Shleifer and Vishny (1989) describe how CEOs can entrench themselves in their position by making manager-specific investments. These investments are more valuable under the current CEO than under the next best alternative, which makes it costly for shareholders to replace the CEO when managerial performance is low.

2.2 CEO incentives from equity-based compensation

Equity-based components in the executive compensation scheme, such as common stock or stock options, can help relieve the agency problem. They establish a situation in which CEO and shareholders share the same benefits and costs, which aligns the incentives of the two, and helps ensure that the CEO implements actions that are line with shareholder interests. Notably, the incentives that are provided by common stock holdings are different from the ones provided by stock option holdings. The cause of this difference is the difference in payoff structure and value drivers between these two assets.

Since the value of common stock is entirely dependent on the firm's share price, CEO stock holdings create a dependence between CEO wealth and firm value. A change in stock price leads to a change in CEO wealth in the same direction, which creates an incentive for the CEO to increase firm value. I will refer to the sensitivity of CEO wealth to firm value as the slope of the CEO wealth-performance relationship.

Unlike common stock, the value of a stock option is not only dependent on the firm's share price, but also on the volatility of the firm's share price. In principle, the asymmetric payoff structure of an option causes its value to increase when expected stock return volatility increases, and return volatility increases as the firm becomes riskier. Since a change in return volatility leads to a change in CEO wealth in the same direction, this creates an incentive for the CEO to increase firm risk. I will refer to the sensitivity of CEO wealth to firm risk as the convexity of the CEO wealth-performance relationship. Of course, option value is not only driven by return volatility, but also for example by the ratio of stock price relative to the option´s exercise price. Details on option valuation and the measurement of CEO incentives will be described in the variable measurement section.

2.3 Managing the CEO wealth-performance relation

As mentioned above, the CEO wealth-performance relationship consists of two dimensions: the slope and the convexity. Common stock holdings add to the slope of the relationship, while stock options add to both the slope and the convexity. Early studies on executive compensation, such as Jensen and Murphy (1990) focus on the slope of the relationship. However, Guay (1999) argues that only managing the slope of the CEO wealth-performance relationship is not sufficient to induce the CEO to make decisions according to shareholder interests. Since shareholders hold well diversified portfolios, they would like the CEO to pursue all actions that are expected to increase firm value, irrespective of the associated risks. CEOs on the other hand, are likely to have a much higher fraction of their financial and human wealth connected to the firm they manage (Cohen, Hall and Viceira, 2000). Due to a lack of diversification, the CEO might choose not to pursue actions that enhance firm value, if these actions are associated with an expected increase in firm risk. The optimal compensation contract should therefore not only provide the CEO with incentives to increase firm value, it should also contain the correct risk-taking incentives. A difference in risk-appetite between the CEO and shareholders can lead to risk-related agency problems, which destroy shareholder value.

These risk-related agency problems are expected to be most severe for growth firms with substantial investment opportunities (Guay, 1999). These firms incur the highest opportunity costs when valuable growth opportunities are not exploited due to CEO risk aversion. This theory implies that there should be cross-sectional differences among firms, in the risk-taking incentives that are provided to the CEO. Growth firms are expected to provide more convexity in the executive compensation scheme to encourage their CEO to pursue valuable, but risk-increasing projects. I use the following hypothesis to test this relationship:

Hypothesis 1: convexity in the executive compensation scheme is positively related to the proportion of firm assets that are growth options.

2.4 The riskiness of CEO decision making

When the executive compensation scheme contains equity-based components, additional risk is imposed on the CEO. Unlike cash salary, stock price and stock price volatility vary over time, which creates uncertainty in the CEOs total compensation. I use Pratt's (1964) certainty equivalent. to describe how managers act under risky conditions. The certainty equivalent models a risk-averse manager's trade-off between a payoff that is certain, versus a payoff that is risky. The certainty equivalent is defined in equation 1:

(1): $Certainty\ Equivalent = E(wealth) - risk\ premium$

The partial derivative with respect to stock return volatility yields:

(2): $$\frac{\partial(certainty\ equivalent)}{\partial(\sigma)} = \frac{\partial\big(E(wealth)\big)}{\partial(\sigma)} - \frac{\partial(risk\ premium)}{\partial(\sigma)}$$

The expression illustrates how the influence of firm risk on a manager's risk appetite can be split into two components. I refer to the first term of the formula as the wealth effect. After taking the partial derivative with respect to return volatility, it captures the expected increase in CEO wealth for an increase in firm risk. Without convexity in the executive compensation scheme, such as when the CEO only holds common stock, the wealth effect is zero. A change in firm risk should not influence the firm's share price, and thus also does not influence the CEO's expected wealth. Naturally, when risk-taking incentives are provided through options, the wealth effect is positive. When stock return volatility increases, the value of the options increases, and thus the expected wealth of the CEO increases.

I refer to the second term of the formula as the risk-aversion effect, which represents the concavity of a risk-averse manager's utility function. After taking the partial derivative with respect to return volatility, it captures the expected decrease in the CEO's utility for an increase in firm risk. The magnitude of the risk-aversion effect depends on the CEO's total wealth, diversification of this wealth, and the manager-specific utility function (Guay, 1999).

The magnitude of the wealth effect, relative to the risk-aversion effect, determines the CEO's overall preference to firm risk. If the wealth effect dominates, the CEO will prefer to increase firm risk. If the risk aversion effect dominates, the CEO will prefer to decrease firm risk. This illustrates that a CEO should be more willing to increase firm risk as convexity in the executive compensation scheme increases. I use the following hypothesis to test this relationship:

Hypothesis 2: firm risk increases as convexity in the executive compensation scheme increases.

The CEO can alter firm risk through the riskiness of managerial decision making. Sanders and Hambrick (2007) present a framework to assess the riskiness of a managerial decision. According to the authors, the risk associated with a decision can be decomposed into three inter-related elements. The first element is the amount at stake. The riskiness of a decision increases in its potential to alter the health of the firm. The second is the estimated variance of the outcomes. A decision becomes riskier as the spread of the potential outcomes increases. The third is the probability of an extreme loss. The riskiness of a decision increases if possible outcomes lead to a loss of all, or most, of the investment made. Sanders and Hambrick (2007) argue that a manager will, consciously or unconsciously, assess the riskiness of each possible decision by placing it into the framework. The manager will then pursue the action that aligns most closely to the manager's risk appetite.

3 Prior literature

This section revolves around prior literature on the agency problem and executive compensation. The first two sections summarize the international studies, which laid out the conceptual frameworks around the topic. The studies are described in chronological order, which means the first section focusses on the slope of the CEO wealth-performance relationship, while the second section focusses on the convexity of the relationship. The third section highlights potential negative effects of excessive risk-taking incentives in the executive compensation scheme. The last two sections describe Dutch studies on executive compensation and the Dutch corporate governance framework.

3.1 Slope of the CEO wealth-performance relation

The idea that executive compensation should be aligned with shareholder interest originates from the study by Jensen and Meckling (1976). The authors define the concept of agency costs and its relationship to the separation of ownership and control. The paper illustrates the importance of a connection between executive compensation and executive wealth, as it ensures that managerial decisions are made to increase shareholder value. Since then, academic interest on executive compensation started to grow, especially in the US. Initially, most of this research focusses on the slope of the executive's wealth-performance relation.

The first influential study was performed by Jensen and Murphy (1990), which focusses on the pay-performance sensitivity (PPS). PPS measures how much CEO pay changes, in dollar terms, for a change in firm value of $1,000. The authors define CEO pay as the sum of cash compensation, new grants of stock and options, plus the increase in value of outstanding stock and option holdings. Although they find a positive relationship between CEO pay and firm performance, this relationship is small. The authors conclude that the firms in their sample do not follow optimal contracting theory. The sample of Jensen and Murphy (1990) includes US firms between 1974 and 1986.

Hall and Liebman (1998) build further on the study by Jensen and Murphy (1990). Besides the PPS, they use several other measures to examine the relationship between executive compensation and firm performance, such as the pay-performance elasticity (PPE). PPE measures the percentage change in CEO pay for a 1 percent change in firm value. The advantage of using percentage changes (PPE) over absolute changes (PPS), is that it better captures cross-sectional variance, and is less sensitive to differences in firm size. Hall and

Liebman (1998) find a strong positive relationship between total executive compensation and firm performance. The positive relationship stems almost entirely from the equity-based component in the CEO compensation scheme. This finding explains the difference in their conclusion compared to Jensen and Murphy (1990), since equity-based compensation is a considerably bigger fraction of total CEO pay in the sample of Hall and Liebman (1998). The sample of Hall and Liebman (1998) includes US firms between 1980 and 1994.

3.2 Convexity of the CEO wealth-performance relation

Early studies, such as Jensen and Meckling (1976) and Smith and Stulz (1985), already point out that CEO risk-aversion can cause misalignment in the interests of executives and shareholders. Still, it took some time before academic interest started to grow on the convexity of the CEO wealth-performance relation. Guay (1999) was the first to provide empirical evidence on the importance of risk-taking incentives in the executive compensation scheme.

First, Guay (1999) explores the cross-sectional determinants of CEO risk-taking incentives. The author uses vega to measure convexity in the CEO wealth-performance relationship and finds that vega is positively related to firm growth opportunities. Second, Guay (1999) explores whether CEOs respond to the risk-taking incentives that are provided to them. The results indicate that they do, as he reports a positive relationship between stock return volatility and vega. The author uses Ordinary Least Squares (OLS) regressions to test his hypothesis. Fixed effects are not included. The sample includes US firms in 1993.

Guay (1999) uses stock options, but also common stock, to calculate vega. However, the author reports that the influence of common stock on vega is negligible, unless the firm is in financial distress. For these firms, the payoff structure for common stock becomes asymmetric, which is similar to the payoff structure of a stock option. Based on this evidence most future research ignores common stock holdings in the calculation of vega.

Coles, Daniel and Naveen (2006) examine the influence of vega on CEO decision making. The authors find a positive relation between vega and the riskiness of policy choices. Higher vega leads to more research and development expenditures, less capital expenditures, less diversification across business segments, higher leverage, and higher stock return volatility. Coles, Daniel and Naveen (2006) are one of the first to note that endogeneity could be an issue when the influence of risk-taking incentives on the riskiness of CEO decision making is examined. The authors argue that these two variables are likely to be jointly determined, because boards are expected to incorporate the effect of the incentives they provide to the CEO when designing the compensation contract. Coles, Daniel and Naveen (2006) use simultaneous equations to address the endogeneity problem, and fixed effects to avoid omitted variable bias. The sample includes US firms between 1992 and 2002.

Armstrong and Vashishtha (2012) examine the influence of vega on total risk, measured by the volatility of stock returns. As an addition, the authors decompose firm risk into idiosyncratic risk and systematic risk. The results indicate a positive relationship between vega and both total risk and systematic risk, but no relation between vega and idiosyncratic risk. This suggests that vega gives CEOs an incentive to increase firm risk through an increase in systematic risk. Armstrong and Vashishtha (2012) explain this result by stating that risk-averse CEOs can hedge any unwanted systematic risk away by trading on the financial market. Executives who do not have the ability to sell, or otherwise hedge their exposure to firm risk, do not value their option portfolio at market value, but will instead value them subjectively according to their personal preferences (Armstrong and Vashishtha, 2012). The authors use instrumental variable analysis to address the endogeneity problem, and fixed effects to avoid omitted variable bias. The sample includes US firms between 1992 and 2007.

3.3 Negative effects of CEO risk-taking incentives

As described in the theoretical framework, convexity in the CEO wealth-performance relationship is essential to avoid risk-related agency problems. Stock options in the executive compensation scheme provide this convexity, and thus help alleviate the issue that shareholders are more risk-seeking than CEOs. Hall and Liebman (1998) describe options as the most direct solution to the conflict of interest between CEO and shareholders. However, literature states multiple examples in which the usage of options in the executive compensation destroys shareholder value.

In specific situations, options might create the wrong incentives. Esty (1997) for example, provides evidence of excessive risk-taking for CEOs that have a negative net worth. These CEOs may engage in projects, even if they are expected to decrease firm value, as long as the projects are sufficiently risky. Besides, CEOs might use the wrong resources to increase firm risk. Cohen, Hall and Viceira (2000) argue that CEOs might increase firm risk through an increase in leverage, which might lead to a deviation from the firm's optimal capital structure. Second, Sanders (2001) finds that manager primarily increase firm risk by doing more acquisitions, which destroy firm value for the acquirer on average (Jensen and Ruback, 1983).

