Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Economics and Management
Dept. of Industrial Economics and Technology Management

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Executive Incentives, Capital Structure, and Risk

Master's thesis in Industrial Economics and Technology Management
Supervisor: Belsom, Einar
June 2021

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Preface

This thesis is the final deliverable of a Master of Science degree in Industrial Economics and Technology Management at the Norwegian University of Science and Technology (NTNU). A project thesis written in the penultimate semester of the degree serves as a foundation for the master's thesis, parts from the project thesis are reused and built upon in this thesis.

My sincere gratitude to Associate Professor Einar Belsom at the Department of Industrial Economics and Technology Management for the excellent guidance and support provided throughout the process as my supervisor. I would also like to express my gratitude towards Asche and Solberg for sharing the data used in their thesis.

Abstract

This thesis explores the topics of executive incentives, capital structure, and risk. While considerable previous research exists on the topics, relatively few studies look at the Norwegian context. A particular focus is placed on the effects of firm leverage on the relationship between CEO option incentives and risk, which is an area of the literature that seems to have received less attention.

Empirical analysis is performed on a sample of Norwegian listed firms with a panel data structure, covering the years 2012, 2014, and 2016. In line with previous research, the findings suggest a positive relationship between CEO option incentives and risk. The results further indicate that leverage could be an important factor affecting this relationship, with a moderating effect of leverage on risk-taking incentives provided by options found for the sample firms.

Sammendrag

Formålet med denne masteroppgaven er å studere relasjonen mellom lederinsentiver, kapitalstruktur og risiko. Selv om en betydelig mengde tidligere forskning har blitt gjort på disse områdene er det gjort relativt få studier i en norsk kontekst. Effekten selskapsgjeld har på relasjonen mellom administrerende direktørs opsjonsinsentiver og risiko er viet et særlig fokus. Dette er en del av litteraturen som virker å ha mottatt mindre oppmerksomhet.

Empirisk analyse gjennomføres på et utvalg av børsnoterte norske selskaper. Utvalget har en paneldatastruktur med observasjoner fra årene 2012, 2014 og 2016. I tråd med tidligere studier indikerer funnene en positiv relasjon mellom administrerende direktørs opsjonsinsentiver og risiko. Resultatene indikerer videre at gjeldsgrad kan være en viktig faktor som påvirker denne relasjonen, og en modererende effekt fra gjeld på risikotakingsinsentivene fra opsjoner er funnet for utvalget som analyseres.

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1. Introduction

One area that has received notable interest in the financial literature is how the incentives provided by firms to their managers affect their behaviour (Hayes et al., 2012). Often building upon the principal-agent framework, the incentives aim to induce managerial effort and achieve goal congruence (Jensen and Meckling, 1976; Eisenhardt, 1989).[1] Tying managerial incentives, such as stock options, to firm performance is expected to stimulate actions from the manager aimed at influencing performance, often through changing firm risk (Williams and Rao, 2006; Hayes et al., 2012). Capital structure decisions are one major lever through which firm risk can be impacted. Finding the optimal incentive structure to provide managers is not, however, an easy feat. Differences in risk preference are an important reason why this is the case and there seems to exist an agreement in the literature that no single structure creates perfect alignment between the principal and the agent (Kolb, 2012). The use of equity-based incentives has been of particular interest in this context, most notably how stock options provide risk-taking incentives to managers (Rajgopal and Shevlin, 2002; Williams and Rao, 2006; YU and Luu, 2014).

The aim of this paper is to study the relationship between executive incentives, capital structure, and risk in a Norwegian context through empirical analysis. A sample of Norwegian listed firms covering the years 2012, 2014, and 2016 has been sourced from Asche and Solberg (2017) and expanded upon with additional data points. Incentive variables covering options, stock ownership, and cash compensation are constructed for the chief executive officer (CEO) of the firms and supplemented with variables capturing CEO characteristics and risk aversion proxies. Using econometric methods, the relationships between CEO incentives and proxies for firm risk and firm leverage are estimated. Particular emphasis is placed on the incentive effects from options.

This paper adds to the smaller body of work that has been done in a Norwegian context. There are comparatively few studies that focus on Norwegian firms, with a significant portion of previous research studying firms in the United States. Of related research with closer geographical proximity, Birkeland et al. (2011) look at the relationship between executive incentives and capital structure for a sample of Nordic firms. Aas (2019) examines whether firm risk differs between the firms that provide options as part of the CEO compensation package and those that do not. Notably, his study is done using the same sample of firms analyzed in this paper. While Birkeland et al. (2011) focus on incentives and capital structure, and the main focus of Aas (2019) is on incentives and firm risk, this paper looks at how the three topics are jointly related. Kim et al. (2017) argue that the effect of firm leverage on the relationship between managerial incentives and risk is an area of the literature that seems to have received less attention. Alongside analyzing the effects of other CEO incentives as well as CEO characteristics, the choice of risk proxies differs from that of Aas (2019). By manually collecting CEO option data, this paper also includes two well-known proxies for CEO risk-taking incentives, vega and delta. These are commonly used in studies covering other geographies but do not appear to have been studied much in a Norwegian setting.

[1] That is, aimed at aligning the goals of the agent with that of the principal.

The paper is structured in the following manner: Section 2 presents a review of existing literature. Section 3 describes the sample used for the empirical analysis, before Section 4 presents the methodological considerations. In Section 5, the results are presented alongside accompanying discussions. Lastly, Section 6 concludes the paper and present some suggested areas for further research.

2. Literature review

The literature review is divided into two parts. The first part looks at the principal-agent theory and how it relates to the topics of interest in this paper, while the second part reviews the literature on executive incentives, capital structure, and risk.

2.1. Principal-agent theory

Agency theory emerged as a field of study during the 1970s. The existing literature at the time focused on risk-sharing among cooperating parties with divergent risk preferences. Agency theory expanded upon this, addressing the relationship created when one party, called the principal, delegates work to another party, called the agent (Eisenhardt, 1989). The potentially conflicting interests between the agents' actions and those desired by the principal are often referred to as the agency problem or the principal-agent problem. The problem is general in nature, and within a business context, it is not restricted to a specific organizational type or industry (Jensen and Meckling, 1976).

There are two main issues addressed by agency theory. The first is the agency problem, arising from the use of an agent in the first place, while the second concerns the actions taken by the principal to monitor and verify the behaviour of the agent. In the simple principal-agent model presented in the literature, the agent is usually assumed to have a higher degree of risk aversion than the principal (Gray and Cannella, 1997). This is often attributed to the principal being able to diversify their investments to a greater extent than the agent. The goal is to find an optimal contract with respect to aligning the interests of the principal and the agent, and Eisenhardt (1989) argues that the use of an outcome-based contract can be beneficial to this extent.

Agency theory presents two main approaches aimed at aligning the interests and actions of the principal and the agent. The first is to monitor the behaviour of the agent and the second is to use incentive mechanisms (Kolb, 2012). Kolb (2012) further states that it is not possible to achieve a perfect alignment between the incentives of the CEO and that of the firm's shareholders, and that someone approaching the problem from a theoretical point of view will accept this inefficiency so