And last, excessive use of options in the executive compensation scheme might over-incentivize CEOs to increase firm risk. Bebchuck, Cohen and Spamann (2010) argue that equity-based compensation led to excessive risk-taking among the executives of Bear Stearns and Lehman between 2000 and 2008. The authors argue that the incentive plans in these banks have played a significant role in the build-up of the financial crisis.

3.4 Executive compensation in the Netherlands

Literature on CEO incentives in the Netherlands is scarce. Especially the determinants of risk-taking incentives, and how these influence CEO decision making, has not triggered academic interest. To my knowledge, there are no studies that focus on convexity in the CEO wealth-performance relation. A possible reason for this gap in the literature is the unavailability of data. Before 2003, Dutch firms were not legally obliged to report on executive compensation in detail. As a result, most firms did report the estimated total value of CEO stock option holdings, but did not report the exact details of these option holdings. These details are essential for an accurate estimation of convexity in the CEO wealth-performance relation. Even after 2003, when firms became legally obliged to report on executive compensation in detail, these details are not stored in an online database. As a result, a manual process is required to create a dataset that can be used for quantitative analysis. However, there are some studies that focus on the slope of the CEO wealth-performance relation, as data on CEO common stock holdings is more easily gathered.

One of these studies is the one by Cornelisse, Duffhues and Kabir (2005). The authors examine whether CEO pay is related to firm performance, but fail to find a relationship between the two. Since Cornelisse, Duffhues and Kabir (2005) measure CEO pay as the sum of base salary and cash bonus, this conclusion could be inaccurate. Equity-based components are not included. As Hall and Liebman (1998) point out, equity-based components in the compensation scheme are the main driver for a connection between CEO wealth and shareholder wealth. The sample of Cornelisse, Duffhues and Kabir (2005) includes Dutch listed firms between 2002 and 2003.

Duffhues and Kabir (2008) examine the pay-performance relationship for a sample of Dutch listed firms between 1998 and 2001. In most model specifications the authors do not find a relationship between CEO pay and firm performance. In some model specifications the authors even report a negative relationship. The analysis by Duffhues and Kabir (2008) suffers from a similar drawback as the one by Cornelisse, Duffues and Kabir (2005). Compensation in the form of stock and options is excluded, except for a small subset of the sample for which the equity-based component is estimated.

To my knowledge, Van der Laan, van Ees and van Witteloostuijn (2010) are the first to include the equity-based components in their analysis. Based on a manually gathered dataset, which includes Dutch listed firms between 2002 and 2006, they find a slightly positive relationship between CEO pay and firm performance.

3.5 Dutch corporate governance

As the previous paragraph shows, Dutch literature indicates that the link between shareholder wealth and CEO wealth is weak, especially before 2003. Although most studies suffer from severe data issues, the general conclusion might be accurate. The Dutch corporate governance structure, which is meant to align these interests, was known to provide little pressure. Dutch firms were characterized by ingenious anti-takeover mechanisms, managerial decisions that do not maximize firm value, and shareholders that do not have influence on executive remuneration (Duffhues and Kabir, 2008). Up from the late 1990s, several initiatives were started to improve corporate governance practices in the Netherlands.

In 1997 the first Dutch corporate governance code was installed by the Peters Committee, named after its chairman. The code-Peters consists of 40 recommendations, which aim to increase the effectiveness of management, supervision of management, and accountability to shareholders (De Jong, De Jong, Mertens and Wasley, 2005). An important characteristic of the code is that it is a self-regulation initiative, meaning that the recommendations are monitored without actual enforcement. Studies that examined the effectiveness of the code-Peters indicate that the recommendations did not significantly influence corporate management.

Jong and Roosenboom (2002) examine the influence of the code on corporate activity of Dutch firms between 1997 and 2002. The authors find that the number of firms that provide information in their annual report regarding compliance with the code is very limited. Besides, the firms that do comply, only seem to do so formally, without it having any effect on corporate management (Jong and Roosenboom, 2002). De Jong, De Jong, Mertens and Wasley (2005) explore the relationship between firm value and corporate governance characteristics, both before and after the recommendations were issued. The authors find that the code did not influence corporate governance in Dutch firms, nor the relationship between corporate governance and firm value.

In 2003 the Tabaksblat Committee was installed, which had the task to create a new corporate governance code. The goal of the new code is to improve several factors, such as transparency in the annual report, insight for the supervisory board, influence of shareholders, and protection of shareholders (Corporate Governance Committee, 2003). Besides, the new code should take international developments into account and build on the observed unsuccessfulness of the recommendations made by the Peters Committee (Akkersmans, Van Ees, Hermes, Hooghiemstra, Van der Laan, Postma and van Witteloostuijn, 2007).

The final version of the code-Tabaksblat was published in December 2003. Up from the fiscal year 2004, all firms listed on the Dutch stock exchange, or firms which have a statutory residence in the Netherlands, are legally required to indicate to what level the firm complies with the corporate governance code in the annual report (Corporate Governance Committee, 2003). Code-Tabaksblat seems to be more successful in achieving its goals than code-Peters. Akkersmans, Van Ees, Hermes, Hooghiemstra, Van der Laan, Postma and Witteloostuijn (2007) examine the acceptance of the code-Tabaksblat. The authors find that the extent of compliance with the code is high. Based on a sample of 150 firms, they find that after 2004 most firms report in much more detail on their corporate governance structure than before 2004.

The code-Tabaksblat is build upon 21 principles, which according to the Committee represent the general consensus on good corporate governance. These principles are translated into 113 concrete best practice provisions. Similar to the corporate governance codes in other countries, the code operates on the comply-or-explain principle. In general, all firms should follow the best practice provisions. If a firm chooses not to comply, it is obliged to accurately explain the reason underlying the deviation from the code in the annual report. A significant part of the best practice provisions is dedicated to the amount, composition, and transparency of the executive compensation scheme. Most of these provisions aim to create a link between executive compensation and firm performance. This ensures that managerial decisions are made to increase medium- and long-term shareholder value, managers do not act out of personal interest, and management failure does net get rewarded (Corporate Governance Committee, 2003).

4 Sample construction

In this section I describe the sample construction process. I will describe the steps in the data gathering process, the data sources, why I lose these observations, how the observations are distributed, and what makes my dataset unique. The sample is based on Dutch listed firms between 2003 and 2013. It contains 281 firm year observations, for firms that traded on the Euronext Amsterdam stock exchange and all required information is publicly available. Quantitative analysis is done in STATA.

To gather the data, I start with retrieving the company identifiers for the listed stocks in my sample from Datastream. I use these identifiers to find CEO compensation characteristics in Capital IQ. The data is available for 1281 firm years. Unfortunately, the details of the stock options that are held by the CEOs in my sample are not stored in a database. However, they are reported in the annual reports. Since the details of executive stock options are essential for the measurement of CEO incentives, I decide to manually collect the option characteristics that are necessary for my analysis. I collect the grant year, maturity year and exercise price for each option in the CEO's option portfolio. I drop 849 firm years from the sample because I am not able to find the annual report (307), there was a CEO change during the year (40) or the CEO did not hold any options (502). For the remaining 432 firm years I copy the option characteristics into an Excel file.

I gather financial report data from Compustat and stock price data from Datastream. 38 firm years are lost after merging the datasets, primarily due to non-matching firm identifiers. I drop financial firms (sic code: 6000 - 6799) to ensure skewed fundamentals do not drive my results, as is usually done in quantitative finance studies. For financial firms, certain fundamentals do not have the same meaning as for non-financial firms. Leverage for example, is usually very high for financials compared to non-financials. This decision leads to a loss of 53 firm years. Last, 60 firm years are dropped because essential data is missing. For example, to avoid inaccurate estimation I require at least 12 months of returns in my calculations for historical volatility and future volatility. Which means the stock must have at least a full year of returns in the previous and next year. Restrictions like this lead to an increase in the accuracy of variable estimation, but to a decrease in sample size.

As mentioned, the final sample contains 281 firm years. Table 11, which is reported at the end of the appendix, shows the distribution of these observations. Panel A shows the amount of observations per year, while panel B shows the amount of observations per firm. The year that contains the most observations is 2006, with an amount of 35 observations. After 2006, the amount of observations decline each year. The lowest value is in 2013, which includes only 14 observations. The primary reason for this decline is that over time, less firms used options to compensate their CEO, which caused more CEOs to be dropped from the sample because they did not hold any options. Panel B shows that the observations are distributed over 46 firms, which indicates that on average each firm is represented approximately 6 times in the sample.

The manual data gathering process makes my dataset unique. It contains precise details on the CEO option holdings in Dutch listed firms. To my knowledge, there is only one other dataset that covers CEO option holdings for Dutch firms, while most studies based on US firms lack detail. Cornelisse, Duffhues and Kabir (2005) exclude CEO equity holdings in the construction of total CEO pay. Since the sample period is before 2003, code-Tabaksblat was not yet installed, which means that most Dutch listed firms did not report the details on executive remuneration. Although the sample of Duffhues and Kabir (2008) is after 2003, the authors choose to estimate CEO equity holdings to save time. The only other dataset that covers CEO option holdings for Dutch listed firms is the one constructed by Van der Laan, van Ees and van Witteloostuijn (2010).

Regarding US studies, the samples of Coles, Daniel and Naveen (2006) and Armstrong and Vashishtha (2012) are constructed with the help of the ExecuComp. This is a dataset that contains proxy statements for US listed firms. A disadvantage of using this dataset is that it excludes options that are “out-of-the-money”, which makes it impossible to estimate the sensitivities of CEO wealth to changes in stock price and stock return volatility with true accuracy. As it is manually gathered, the sample of Guay (1999) does include similar detail to mine. The trade-off is that our samples are smaller in size, while accuracy is higher.

5 Variable measurement

The following section describes the measurement of the slope and convexity in the CEO wealth-performance relation. Table 1, which is reported at the end of the section, provides a short description on the measurement of vega, delta, and all other variables that are used in the analysis. The table presents the definition, the data source, and the unit of measurement. The usage of these variables will be described in more detail in the analysis section.

As explained in the theoretical framework, stock options in the executive compensation scheme help align the interests of the CEO and shareholders. They provide the CEO with an incentive to increase firm value and firm risk, since their personal wealth becomes dependent on these factors. I quantify the strength of this dependence with the variables vega and delta.

Vega captures the incentives that are provided to the CEO to increase firm risk, measured as the sensitivity of CEO wealth to stock return volatility. Vega is defined as the euro change in risk-neutral valuation of the CEO's option portfolio for a 0.01 change in the standard deviation of underlying stock returns. Delta captures the incentives that are provided to the CEO to increase firm value, measured as the sensitivity of CEO wealth to stock price. Delta is defined as the euro change in risk-neutral valuation of the CEO's option portfolio for a 1 percent change in stock price.

I ignore CEO stock holdings in the estimation of CEO incentives since Guay (1999) shows that the risk-taking incentives provided by stock is negligible, except for firms in financial distress. For these firms, the payoff structure for common stock becomes asymmetric, similar to the payoff structure for stock options. My definitions for vega and delta, and my decision to ignore stock holdings in the measurement of CEO incentives, is in line with prior literature (e.g. Guay, 1999; Coles, Daniel and Naveen, 2006; Armstrong and Vashishtha, 2012).

5.1 The Black-Scholes model

I use the Black and Scholes (1973) option pricing model, as modified by Merton (1973) to account for dividend payouts, to calculate the risk-neutral value of CEO stock option holdings. Black and Scholes (1973) argue that when options are correctly priced in the market, there should be no opportunity on generating riskless profits by creating a portfolio of long and short positions in options and the underlying stock. Based on this principle they derive the following option valuation formula for European call options:

(3): $Option\ value = \left[Se^{-dT}N(Z) - Xe^{-rT}N\left(Z - \sigma T^{\frac{1}{2}}\right)\right]$

Where

Z = (4): $[\ln(S/X) + T(r - d + \sigma\hat{}2/2)]/(\sigma T\hat{}(1/2))$

N = cumulative probability function for the normal distribution

S = price of the underlying stock

X = exercise price of the option

σ = expected stock return volatility

r = risk-free interest rate

T = time to maturity of the option in years

d = expected dividend yield

Even though the option valuation formula is mathematically sophisticated, it can be interpreted using some relatively easy principles. First, option value is increasing in expected return volatility. An option gives the holder the right, but not the obligation, to exercise the option. This means that the value of an option can never be less than zero. On the other hand, the upside is unlimited, which makes holding an option more valuable if returns are more volatile. Second, option value is increasing in the ratio of the stock price relative to the exercise price. The higher this ratio, the more likely it is that the option ends in the money at expiration. Third, option value is increasing in time to maturity. The longer the option has until expiration, the more time is left for an event to occur to make the option end up in the money. Fourth, option value is decreasing in expected dividend yield. Stock prices typically drop by an amount equal to the dividends paid on the ex-dividend date. Option holders do not receive these dividends. Because stock price drops, the ratio of stock price to exercise drops, and thus option value drops.

5.2 Parameter estimation

I estimate the parameters for the option valuation model as follows: Expected sock return volatility (σ) equals the annualized standard deviation of returns over the previous 60 months. First, the monthly returns are winsorized at the 5^{th} and 95^{th} percentiles. Then, the standard deviation of monthly returns is estimated and multiplied by the square root of 12. I require at least 12 months to avoid inaccurate estimation. If the stock has traded for less than a year, I use the average annualized volatility of all other firms in the sample. The risk-free rate (r) equals the interest rate on a Dutch government bond with a 10-year maturity. I estimate the expected dividend yield (d) by dividing the dividends paid over the previous fiscal year by the stock price at the beginning of the current fiscal year. My parameter estimation techniques are similar to the ones applied by Armstrong and Vashishtha (2012). The parameters for stock price (S), exercise price (X) and time to maturity (T) do not require estimation, as they are either provided by Datastream or manually gathered from the annual reports.

5.3 Sensitivity estimation

Consistent with Core and Guay (2002), I measure the vega of an option as the partial derivative of option value with respect to stock return volatility, multiplied by 0.01. The delta of an option is measured as the partial derivative of option value with respect to stock price, multiplied by 1 percent of stock price. I calculate the total CEO incentives in a certain year by summing the vega and delta over all options in executive's option portfolio. The measurement of vega ad delta is specified in equations 5 and 6 respectively:

$$(5): Vega = \left[\frac{\partial(option\ value)}{\partial(stock\ return\ volatility)}\right] * 0.01 = \mathrm{e}^{-\mathrm{dT}} N'(Z) S T^{\frac{1}{2}} * (0.01)$$

Where N' is the normal density function.

$$(6): Delta = \left[\frac{\partial(option\ value)}{\partial(stock\ price)}\right] * \frac{stock\ price}{100} = \mathrm{e}^{-\mathrm{dT}} N(Z) * \left(\frac{stock\ price}{100}\right)$$

An alternative to measuring delta in dollars, or euros in my case, is to measure these incentives in fractional firm holdings (e.g. Jensen and Murphy, 1990). Delta is then measured as the change in the risk-neutral value of the executive's equity portfolio for a certain dollar change in firm value, instead of a percentage change in firm value. Core, Guay and Larcker (2003) and Baker and Hall (2004) argue that the method should be chosen according to how CEO actions are assumed to affect firm value. When CEO actions are assumed to primarily affect the dollar returns of the firm, for example through the purchase of a luxurious asset that benefits the executive, the fractional-holdings measure is appropriate. When CEO actions are assumed to primarily affect the percentage returns of the firm, for example through the implementation of a certain corporate strategy, the dollar-holdings method is appropriate. Since my study focusses on whether strategic CEO decision making influences firm risk, I implement the dollar-holdings measure.

Table 1: Variable construction

This table presents the definition, the data source, and the unit of measurement, for all variables that are used in the analysis. Data sources include the Annual Report (AR), Capital IQ (IQ), Compustat (CO) and Datastream (DA). Variables that are expressed in their natural logarithm are denoted with (ln). The Compustat and Datastream items are denoted with (item).

Name	Definition	Source	Unit
Age	Current year - CEO's year of birth.	IQ	Year
Book Leverage	(*Long-Term Debt* + *Debt in Current Liabilities*) / *Total Assets*	CO	Ratio
Book Value of Equity	Common equity (item: ceq).	CO	Million
Book-to-Market	*Total Assets* / (*Total Assets* - *Book Value of Equity* + *Market Cap)*	CO, DA	Ratio
CAPEX	(Investment in PPE (item: capx) - Sale of PPE (item: sppiv)) / *Total Assets*	CO	Ratio
Cash Compensation	Salary + Cash Bonus received by the CEO during the fiscal year (ln).	IQ	Million
Debt in Current Liabilities	Sum of short term notes and long-term debt due less than one year (item: dlc).	CO	Million
Delta	Change in *Risk-Neutral Value* of the CEO’s option portfolio for a 1% change in *Stock Price* (ln).	AR, DA	Thousand
Exercise Price	Price at which the underlying stock can be bought.	AR	Unit
Expected Dividend Yield	Dividends (item: dvt) paid over the previous fiscal year / *Stock Price* at the beginning of the fiscal year.	CO, DA	Ratio
Expected Return Volatility	Annualized standard deviation of logarithmic stock returns over the previous 60 months, with a minimum of 12 months.	DA	Unit
Growth Expenditures	*R&D - CAPEX*	CO	Unit
Idiosyncratic Risk	Standard deviation of monthly residuals from the CAPM model over the future 60 months, with a minimum of 12 months.	DA	Unit
Long-Term Debt	Debt obligations due more than one year (item: dltt).	CO	Million
Market Cap	*Shares Outstanding* * *Stock Price.*	CO, DA	Billion

Market Return	Monthly logarithmic return on the MSCI NL index (item: msciethl).	DA	Unit
Portfolio Value	Sum of the *Risk-Neutral Value* for all options in the CEO’s option portfolio.	AR	Million
Price-to-Strike	Simple average of *Share Price* / *Exercise price* for all options in the CEO’s option portfolio.	DA, AR	Ratio
R&D	Research and Development expense (item: xrd) / *Total Assets*, set to zero if missing.	CO	Ratio
Return	Monthly logarithmic stock return.	DA	Unit
Risk-Free Rate	Interest rate on a Dutch government bond with a 10-year maturity.	DA	Unit
Risk-Neutral Value	Option value, based on the Black-Scholes formula for European call options, as modified by Merton to account for dividend yields.	AR, DA	Unit
Sales	Revenues (item: sale).	CO	Billion
Shares Outstanding	Common shares outstanding (item: cshoi).	CO	Million
Stock price	Closing price, not adjusted for bonus and right issues (item: up).	DA	Unit
Systematic Risk	Standard deviation of predicted monthly stock returns by the CAPM model over the future 60 months, with a minimum of 12 months.	DA	Unit
Time to Maturity	Current year - Maturity year of the option.	AR	Year
Total Assets	Book value of assets (item: at).	CO	Billion
Total Risk	Standard deviation of monthly stock returns over the future 60 months, with a minimum of 12 months.	DA	Unit
Vega	Change in *Risk-Neutral Value* of the CEO’s option portfolio for a 0.01 change in *Expected Return Volatility* (ln).	AR, DA	Thousand

6 Analysis

6.1 Descriptive statistics

Table 2, which is reported at the end of the section, presents descriptive statistics on the core variables. I present the mean, median, standard deviation, 10th percentile and 90th percentile. The variables are grouped into CEO Characteristics, Black-Scholes Parameters, Firm Characteristics and Risk Measures. I will describe the results, substantiate the findings, and compare the results to the ones in the related studies from Guay (1999), Coles, Daniel and Naveen (2006), and Armstrong and Vashishtha (2012). I will mainly focus on the results that differ from the ones in these studies. Some of the findings will only be compared to one or two of the related studies, since not all studies use the same set of variables. Besides, some studies provide less detail. For example, Coles, Daniel and Naveen (2006) and Armstrong and Vashishtha (2012) provide descriptive statistics on vega, but do not report the Black-Scholes parameters underlying the calculation, while Guay (1999) does. When a study is not mentioned in the comparison, this means that descriptive statistics on the variable are not reported in that particular study.

6.1.1 CEO characteristics and Black-Scholes parameters

The mean (median) vega is €22,320 (€11,480). The mean (median) delta is €32,520 (€13,680). These results imply that on average the value of the CEO’s option portfolio increases with €22,320 for an increase in volatility of stock returns of 0.01, and with €32,520 for a 1 percent increase in stock price. Dutch listed firms provide less risk-taking incentives to their CEO than US listed firms. Guay (1999), Coles, Daniel and Naveen (2006), and Armstrong and Vashishtha (2012) report a mean vega of $45,970, $80,000, $100,000 respectively.

The question that arises is: what drives this difference in vega? A difference in the number of options, the time to maturity of the options, the price-to-strike ratio of the options, or volatility of the underlying asset, are all possible explanations. The main driver for the difference in vega seems to be a difference in time to maturity. The mean (median) time to maturity in my sample is 4.36 (4.00) years. Guay (1999) reports a mean of 7.18 years. Vega increases in time-to-maturity as uncertainty around the underlying increases. It becomes easier to estimate what the price of the underlying stock will be when the option gets closer to expiration. Accordingly, more time-to-maturity means less precision, and thus more sensitivity to changes in expected return volatility. The difference could indicate that, on average, the life of the granted options in Dutch firms is shorter. Or that the option portfolios consist of option grants that are relatively further in the past, which is an indication that options are becoming a less significant component in executive compensation schemes in the Netherlands. The second argument seems to be true, as was explained in the sample construction section.

The difference in the amount of options held by the CEOs is relatively small. I report a mean option amount of 276,260, while Guay (1999) reports a mean of 257,890. Similarly, the difference in price-to strike ratio is relatively small. The mean (median) price-to-strike ratio in my sample is 1.46 (1.26). Guay (1999) reports a mean of 1.50. The price-to-strike ratio influences vega, since the closer an option is to being "at the money", the higher the option's vega will be. The value of an option with a price-to-strike ratio much greater than one changes almost linearly with changes in stock price, which makes the option less sensitive to changes in expected return volatility (Guay, 1999).

Whether there is a difference in expected volatility of the underlying asset is hard to judge. Guay (1999) does not report descriptive statistics on expected return volatility. The mean (median) expected return volatility in my sample is 0.34 (0.32). Guay (1999) uses a slightly different method for the calculation of the Black and Scholes (1973) option pricing model parameter. Namely, the annualized standard deviation over the previous 120 trading days. I use the annualized standard deviation of stock returns over the previous 60 months, which is similar to the method applied by Armstrong and Vashishtha (2012). The difference in calculation method, time period, and region could be a second driver for a difference in vega.

As expected, since vega is on average smaller, the average option portfolio value is also smaller. The mean (median) portfolio value is €1.76 (€0.57) million. Guay (1999) reports mean of $4.23 million. The level of cash compensation is relatively similar across all four studies. The mean (median) cash compensation in my sample is €0.96 (€0.64) million. Guay (1999), Coles, Daniel and Naveen (2006), and Armstrong and Vashishtha (2012) report a mean cash compensation of $1.10 million, $1.14 million, $1.16 million respectively.

6.1.2 Firm characteristics and risk measures

The sample contains relatively big firms, which is probably caused by the manual nature of the dataset, as it constraints the number of firms that can be included in the sample. Besides, for the construction of my sample it is essential that the annual report is still available. For small firms it is more difficult to find the annual report than it is for big firms. The mean (median) sales is €17.06 (€1.38) billion. Coles, Daniel and Naveen (2006), and Armstrong and Vashishtha (2012) report a mean of $3.8 billion and $4.4 billion respectively. Descriptive statistics on book leverage, book-to-market, R&D, CAPEX and growth expenditures are in line with prior literature. These variables are not influenced by the difference in firm size as they are scaled by total assets.

Descriptive statistics on the risk measures do provide some differences. While systematic risk is in line with prior research, I find that average values on total risk and idiosyncratic risk are higher. The mean (median) total risk is 0.11 (0.10), and idiosyncratic risk is 0.09 (0.08). Armstrong and Vashishtha (2012) report a mean of 0.07 and 0.04 respectively. I suppose the main driver for this difference is the sample period. My sample ranges from 2003 to 2013, while the one of Armstrong and Vashishtha (2012) ranges from 1992 to 2007. This means that my sample covers the financial crisis, while theirs does not. During this period volatility increased, which causes the CAPM to lose some of its predictive power. Consequently, residuals from the CAPM increase, and therefore the standard deviation of these residuals increase. Since I use the same calculation methodology as Armstrong and Vashishtha (2012), the method underlying the construction of these variables is not a driver for the difference in risk measures.

6.1.3 Conclusion

The descriptive statistics indicate that CEOs of Dutch firms receive less convexity in their executive compensation scheme than their US counterparts. Besides, total CEO pay is lower in Dutch firms, unless stock-based compensation, which is ignored in this analysis, is significantly higher. The magnitude of the difference is probably even greater than the reported numbers make believe. Total CEO pay in my sample is lower, even though the firms are on average bigger, and the sample period is 10 to 20 years later. Hall and Liebman (1998) show that CEO pay is positively related to firm size and increases over time. I expect the difference in risk-taking incentives and total CEO pay to be even bigger when CEO pay in Dutch firms would be compared to CEO pay in US firms, which have similar size, and are compared over the same time period.

In the regressions that follow, vega, delta, cash compensation and sales are expressed in their natural logarithm. The large discrepancy between the mean and the median implies that these variables follow a skewed distribution. After logarithmic transformation the data is closer to the normal distribution, which reduces heteroscedasticity. Heteroscedasticity is a concern when applying linear regression as it can invalidate significance tests on the regression coefficients (White, 1980).

Table 2: Descriptive statistics

This table presents the mean, median, standard deviation, 10th percentile, 90th percentile and amount of observations for the core variables that are used in the analysis. The variables are grouped into CEO Characteristics, Black-Scholes Parameters, Firm Characteristics and Risk Measures The reported value for the Black-Scholes Parameter is the simple average for all options in the CEO's option portfolio in a certain year.. The sample contains 281 year observations, for firms that traded on the Euronext Amsterdam between 2003 and 2013 and all required information is publicly available. None of the variables is expressed in its natural logarithm. The variable construction is described in table 1.

	Mean	Median	Standard Deviation	10th Percentile	90th Percentile	N
CEO Characteristics						
Vega (€ 000s)	22.32	11.48	33.88	0.25	53.40	281
Delta (€ 000s)	32.52	13.68	48.65	0.89	86.15	281
Cash Compensation (€ millions)	0.96	0.64	0.90	0.26	2.01	281
Portfolio Value (€ millions)	1.76	0.57	2.77	0.03	4.98	281
Price-to-Strike	1.46	1.26	0.96	0.75	2.37	281
Number of Options (000s)	276.26	160.00	358.48	25.00	677.85	281
Black-Scholes Parameters						
Stock Price	20.73	17.60	15.11	3.80	42.90	281
Exercise Price	17.56	15.04	11.83	4.89	35.85	281
Expected Return Volatility	0.34	0.32	0.13	0.21	0.52	281
Risk-Free Rate	0.03	0.04	0.01	0.02	0.04	281
Time to Maturity (years)	4.36	4.00	2.00	2.00	7.38	281
Expected Dividend Yield	0.02	0.02	0.03	0.00	0.05	281
Firm Characteristics						
Sales (€ billions)	17.06	1.38	67.33	0.06	25.42	281
Book Leverage	0.21	0.20	0.14	0.05	0.39	281
Book-to-Market	0.73	0.73	0.24	0.42	1.04	281
R&D	0.03	0.00	0.10	0.00	0.09	281
CAPEX	0.06	0.04	0.07	0.02	0.10	281
Growth Expenditures	-0.02	-0.03	0.12	-0.10	0.05	281
Risk Measures						
Total Risk	0.11	0.10	0.06	0.06	0.17	281
Systematic Risk	0.05	0.05	0.03	0.02	0.08	281
Idiosyncratic Risk	0.09	0.08	0.06	0.05	0.15	281

6.2 The relation between CEO risk-taking incentives and firm growth opportunities

The second section of the analysis is on the determinants of risk-taking incentives. As explained in the theoretical framework, it is most costly for growth firms if CEO risk-aversion leads to the CEO passing up on valuable, but risky projects. These firms are expected to provide more convexity in the compensation scheme of their CEO to reduce risk-related agency costs. To test the first hypothesis, I regress vega on a range of variables that capture growth opportunities, a range of controls, and a combination of fixed effects. The model is specified in equation 7:

$$(7): Vega_{i,t} = \alpha + \beta_1 R\&D_{i,t} + \beta_2 CAPEX_{i,t} + \beta_3 BM_{i,t} + \beta_4 Delta_{i,t} + \beta_5 Cash_{i,t} + \beta_6 Sales_{i,t} + \mu_s + \eta_t + \epsilon_{i,t}$$

I use the Ordinary Least Squares (OLS) method to estimate the parameters in equation 7. *Vega* refers to the convexity in the CEO wealth-performance relationship. *R&D* and *CAPEX* are the two proxies that capture cross-sectional variation in growth opportunities. I predict a positive coefficient on R&D and a negative coefficient on CAPEX. I replace R&D and CAPEX in a second regression specification with one variable that measures the expenditures on R&D relative to CAPEX: growth expenditures. By constructing one variable out of the two proxies I make it easier to draw a conclusion from the regression results. I predict a positive coefficient on growth expenditures.

My choice for the selection of the proxies for growth opportunities, and the predicted sign for these variables, is based on prior literature. Coles, Daniel, and Naveen (2006) argue that firms with a lot of growth opportunities are expected to allocate funds away from CAPEX to R&D, and vice versa. Besides, Long, Wald and Zhang (2002) find a positive coefficient on R&D and a negative coefficient on CAPEX, when the present value of growth options is regressed on these variables. The authors argue that R&D is positively related to firm growth as it stimulates the creation of growth options. It increases the likelihood on generating higher future income and generating new products. On the other hand, CAPEX is negatively related to firm growth, as investment indicates the exercise of these growth options. For firms with a lot of growth opportunities it is optimal to delay investment, since as with regular options, the value of the growth options may increase over time.

6.2.1 Controls

BM, *Delta*, *Cash*, and *Sales* are the control variables. Controls are included in all model specifications to avoid omitted variable bias. The effects of all other variables that influence the dependent variable need to be captured in the model to be able to estimate accurate regression coefficients for the explanatory variables of interest. In my selection of the control variables I follow Guay (1999) and Coles, Daniel and Naveen (2006).

The first control is book-to-market, which captures the market's view on the growth of future cash flows. A low ratio is a sign that the market expects future cash flows to grow, as investors are willing to pay a premium for the book value of assets. The second control is CEO cash compensation, which controls for the level of outside wealth and captures variation in risk aversion between CEOs. The greater the outside wealth of the CEO, the better the executive is expected to be diversified, and thus the lower the risk aversion is likely to be (Guay, 1999). The third control is delta, which controls for the relation between investment opportunities and the CEO's wealth-performance slope. According to Smith and Watts (1992), it is difficult to monitor management of investment opportunities. To reduce agency costs, firms with substantial investment opportunities are expected to increase the relationship between CEO wealth and firm performance (Guay, 1999), which leads to a positive relationship between growth opportunities and delta. The last control is sales, which is a proxy for firm size. As Guay (1999) argues, large firms are more likely to have a formal incentive compensation plan. Besides, Hall and Liebman (1998) show a positive relationship between the level of total executive compensation and firm size.

6.2.2 Fixed effects

The symbols μ and η respectively refer to the industry fixed effects, based on 2-digit SIC codes, and year fixed effects. Some model specifications include both fixed effects, others only include industry fixed effects, while the regressions are also estimated without any fixed effects. The fixed effects control for unobserved changes in the industry and macroeconomic environment, which simultaneously affect the dependent and independent variables. By controlling for these unobserved factors, the threat of omitted variable bias is minimized. Any covariation that is caused by years or industries having unusual characteristics is captured within the model.

For example, in the Chemical & Allied Products sector (SIC code 28) R&D expenditures were high compared to the Trucking & Warehousing sector (SIC code 42). If besides R&D, vega was also high in the Chemical sector compared to the Trucking sector, for a different reason than high R&D, this would contaminate the regression results. Inclusion of industry fixed effects deals with this potential problem, by first estimating the mean for each variable within an industry, and then subtracting the industry mean from the observed value. Results from the regressions with industry fixed effects indicate whether differences in the explanatory variable, around the mean for that variable within an industry, drive differences in vega. When year fixed effects are added, the implication changes to variation around the mean within an industry, in a certain year.

In the tables that are reported in the appendix, I estimate each regression with firm fixed effects instead of industry fixed effects. I choose to focus on industry fixed effects in the analysis in the main text, since Coles, Daniel and Naveen (2006) give two arguments which suggest that firm fixed effects may not be suitable for the empirical context in this paper. As CEO replacements are infrequent, the level of value maximizing vega is relatively stable over time, and thus most variation in vega arises cross sectionally, rather than in the time series. Besides, when CEOs respond quickly to changes in their risk-taking incentives, the effect these changes have on the riskiness of the firm are only visible in the first one or two years after the change in CEO incentives. Both arguments indicate that the use of firm fixed effects in this empirical context will substantially increase the hurdle to detect a significant relationship between vega and firm growth options on the one hand, and between future firm risk and vega on the other hand. In line with these arguments, Armstrong and Vashishtha (2012) also focus on industry fixed effects over firm fixed effects, although the authors do not explain their reason to do so.

6.2.3 Standard errors

T-statistics on the regression coefficients are calculated based on robust standard errors clustered at the firm level. As Cameron and Miller (2015) point out, an essential element for accurate statistical inference is to apply a standard error calculation method that fits the empirical context. Since my analysis is based on panel data, model errors for each individual firm are likely to be correlated over time, but errors are uncorrelated across firms. Clustered standard errors control for this within-firm error correlation, which reduces the probability of misleading statistical inference. Failure to control for this correlation can lead to misleadingly small standard errors, which in turn lead to overstated t-statistics (Cameron and Miller, 2015). The choice to use clustered standard errors increases the hurdle to find significant results, as standard errors are larger in general.

As an addition, to minimize the threat of heteroscedasticity, t-statistics on the regression coefficients are based on robust standard errors, which are consistent under heteroscedasticity. There is no drawback for using robust standard errors, since they are appropriate even when heteroscedasticity is not apparent. Robust standard errors are similar to regular standard errors in the absence of heteroscedasticity, but diverge otherwise (White, 1980).

6.2.4 Results

Table 3, which is reported at the end of the section, presents results from OLS regressions of vega on growth opportunities. In panel A, the two proxies for growth opportunities, R&D and CAPEX, are separately included in the model. In panel B, these two variables are combined into one variable, growth expenditures, which equals the difference between R&D and CAPEX. Columns 1 and 2 include industry fixed effects. Column 1 also includes year fixed effects, whereas column 3 does not include any fixed effects. In discussing the findings, I will mainly focus on the coefficients from the regressions that include industry fixed effects and year fixed effects (column 1 in Panels A and B). I will highlight the cases where these results are different to the results from other model specifications. By doing this I aim to avoid repetition of the same conclusion, while I still clearly explain the regression results.

The coefficient on R&D is 1.955, with a t-statistic of 2.03, which indicates statistical significance at the 5 percent level. The coefficient on CAPEX is -2.458, with a t-statistic of -1.78, which indicates significance at the 10 percent level. These results confirm the expected relationships. R&D is positively related to vega, while CAPEX is negatively related to vega. The coefficient on growth expenditures, which measures R&D expenditures relative to CAPEX, is 2.187, with a t-statistic of 2.62. This indicates statistical significance at the 1 percent level. Again, the sign on the coefficient is as expected. The results on all three variables are relatively similar across the columns. Although there are slight changes in the magnitude and the significance of the coefficients, these are marginal, and do not change the conclusions that are drawn from the regression results.

Since vega is expressed in its natural logarithm, the coefficient on growth expenditures needs to be transformed to assess the numerical relation between the two. After transformation the results indicate that, on average, a change in growth expenditures of 1 unit leads to a change in vega of 790.84 percent (=(exp(2.187)-1)*100). I use the descriptive statistics from table 2 to put this number in context and relate statistical significance to economic significance. A one standard deviation increase in growth expenditures refers to a change in vega of approximately 94.90 percent (=790.84*0.12).

The coefficient on sales is statistically significant at the 10 percent level. Coefficients on the other controls are all significant at the 1 percent level. The coefficient on book-to-market is 1.846, with a t-statistic of 3.12. The sign on the coefficient is surprising. I expected a negative relationship, as book-to-market reflects the market's view on growth of future cashflows. The coefficient on delta is 0.961, with a t-statistic of 18.01. This finding is in line with Guay (1999), who argues that this relationship stems from the positive correlation between growth opportunities and delta. As it is difficult to monitor investment opportunities, growth firms increase the link between CEO wealth and firm performance. Surprisingly, Coles, Daniel and Naveen (2006) find that vega does not depend on delta. The coefficient on cash compensation is 1.044, with a t-statistic of 3.17. When fixed effects are not included (column 3), the coefficient decreases in magnitude and loses its significance. The positive sign on the coefficient is somewhat surprising, since the variable proxies for the outside wealth of the CEO. When this is high, CEO risk-aversion is expected to be lower, which means the CEO needs to be less incentivized to take risk. On the other hand, the positive relationship probably stems from the fact that the different compensation components grow together if the weights in the total executive compensation scheme remain the same. The coefficient on sales is -0.147, with a t-statistic of -1.84. The coefficient decreases in magnitude and loses its significance in columns 2 and 3. The results seem to indicate a slightly negative relationship between vega and sales.

Table 7, which is reported in the appendix, presents results on the regressions in which industry fixed effects are replaced by firm fixed effects. In general, the magnitude of the regression coefficients and the t-statistics on the coefficients slightly decrease. The coefficient on R&D is 1.551, with a t-statistic of 2.10. The coefficient on CAPEX is -2.060, with a t-statistic of -1.84. And the coefficient on growth expenditures is 1.853, with a t-statistic of 2.43. The relatively small t-statistics are as expected. Firm fixed effects remove cross sectional variation in vega, so the model tests whether vega changes when firm characteristics or CEO characteristics change over time. As Coles, Daniel and Naveen (2006) point out, most variation in vega arises in the cross section, as CEO replacements are infrequent, and thus value maximizing vega is relatively stable over time.

6.2.5 Conclusion

As the relationship holds across all model specifications, and both statistical significance as well as economic significance are strong, I do not reject the first hypothesis. I conclude that convexity in the executive compensation scheme is positively related to the proportion of assets that are growth options. This finding is in line with Guay (1999) and Coles, Daniel and Naveen (2006). The combination of fixed effects does not significantly influence the regression results.

Table 3: OLS regressions of Vega on Growth Expenditures

This table presents OLS regressions of Vega on firm growth opportunities and a set of control variables. Panel A separately includes the two proxies for firm growth opportunities: R&D and CAPEX. In Panel B the proxies are replaced with one variable that measures the expenditures on R&D relative to CAPEX: Growth Opportunities. Columns 1 and 2 include industry fixed effects. Column 1 also includes year fixed effects, whereas column 3 does not include any fixed effects. The variable construction is defined in Table 1. The sample is described in Table 2. t-statistics based on robust standard errors clustered at the firm level are within parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level respectively.

Panel A: OLS on Log(Vega)	(1)	(2)	(3)
R&D	1.955**	2.055**	2.274**
	(2.03)	(2.23)	(2.49)
CAPEX	-2.458*	-2.595**	-2.880
	(-1.78)	(-2.01)	(-1.38)
Book-to-Market	1.817***	2.158***	1.589**
	(3.07)	(3.86)	(2.39)
Log(Delta)	0.959***	0.900***	0.951***
	(18.36)	(19.18)	(13.86)
Log(Cash Compensation)	1.063***	0.569**	0.240
	(3.15)	(2.05)	(0.94)
Log(Sales)	-0.157*	-0.041	-0.034
	(-1.82)	(-0.54)	(-0.40)
Observations	281	281	281
R-squared	0.706	0.670	0.711
Industry FE	YES	YES	NO
Year FE	YES	NO	NO

Panel B: OLS on Log(Vega)	(1)	(2)	(3)
Growth Expenditures	2.187***	2.301***	2.511**
	(2.62)	(2.93)	(2.23)
Book-to-Market	1.846***	2.180***	1.593**
	(3.12)	(3.94)	(2.38)
Log(Delta)	0.961***	0.902***	0.951***
	(18.01)	(19.06)	(13.86)
Log(Cash Compensation)	1.044***	0.547**	0.206
	(3.17)	(2.07)	(0.75)
Log(Sales)	-0.147*	-0.030	-0.021
	(-1.84)	(-0.43)	(-0.24)
Observations	281	281	281
R-squared	0.706	0.670	0.710
Industry FE	YES	YES	NO
Year FE	YES	NO	NO

6.3 The relation between stock return volatility and CEO risk-taking incentives

The third part of the analysis is on whether risk-taking incentives influence the riskiness of CEO decision making. As explained in the theoretical framework, CEOs should be more willing to expose their wealth to firm risk when convexity in the compensation scheme increases. If CEOs include the risk-taking incentives provided to them in their decision making, they will increase the riskiness of their actions. This leads to a positive relation between firm risk and vega, assuming that the riskiness of CEO decision-making influences the riskiness of the firm. To test the second hypothesis, I regress future total risk on vega, a range of controls, and a combination of fixed effects. The model is specified in equation 8:

$$(8): Total\ risk_{i,t+1} = \alpha + \beta_1 vega_{i,t} + \beta_2 sales_{i,t} + \beta_3 leverage_{i,t} + \beta_4 R\&D_{i,t} + \beta_5 CAPEX_{i,t} + \beta_6 BM_{i,t} + \mu_s + \eta_t + \epsilon_{i,t}$$

Total Risk refers to the dispersion of returns, or stock return volatility. It is measured by the standard deviation over the 60 months after the compensation measurement date. I require a minimum of 12 months to avoid inaccurate estimation. *Vega*, μ and η have the same definition as in equation 7. I predict a positive coefficient on vega.

6.3.1 Controls

Sales, *leverage*, *R&D*, *CAPEX* and *BM* are the control variables. The first control is sales, which captures variation in firm size. In general, small firms are riskier than big firms, as is shown in prior literature (e.g. Guay, 1999; Coles, Daniel and Naveen, 2006; Armstrong and Vashishtha, 2012). They have less financial resources, limited access to external capital, less proven business models, lower stock liquidity and less diversified revenue streams.

The second control is book leverage, which captures variation in capital structure. The direction of the relationship between leverage and firm risk is ambiguous. On the one hand leverage creates an incentive to shift wealth from bond- to shareholders (Leland, 1998), which leads to a positive relationship. On the other hand, the probability on financial distress is higher for risky firms, which could be reduced by lower leverage, and thus predicts a negative relationship (Lewellen, 2006). I include book leverage over market leverage, even though market leverage is more directly related to CEO wealth through the incentives provided in the executive compensation scheme. As Coles, Daniel, and Naveen (2006) point out, book leverage is a more accurate reflection of managerial decision making. Changes in market leverage could be driven by changes in stock price, instead of managerial decision making, because the CEO does not have active control over the market capitalization of the firm.

The last controls are R&D, CAPEX and book-to-market. Guay (1999) argues that these variables, which are related to growth opportunities as explained in the previous section, might have a direct effect on firm risk. Schwert (2002) confirms this statement, as he finds that variation in growth opportunities explains variation in earnings volatility, and thus stock return volatility. By capturing this direct effect within the regression model, I avoid a spurious relation between firm risk and vega.

6.3.2 Endogeneity Problem

As Coles, Daniel and Naveen (2006) and Armstrong and Vashishtha (2012) point out, endogeneity could be an issue when the influence of vega on firm risk is analysed. The provided risk-taking incentives could influence the riskiness of CEO decision making, but because boards know this, they are likely to incorporate the effect of the provided incentives when designing the compensation contract. This joint determination of managerial decisions and the compensation contract characteristics leads to reverse causality. The independent variable influences the dependent variable, but also the other way around. When this is the case, one of the assumptions for Ordinary Least Squares (OLS) estimation is violated. The endogenous variable is correlated with the error term, which causes biased regression coefficients from OLS. The fact that some papers regress firm risk on vega (e.g. Guay, 1999; Cohen, Hall and Viceira, 2000; Coles, Daniel and Naveen, 2006; Armstrong and Vashishtha, 2012), while others regress vega on firm risk (Guay, 1999; Coles, Daniel and Naveen, 2006), provides evidence that an endogeneity problem might be apparent in this empirical context.

Cohen, Hall and Viceira (2000) argue that the effects of endogeneity are minimized by including fixed effects in the model. As an addition, I follow Coles, Daniel and Naveen (2006) and Armstrong and Vashishtha (2012), and estimate the relationship between firm risk and vega with a multiple equation model. Besides OLS, I use the 2SLS method to estimate the parameters in equation 8. In the first stage I regress vega on the exogenous controls from equation 8 and a set of instruments. This regression is very similar to the one specified in equation 7. In the second stage I replace vega with the predicted value from the first stage and regress total risk on predicted vega as specified in equation 8. By treating vega as endogenous, implementation of 2SLS, inclusion of several combinations of fixed effects, and calculation of t-statistics based on robust standard errors clustered at the firm level, I expect to isolate causality and avoid spurious inferences.

6.3.3 Instrumental variables

The instruments in the first stage of the 2SLS regression are CEO cash compensation and delta. I expect these variables to be correlated with vega, but not with firm risk, other than through the relationship with vega. In short, I choose these instruments since I suppose that shareholders choose a combination of cash, delta and vega to provide the optimal incentives to their CEO. As I will explain in more detail in the following paragraphs, I hypothesize that the level of cash compensation and delta influence the CEO's risk appetite. I expect shareholders to incorporate the influence these components have on the CEO's risk appetite, and adjust the CEO's risk appetite to the optimal level through the risk-taking incentives provided in the executive compensation scheme.

Cash compensation proxies for the level of outside wealth of the CEO. When the level of cash compensation increases, the CEO's outside wealth increases, which means better diversification and thus lower risk-aversion. As explained in the theoretical framework, risk-related agency problems occur because the CEO's risk-appetite is lower than the risk appetite of shareholders. Since cash compensation increases the CEO's risk appetite, an increase in the level of cash compensation means that the executive compensation scheme needs to contain less risk-taking incentives to align the incentives of CEO and shareholders. This implies a negative relationship between vega and cash compensation.

Delta measures the sensitivity of CEO wealth to firm value. When delta increases, CEO wealth is more dependent on firm performance, which means less diversification and thus higher risk-aversion. Since delta increases CEO risk aversion, the influence on vega is exactly opposite compared to the effect cash compensation has on vega. When delta increases, the executive compensation scheme needs to contain more risk-taking incentives to align the incentives of CEO and shareholders. This implies a positive relationship between vega and delta.

6.3.4 Validity of the instrumental variables

There are two main requirements that must be met by the instrumental variables for them to be considered valid instruments. First, they need to have high correlation with the endogenous variable, which leads to an accurate prediction for vega, and thus a strong first stage in the 2SLS regression. Second, the instruments cannot suffer from the same endogeneity problem as vega itself. To ensure they are not correlated with the error term in the explanatory equation, and establish satisfaction of the exclusion restriction, they should not have a direct effect on firm risk. I report several post-estimation tests to assess the validity of the instruments.

Hansen's (1982) J statistic tests the validity of the overidentifying restriction, which is implied by having more instruments than endogenous regressors in the model. A significant test statistic indicates that the instruments are correlated with the error term in the explanatory equation.

The Stock and Yogo (2005) F-statistic tests for weak identification based on the bias of the instrumental variable estimator relative to the bias of OLS. In their paper, Stock and Yogo (2005) report a table which includes critical values for the test. For a model that includes one endogenous variable and two instrumental variables, the 10 percent critical value is 9.08. The 5 percent critical value is 13.91. The null of weak identification is rejected when the F-statistic exceeds the critical value.

The Kleibergen and Paap (2006) LM statistic tests for underidentification. The test checks whether the instruments are relevant estimators for the endogenous regressor by testing the correlation between them. A significant test statistic indicates that the null of underidentification is rejected.

Finally, the Durbin-Wu-Hausman (1978) statistic tests whether the variable that is treated as endogenous could instead be treated as exogenous. When the endogenous regressors are exogenous, coefficient estimates from OLS are more efficient than those from 2SLS. A significant test statistic indicates that vega should be treated as endogenous.

6.3.5 Results

Table 4, which is reported at the end of the section, presents results from regressions of total risk on vega. Panel A shows results from OLS regressions, while Panel B presents results from 2SLS regressions. Coefficient estimates from the first stage of 2SLS, in which the predicted value for vega is estimated, are not reported. As the estimated model in the first stage is very similar to the one specified in equation 7, the results from this stage do not differ much from the ones reported in table 3. Besides, the post-estimation tests will be used to asses the predictive power of the first stage. Columns 1 and 2 include industry fixed effects. Column 1 also includes year fixed effects, whereas column 3 does not include any fixed effects. In discussing the findings, I will mainly focus on the coefficients from the OLS regression that includes industry fixed effects and year fixed effects (column 1 in panel A). I will highlight the cases where these results are different to the results from other model specifications or estimation techniques.

The coefficient on vega is 0.0036, with a t-statistic of 2.16, which indicates statistical significance at the 5 percent level. Since vega is expressed in its natural logarithm, the effect of vega on total risk can not be interpreted by unit changes. Rather, the coefficient indicates that, on average, a one percent increase in vega leads to an increase in total risk of 0.000036 (=0.0036/100). I use the descriptive statistics from table 2 to put this number in context and relate statistical significance to economic significance. A one standard deviation increase from the median of vega refers to a percentage increase of 295.12 (=33.88/11.48*100). In turn, this leads to an increase in total risk of 0.01 (=295.12*0.000036). Since the median of total risk is 0.10, this indicates an increase of approximately 10 percent (=0.10/0.01).

The coefficient on vega is relatively similar in magnitude and statistical significance in the model specification that only includes industry fixed effects (column 2 in panel A). Although the t-statistic on vega is slightly higher in column 1, the coefficient in column 2 remains significant at the 10 percent level. When fixed effects are excluded from the model, the relationship seems to disappear (column 3 in panel A). The coefficient on vega sharply decreases in magnitude and the t-statistic is substantially smaller than in the models that do include fixed effects. A similar pattern holds for the 2SLS regression results in panel B. A notable difference between panel A and panel B is that the coefficient on vega in column 2 does not remain significant at the 10 percent level. A general conclusion is that t-statistics in panel B are lower than the ones in panel A. Besides, t-statistics decrease as fixed effects get excluded from the model.

Results from the 2SLS post-estimation tests are similar for all three columns in panel B. In short, these results indicate that the instruments are valid, the model is correctly specified, but coefficient estimates from OLS are more efficient. Hansen’s (1982) J-statistic is not significant at any of the conventional significance levels; the overidentifying restriction is valid and the instruments are not correlated with the error term in the explanatory equation. The Stock and Yogo (2005) F-statistic rejects the null of weak identification at the 5% significance level, which indicates a strong first stage. The Kleibergen and Paap (2006) LM statistic rejects the null of underidentification at the 1% significance level. There is strong correlation between the instruments and vega. Finally, the Durbin-Wu-Hausman (1978) statistic is not significant at any of the conventional significance levels. Vega, which is treated as endogenous in the 2SLS model, could instead be treated as exogenous.

The coefficient on CAPEX is not significant at any of the conventional confidence levels. Regression coefficients on the other controls are all at least significant at the 5 percent level. The coefficient on sales is -0.0073, with a t-statistic of -2.85. This confirms the expected negative relationship between firm size and total risk. The coefficient on book leverage is 0.0472, with a t-statistic of 2.62. The positive sign indicates a positive relationship between book leverage and total risk. Even though the probability on financial distress is higher for risky firms, the incentive to shift wealth from bond- to shareholders, which is created by leverage, dominates. The coefficients on R&D, CAPEX and book-to-market all have the same sign as in the regression in table 3. The results suggest that these variables, which are related to growth opportunities, do not only influence vega, but also have a direct influence on total risk.

Table 8, which is reported in the appendix, presents results on the regressions in which industry fixed effects are replaced by firm fixed effects. The coefficient on vega decreases in magnitude and does not remain significant at any of the conventional significance levels. The coefficient on vega from OLS regression (column 1 in panel A) is 0.0017, with a t-statistic of 0.97. The coefficient on vega from 2SLS regression (column 1 in panel B) is 0.0026, with a t-statistic of 0.99. Coefficient estimates do not change much when year fixed effects are excluded (column 2 in panels A and B). The relatively small t-statistics are in line with expectations. As Coles, Daniel and Naveen (2006) point out, inclusion of firm fixed effects reduces the power of the model to find a significant relationship between vega and firm risk. When CEOs respond quickly to changes in their risk-taking incentives, the effect these changes have on the riskiness of the firm are only visible in the first one or two years after the change in CEO incentives.

6.3.6 Conclusion

Even though the tests results are less convincing as the ones on the first hypothesis, I do not reject the second hypothesis. I conclude that firm risk increases as convexity in the executive compensation scheme increases. This finding is in line with prior literature (e.g. Guay, 1999; Coles, Daniel and Naveen, 2006; Armstrong and Vashishtha, 2012). Industry fixed effects, as well as year fixed effects, are an essential inclusion in the model. The relationship between vega and total risk does not hold when fixed effects are removed, or when industry fixed effects are replaced with firm fixed effects. The post-estimation tests indicate that the instruments are valid, the 2SLS model is correctly specified, but results from OLS are consistent. Coefficient estimates from OLS are slightly stronger than the ones from 2SLS.

Table 4: OLS and 2SLS regressions of Total Risk on Vega

Panel A presents OLS regressions of Total Risk on Vega and a set of control variables. Panel B presents 2SLS regressions of Total Risk on Vega and a set of control variables. Vega is treated as endogenous in panel B. The instruments for Vega are Delta and Cash Compensation. Coefficient estimates from the first stage are not reported. Columns 1 and 2 include industry fixed effects. Column 1 also includes year fixed effects, whereas column 3 does not include any fixed effects. The variable construction is defined in Table 1. The sample is described in Table 2. t-statistics based on robust standard errors clustered at the firm level are within parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level respectively. Hansen's J-statistic tests the validity of the overidentifying restriction. The Stock-Yogo F-statistic tests for weak identification. The Kleibergen-Paap LM-statistic tests for underidentification. The Durbin-Wu-Hausmann statistic tests for endogeneity of vega.

Panel A: OLS on Total Risk	(1)	(2)	(3)
Log(Vega)	0.0036**	0.0032*	0.0009
	(2.16)	(1.66)	(0.36)
Log(Sales)	-0.0073***	-0.0068**	-0.0073**
	(-2.85)	(-2.48)	(-2.17)
Book Leverage	0.0472***	0.0250	0.0235
	(2.62)	(1.08)	(0.75)
R&D	0.1636***	0.1515***	0.1084***
	(5.37)	(4.46)	(3.66)
CAPEX	-0.0637	-0.0384	-0.1155**
	(-1.59)	(-1.20)	(-2.14)
Book-to-Market	0.0743**	0.0508	0.0571
	(2.31)	(1.48)	(1.52)
Observations	281	281	281
R-squared	0.166	0.146	0.131
Industry FE	YES	YES	NO
Year FE	YES	NO	NO

Panel B: 2SLS on Total Risk	(1)	(2)	(3)
Log(Vega)	0.0034*	0.0048	0.0010
	(1.68)	(1.44)	(0.27)
Log(Sales)	-0.0072***	-0.0076**	-0.0073*
	(-2.71)	(-2.42)	(-1.84)
Book Leverage	0.0467***	0.0285	0.0237
	(2.59)	(1.34)	(0.77)
R&D	0.1631***	0.1544***	0.1082***
	(5.33)	(4.35)	(3.58)
CAPEX	-0.0635	-0.0386	-0.1156**
	(-1.58)	(-1.19)	(-2.12)
Book-to-Market	0.0738**	0.0540	0.0574
	(2.24)	(1.45)	(1.42)
Observations	281	281	281
Industry FE	YES	YES	NO
Year FE	YES	NO	NO
Hansen J (test)	0.00	0.11	1.47
Hansen J (p-value)	0.97	0.75	0.23
Stock-Yogo F (test)	141.38	167.07	97.40
Kleibergen-Paap LM (test)	12.99	10.86	13.09
Kleibergen-Paap LM (p-value)	0.00	0.00	0.00
Durbin-Wu-Hausmann (test)	0.06	1.17	0.55
Durbin-Wu-Hausmann (p-value)	0.81	0.28	0.46

6.4 The relation between systematic risk, idiosyncratic risk and CEO risk-taking incentives

As an addition to my main research questions, I investigate whether CEO's add to the systematic risk or the idiosyncratic risk of their firm. I apply the same methodology as in the regressions of total risk on vega. The only thing that changes is the dependent variable in the OLS and 2SLS regressions. I regress future systematic risk and future idiosyncratic risk on vega, a range of controls, and a combination of fixed effects.

Systematic risk, or market risk, is the correlation of stock price to market movements. According to Cohen, Hall and Viceira (2000), an increase in systematic risk could lower firm value, even if expected cash flows are unchanged. As systematic risk cannot be mitigated trough diversification, investors might require a higher expected return, and thus increase the rate at which future cash flows are discounted. Idiosyncratic risk is the firm's specific risk. An increase in idiosyncratic risk only leads to a change in firm value when the expected cash flows are changed (Cohen, Hall and Viceira, 2000). As investors can mitigate any unwanted idiosyncratic risk through diversification, it should not influence the discount rate of future cash flows.

The argument of Cohen, Hall and Viceira (2000) implies that a CEO that aims to maximize firm value, would prefer to increase idiosyncratic risk over systematic risk. Armstrong and Vashishtha (2012) argue the contrary. According to them, executives would rather increase firm risk through systematic risk than idiosyncratic risk, since risk-averse CEO's can hedge any unwanted systematic risk away by trading on the financial market. Executives who do not have the ability to sell, or otherwise hedge their exposure to firm risk, do not value their option portfolio at market value, but will instead value them subjectively according to their personal preferences (Armstrong and Vashishtha, 2012). Since both arguments have strengths and weaknesses, I do not provide a prediction or hypothesis in this section.

6.4.1 Decomposition of stock return volatility

I use the CAPM model, which models the relationship between risk and expected return, to decompose monthly firm returns into the two components of risk. First, I regress realized monthly firm returns on monthly market returns to estimate the stock's beta. The regression parameters are estimated over the 60 months after the compensation measurement date. I require a minimum of 12 months to avoid inaccurate estimation. Next, I predict monthly returns over the same time period, by multiplying the estimated beta with the realized firm returns.

Systematic risk equals the standard deviation of the predicted monthly returns. Last, I estimate the residuals from the CAPM model by taking the difference between the realized firm returns and the predicted firm returns. Idiosyncratic risk equals the standard deviation of the residuals. The measurement of systematic risk and idiosyncratic risk is specified in equations 9, 10 and 11:

(9): $R_{i,t} = \alpha + \beta_1 R_{m,t} + \epsilon_{i,t}$

(10): $Systematic\ risk = \sigma\left(\beta_1 * R_{m,t}\right)$

(11): $Idiosyncratic\ risk = \sigma(R_{i,t} - \beta_1 R_{m,t})$

6.4.2 Results on systematic risk

Table 5, which is reported at the end of the section, presents results from OLS regressions of the two components of risk on vega. In panel A the dependent variable is systematic risk. In panel B the dependent variable is idiosyncratic risk. Columns 1 and 2 include industry fixed effects. Column 1 also includes year fixed effects, whereas column 3 does not include any fixed effects. Table 6 is structured in the same way, but 2SLS is used instead of OLS. In discussing the findings, I will mainly focus on the coefficients from the OLS regressions that include industry fixed effects and year fixed effects (column 1 in panels A and B of table 5). I will highlight the cases where these results are different to the results from other model specifications.

Results from OLS regressions of systematic risk on vega (panel A in table 5) are noticeably different from the results from OLS regressions of total risk on vega (panel A in table 4). The coefficient on vega is 0.0008, with a t-statistic of 0.87, which fails to indicate statistical significance at any of the conventional significance levels. In columns 2 and 3, the coefficient is either zero or slightly negative. The mixed results, and relatively weak t-statistics, do not indicate that vega drives systematic risk. The regression technique does not influence this conclusion; coefficient estimates from 2SLS regressions (panel A in table 6) are similar to the ones from OLS regressions (panel A in table 5). Besides, when industry fixed effects are replaced by firm fixed effects, the regression results do not indicate that vega drives systematic risk (panel A of tables 9 and 10 in the appendix).

In panel A of table 6, the small p-value on Hansen's (1982) J-statistic indicates that the overidentifying restriction is invalid; the instruments might be correlated with the error term in the explanatory equation. The Durbin-Wu-Hausman (1978) statistic indicates that coefficient estimates from OLS are more efficient than those from 2SLS. The Stock and Yogo (2005) F-statistic and Kleibergen and Paap (2006) LM statistic are equal to the reported numbers on these statistics in table 4. These do not change as long as the endogenous variable and instruments remain the same.

6.4.3 Results on idiosyncratic risk

Results from OLS regressions of idiosyncratic risk on vega (panel B in table 5) are similar to the results from OLS regressions of total risk on vega (panel A in table 4). The coefficient on vega is 0.0033, with a t-statistic of 2.14, which refers to statistical significance at the 5 percent level. The coefficient indicates that, on average, a one percent increase in vega leads to an increase in idiosyncratic risk of 0.000033 (=0.0033/100). The descriptive statistics in table 2 show that a one standard deviation increase from the median of vega refers to a percentage increase of 295.12 (=33.88/11.48*100). In turn, this leads to an increase in idiosyncratic risk of 0.01 (=295.12*0.000033). Since the median of idiosyncratic risk is 0.08, this indicates an increase of approximately 12.5 percent (=0.01/0.08).

The patterns that we observed in table 4 (regressions of total risk on vega), are also visible in panel B of tables 5 and 6 (regressions of idiosyncratic risk on vega). A general conclusion is that t-statistics from 2SLS are lower than the ones from OLS. Besides, t-statistics decrease as fixed effects get excluded from the model. When fixed effects are excluded from the model, the relationship between idiosyncratic risk and vega seems to disappear (column 3 in panel B of table 5). A notable exception is that none of the regression coefficients on vega is significant when the model is estimated with 2SLS (panel B in table 6). Post-estimation test statistics from the 2SLS regressions of idiosyncratic risk on vega (panel B in table 6) indicate that the instruments are valid, the model is correctly specified, but coefficient estimates from OLS are more efficient. Vega does not seem to drive idiosyncratic risk when industry fixed effects are replaced by firm fixed effects (panel B of tables 9 and 10 in the appendix).

6.4.4 Conclusion

The results indicate that vega does not drive systematic risk. The coefficient on vega is close to zero and t-statistics are low, irrespective of the regression technique or combination of fixed effects. On the other hand, some of the results suggest that vega drives idiosyncratic risk. The coefficient on vega is positive and statistically significant in the OLS regressions that include either industry fixed effects, or a combination of industry fixed effects and year fixed effects. This result is not robust to the implementation of 2SLS instead of OLS. The coefficient remains positive in the 2SLS regressions, with a similar magnitude as in the OLS regressions, but since t-statistics are lower, the coefficient is not significant at any of the conventional significance levels. The findings are mostly in line with Cohen, Hall and Viceira (2000), and seem to contradict the findings from Armstrong and Vashishtha (2012). More research is needed to confidently argue that CEOs choose to increase idiosyncratic over systematic risk as vega increases.

Table 5: OLS regressions of Systematic Risk and Idiosyncratic Risk on Vega

Panel A presents OLS regressions of Systematic Risk on Vega and a set of control variables. Panel B presents OLS regressions of Idiosyncratic Risk on Vega and a set of control variables. Columns 1 and 2 include industry fixed effects. Column 1 also includes year fixed effects, whereas column 3 does not include any fixed effects. The variable construction is defined in Table 1. The sample is described in Table 2. t-statistics based on robust standard errors clustered at the firm level are within parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level respectively.

Panel A: OLS on Systematic Risk	(1)	(2)	(3)
Log(Vega)	0.0008	0.0000	-0.0014
	(0.87)	(0.02)	(-1.35)
Log(Sales)	0.0037***	0.0038***	0.0028**
	(3.07)	(2.99)	(2.03)
Book Leverage	0.0104	0.0034	-0.0042
	(0.60)	(0.15)	(-0.18)
R&D	0.0226	-0.0108	-0.0149
	(1.33)	(-0.47)	(-0.49)
CAPEX	0.0283	0.0400	-0.0202
	(0.93)	(1.05)	(-0.71)
Book-to-Market	0.0170*	-0.0128	-0.0158
	(1.83)	(-1.48)	(-1.39)
Observations	281	281	281
R-squared	0.197	0.132	0.066
Industry FE	YES	YES	NO
Year FE	YES	NO	NO

Panel B: OLS on Idiosyncratic Risk	(1)	(2)	(3)
Log(Vega)	0.0033**	0.0033*	0.0016
	(2.14)	(1.74)	(0.64)
Log(Sales)	-0.0101***	-0.0097***	-0.0098***
	(-4.05)	(-3.63)	(-2.97)
Book Leverage	0.0434**	0.0241	0.0286
	(2.42)	(1.08)	(0.98)
R&D	0.1520***	0.1566***	0.1097***
	(4.86)	(4.54)	(3.28)
CAPEX	-0.0746**	-0.0541*	-0.1068**
	(-2.10)	(-1.73)	(-2.24)
Book-to-Market	0.0716**	0.0626*	0.0725*
	(2.21)	(1.81)	(1.92)
Observations	281	281	281
R-squared	0.212	0.206	0.182
Industry FE	YES	YES	NO
Year FE	YES	NO	NO

Table 6: 2SLS regressions of Systematic Risk and Idiosyncratic Risk on Vega

Panel A presents 2SLS regressions of Systematic Risk on Vega and a set of control variables. Panel B presents 2SLS regressions of Idiosyncratic Risk on Vega and a set of control variables. Vega is treated as endogenous in both panels. The instruments for Vega are Delta and Cash Compensation. Coefficient estimates from the first stage are not reported. Columns 1 and 2 include industry fixed effects. Column 1 also includes year fixed effects, whereas column 3 does not include any fixed effects. The variable construction is defined in Table 1. The sample is described in Table 2. t-statistics based on robust standard errors clustered at the firm level are within parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level respectively. Hansen's J-statistic tests the validity of the overidentifying restriction. The Stock-Yogo F-statistic tests for weak identification. The Kleibergen-Paap LM-statistic tests for underidentification. The Durbin-Wu-Hausmann statistic tests for endogeneity.

Panel A: 2SLS on Systematic Risk	(1)	(2)	(3)
Log(Vega)	0.0008	-0.0001	-0.0022*
	(0.79)	(-0.09)	(-1.92)
Log(Sales)	0.0037***	0.0038***	0.0034***
	(2.93)	(3.03)	(2.58)
Book Leverage	0.0104	0.0031	-0.0056
	(0.60)	(0.15)	(-0.24)
R&D	0.0226	-0.0110	-0.0137
	(1.30)	(-0.48)	(-0.44)
CAPEX	0.0284	0.0400	-0.0193
	(0.93)	(1.06)	(-0.66)
Book-to-Market	0.0169*	-0.0130	-0.0178
	(1.68)	(-1.36)	(-1.43)
Observations	281	281	281
Industry FE	YES	YES	NO
Year FE	YES	NO	NO
Hansen J (test)	5.20	7.43	6.32
Hansen J (p-value)	0.02	0.01	0.01
Stock-Yogo F (test)	141.38	167.07	97.40
Kleibergen-Paap LM (test)	12.99	10.86	13.09
Kleibergen-Paap LM (p-value)	0.00	0.00	0.00
Durbin-Wu-Hausmann (test)	0.22	0.25	0.27
Durbin-Wu-Hausmann (p-value)	0.64	0.62	0.60

Panel B: 2SLS on Idiosyncratic Risk	(1)	(2)	(3)
Log(Vega)	0.0030	0.0050	0.0021
	(1.52)	(1.46)	(0.54)
Log(Sales)	-0.0100***	-0.0105***	-0.0101**
	(-3.79)	(-3.39)	(-2.53)
Book Leverage	0.0428**	0.0277	0.0293
	(2.41)	(1.39)	(1.04)
R&D	0.1514***	0.1595***	0.1090***
	(4.85)	(4.44)	(3.16)
CAPEX	-0.0744**	-0.0542*	-0.1073**
	(-2.09)	(-1.75)	(-2.24)
Book-to-Market	0.0710**	0.0659*	0.0735*
	(2.15)	(1.76)	(1.82)
Observations	281	281	281
Industry FE	YES	YES	NO
Year FE	YES	NO	NO
Hansen J (test)	0.13	0.91	0.65
Hansen J (p-value)	0.71	0.34	0.42
Stock-Yogo F (test)	141.38	167.07	97.40
Kleibergen-Paap LM (test)	12.99	10.86	13.09
Kleibergen-Paap LM (p-value)	0.00	0.00	0.00
Durbin-Wu-Hausmann (test)	0.05	2.00	0.11
Durbin-Wu-Hausmann (p-value)	0.82	0.16	0.74

7 Conclusion

In this paper, I explore the determinants of CEO risk-taking incentives and how CEOs respond to these incentives. I find that firms that are characterised by growth options (i.e. high R&D and low CAPEX) provide more convexity in the executive compensation scheme of their CEO. These firms incur higher opportunity costs when CEO risk-aversion leads to underinvestment in valuable risk-increasing projects. CEOs respond to these incentives by increasing the riskiness of the firm they manage. The increase in personal wealth from an increase in firm risk offsets the low risk appetite of a risk averse CEO. CEOs seem to prefer to increase firm risk through idiosyncratic risk, rather than through systematic risk. Unlike idiosyncratic risk, an increase in systematic risk might lower firm value, as investors might require a higher expected return, and thus increase the rate at which future cash flows are discounted.

The analysis is done on an unexplored, manually gathered dataset, consisting of Dutch firms between 2003 and 2013. The main findings are in line with studies that do a similar analysis on US firms (e.g. Guay, 1999; Cohen, Hall and Viceira, 2000; Coles, Daniel and Naveen, 2006), even though descriptive statistics on the sample slightly differ, and Dutch firms are exposed to a different corporate governance framework than US firms. The sample size is relatively small, and option-based compensation seems to be lower for Dutch firms relative to US firms. I apply several econometric remedies to isolate causality and to avoid spurious inferences. Most importantly, I use different combinations of fixed effects, I implement instrumental variable analysis, and calculate t-statistics based on robust standard errors clustered at the firm level.

The paper provides a descriptive analysis on how Dutch firms compensate and incentivize their CEO. Besides, the results can assist shareholders in providing the correct incentives to their CEO through the design of the executive compensation scheme. I emphasize that encouraging the CEO to increase stock price is not sufficient to induce the CEO to make decisions according to shareholder interest, since a difference in risk-appetite between CEO and shareholders can lead to risk-related agency problems. Risk-averse CEOs, who are expected to have higher fraction of their personal wealth linked to the firm compared to shareholders, are likely to take fewer risk than optimal. The analysis seems to indicate that over time, Dutch firms reduced the amount of option grants to their CEO. Unless these firms provide risk-taking incentives through other mechanisms, the firms that are reducing option grants might suffer from underinvestment in valuable projects. Future research could build on this paper by relating CEO risk-taking incentives to firm performance. By trying to estimate the optimal incentive structure according to firm characteristics, this could answer the question whether under-incentivizing the CEO to take risks leads to underinvestment in valuable risk-increasing projects, and thus low relative firm performance.

Besides, another method could be used to control for the endogeneity problem that is caused by reverse causality between vega and firm risk. I use the variables delta and cash compensation as instruments for vega. Even though I argue why these variables should be related to vega, I acknowledge that these instruments are not perfect, as they might be related to firm risk. If projects that increase firm value are relatively risky, higher delta provides the CEO with an incentive to pursue these projects, and thus increase firm risk (Coles, Daniel and Naveen, 2006). On the other hand, higher delta increases the CEO's exposure to firm value, which could cause a risk-averse CEO to decrease firm risk (Guay, 1999). These arguments contradict each other, and thus do not provide a prediction for the relationship between delta and firm risk, but they do indicate that a relationship might be apparent. This would invalidate the usage of delta as an instrument for vega, even though the post-estimation tests in my analysis indicate that the instruments are valid, and the model is well specified.

Instead of instrumental variable analysis, one could use the differences-in-differences method to deal with the endogeneity problem. Low (2009) provides an example of such a study on US firms. The author examines whether a change in takeover regulation in Delaware, which influences CEO incentives in this region, causes CEOs to alter firm risk. The differences-in-differences method overcomes the problem to find valid instruments, but an exogenous shock which significantly influences the explanatory variable, is an essential element for this method. Like the quest to a valid set of instruments, such an exogenous shock can be hard to find.

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Appendix

Table 7: OLS regressions of Vega on Growth Expenditures (Firm FE)

This table presents OLS regressions of Vega on firm growth opportunities and a set of control variables. Panel A separately includes the two proxies for firm growth opportunities: R&D and CAPEX. In Panel B the proxies are replaced with one variable that measures the expenditures on R&D relative to CAPEX: Growth Opportunities. Column 1 includes firm fixed effects and year fixed effects. Column 2 only includes firm fixed effects. The variable construction is defined in Table 1. The sample is described in Table 2. t-statistics based on robust standard errors clustered at the firm level are within parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level respectively.

Panel A: OLS on Log(Vega)	(1)	(2)
R&D	1.551**	2.124**
	(2.10)	(2.57)
CAPEX	-2.060*	-2.169**
	(-1.84)	(-2.52)
Book-to-Market	2.239***	3.139***
	(3.14)	(4.15)
Log(Delta)	0.960***	0.913***
	(21.71)	(17.42)
Log(Cash Compensation)	0.450	-0.021
	(1.23)	(-0.07)
Log(Sales)	-0.473**	-0.574**
	(-2.16)	(-2.11)
Observations	281	281
R-squared	0.652	0.627
Firm FE	YES	YES
Year FE	YES	NO

Panel B: OLS on Log(Vega)	(1)	(2)
Growth Expenditures	1.853**	2.150***
	(2.43)	(3.16)
Book-to-Market	2.263***	3.141***
	(3.17)	(4.19)
Log(Delta)	0.962***	0.913***
	(22.06)	(17.87)
Log(Cash Compensation)	0.433	-0.022
	(1.21)	(-0.08)
Log(Sales)	-0.480**	-0.574**
	(-2.20)	(-2.11)
Observations	281	281
R-squared	0.652	0.627
Firm FE	YES	YES
Year FE	YES	NO

Table 8: OLS and 2SLS regressions of Total Risk on Vega (Firm FE)

Panel A presents OLS regressions of Total Risk on Vega and a set of control variables. Panel B presents 2SLS regressions of Total Risk on Vega and a set of control variables. Vega is treated as endogenous in panel B. The instruments for Vega are Delta and Cash Compensation. Coefficient estimates from the first stage are not reported. Column 1 includes firm fixed effects and year fixed effects. Column 2 only includes firm fixed effects. The variable construction is defined in Table 1. The sample is described in Table 2. t-statistics based on robust standard errors clustered at the firm level are within parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level respectively. Hansen's J-statistic tests the validity of the overidentifying restriction. The Stock-Yogo F-statistic tests for weak identification. The Kleibergen-Paap LM-statistic tests for underidentification. The Durbin-Wu-Hausmann statistic tests for endogeneity of vega.

Panel A: OLS on Total Risk	(1)	(2)
Log(Vega)	0.0017	0.0015
	(0.97)	(0.69)
Log(Sales)	-0.0267	-0.0146
	(-1.14)	(-1.50)
Book Leverage	0.0439	-0.0029
	(1.52)	(-0.06)
R&D	0.0976**	0.0644**
	(2.38)	(2.18)
CAPEX	-0.0639	-0.0419
	(-1.05)	(-0.97)
Book-to-Market	0.0712	0.0417
	(1.22)	(0.77)
Observations	281	281
R-squared	0.056	0.025
Firm FE	YES	YES
Year FE	YES	NO

Panel B: 2SLS on Total Risk	(1)	(2)
Log(Vega)	0.0026	0.0044
	(0.99)	(0.97)
Log(Sales)	-0.0265	-0.0137
	(-1.15)	(-1.44)
Book Leverage	0.0468*	0.0064
	(1.70)	(0.15)
R&D	0.1008**	0.0733**
	(2.32)	(2.04)
CAPEX	-0.0632	-0.0381
	(-1.04)	(-0.91)
Book-to-Market	0.0725	0.0454
	(1.22)	(0.79)
Observations	281	281
Firm FE	YES	YES
Year FE	YES	NO
Hansen J (test)	1.04	0.49
Hansen J (p-value)	0.31	0.49
Stock-Yogo F (test)	229.38	178.78
Kleibergen-Paap LM (test)	6.81	6.62
Kleibergen-Paap LM (p-value)	0.03	0.04
Durbin-Wu-Hausmann (test)	0.00	0.53
Durbin-Wu-Hausmann (p-value)	0.98	0.46

Table 9: OLS regressions of Systematic Risk and Idiosyncratic Risk on Vega (Firm FE)

Panel A presents OLS regressions of Systematic Risk on Vega and a set of control variables. Panel B presents OLS regressions of Idiosyncratic Risk on Vega and a set of control variables. Column 1 includes firm fixed effects and year fixed effects. Column 2 only includes firm fixed effects. The variable construction is defined in Table 1. The sample is described in Table 2. t-statistics based on robust standard errors clustered at the firm level are within parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level respectively.

Panel A: OLS on Systematic Risk	(1)	(2)
Log(Vega)	-0.0001	-0.0007
	(-0.13)	(-1.37)
Log(Sales)	-0.0019	-0.0132***
	(-0.54)	(-3.04)
Book Leverage	0.0041	-0.0006
	(0.43)	(-0.04)
R&D	0.0039	-0.0057
	(0.40)	(-0.50)
CAPEX	-0.0082	-0.0036
	(-0.71)	(-0.20)
Book-to-Market	0.0031	-0.0240***
	(0.34)	(-2.83)
Observations	281	281
R-squared	0.006	0.154
Firm FE	YES	YES
Year FE	YES	NO

Panel B: OLS on Idiosyncratic Risk	(1)	(2)
Log(Vega)	0.0017	0.0018
	(0.97)	(0.79)
Log(Sales)	-0.0282	-0.0093
	(-1.24)	(-1.00)
Book Leverage	0.0422	-0.0049
	(1.46)	(-0.10)
R&D	0.0921**	0.0620**
	(2.34)	(2.20)
CAPEX	-0.0636	-0.0427
	(-1.07)	(-1.02)
Book-to-Market	0.0752	0.0587
	(1.32)	(1.08)
Observations	281	281
R-squared	0.063	0.036
Firm FE	YES	YES
Year FE	YES	NO

Table 10: 2SLS regressions of Systematic Risk and Idiosyncratic Risk on Vega (Firm FE)

Panel A presents 2SLS regressions of Systematic Risk on Vega and a set of control variables. Panel B presents 2SLS regressions of Idiosyncratic Risk on Vega and a set of control variables. Vega is treated as endogenous in both panels. The instruments for Vega are Delta and Cash Compensation. Coefficient estimates from the first stage are not reported Column 1 includes firm fixed effects and year fixed effects. Column 2 only includes firm fixed effects. The variable construction is defined in Table 1. The sample is described in Table 2. t-statistics based on robust standard errors clustered at the firm level are within parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level respectively. Hansen's J-statistic tests the validity of the overidentifying restriction. The Stock-Yogo F-statistic tests for weak identification. The Kleibergen-Paap LM-statistic tests for underidentification. The Durbin-Wu-Hausmann statistic tests for endogeneity.

Panel A: 2SLS on Systematic Risk	(1)	(2)
Log(Vega)	-0.0002	-0.0008
	(-0.31)	(-1.07)
Log(Sales)	-0.0019	-0.0132***
	(-0.55)	(-3.05)
Book Leverage	0.0037	-0.0010
	(0.38)	(-0.07)
R&D	0.0034	-0.0060
	(0.34)	(-0.52)
CAPEX	-0.0083	-0.0038
	(-0.73)	(-0.21)
Book-to-Market	0.0029	-0.0242***
	(0.31)	(-2.69)
Observations	281	281
Firm FE	YES	YES
Year FE	YES	NO
Hansen J (test)	0.25	2.97
Hansen J (p-value)	0.62	0.09
Stock-Yogo F (test)	229.38	178.78
Kleibergen-Paap LM (test)	6.81	6.62
Kleibergen-Paap LM (p-value)	0.03	0.04
Durbin-Wu-Hausmann (test)	0.28	0.51
Durbin-Wu-Hausmann (p-value)	0.59	0.47

Panel B: 2SLS on Idiosyncratic Risk	(1)	(2)
Log(Vega)	0.0026	0.0049
	(1.04)	(1.06)
Log(Sales)	-0.0280	-0.0083
	(-1.24)	(-0.92)
Book Leverage	0.0454	0.0051
	(1.64)	(0.12)
R&D	0.0956**	0.0715**
	(2.29)	(2.06)
CAPEX	-0.0629	-0.0386
	(-1.06)	(-0.97)
Book-to-Market	0.0767	0.0628
	(1.31)	(1.09)
Observations	281	281
Firm FE	YES	YES
Year FE	YES	NO
Hansen J (test)	1.11	0.11
Hansen J (p-value)	0.29	0.74
Stock-Yogo F (test)	229.38	178.78
Kleibergen-Paap LM (test)	6.81	6.62
Kleibergen-Paap LM (p-value)	0.03	0.04
Durbin-Wu-Hausmann (test)	0.01	1.23
Durbin-Wu-Hausmann (p-value)	0.90	0.27

Table 11: Distribution of the observations over years and firms

Panel A presents the amount of observations per year. Panel B presents the amount of observations per firm. The sample contains 281 year observations, for firms that traded on the Euronext Amsterdam between 2003 and 2013 and all required information is publicly available.

Panel A

#	Year	N
1	2003	30
2	2004	33
3	2005	33
4	2006	35
5	2007	29
6	2008	27
7	2009	23
8	2010	21
9	2011	20
10	2012	16
11	2013	14
		281

Panel B

#	Company Name	N
1	ARCADIS NV	10
2	ASM International NV	9
3	ASML Holding NV	8
4	Ahold Delhaize	4
5	Akzo Nobel N.V.	9
6	Ballast Nedam NV	8
7	Beter Bed Holding NV	10
8	Compagnie de Saint-Gobain S.A.	6
9	Corbion N.V.	2
10	Corporate Express B.V.	4
11	Crucell N.V.	4
12	DOCDATA N.V.	10

13	Draka Holding B.V.	1
14	Esperite N.V.	2
15	Fugro NV	9
16	Gamma Holding NV	6
17	HES Beheer NV	10
18	HITT NV	3
19	ICT Group N.V.	6
20	Koninklijke DSM N.V.	10
21	Koninklijke KPN N.V.	8
22	Koninklijke Philips N.V.	10
23	Koninklijke Ten Cate nv	10
24	Koninklijke Wessanen N.V.	3
25	MacIntosh Retail Group NV	10
26	NedSense Enterprises NV	2
27	Neways Electronics International NV	7
28	Nutreco N.V.	4
29	OctoPlus N.V.	2
30	Océ Holding B.V.	7
31	Ordina NV	6
32	Pharming Group NV	6
33	PostNL N.V.	3
34	Randstad Holding NV	11
35	RoodMicrotec NV	8
36	Royal Dutch Shell plc	8
37	Royal Imtech N.V.	6
38	Royal Vopak NV	4
39	Simac Techniek NV	4
40	Sligro Food Group NV	4
41	TIE Kinetix N.V.	3
42	TKH Group NV	4
43	TomTom NV	5
44	USG People NV	4
45	Unilever N.V.	4
46	Wolters Kluwer N.V.	7
		281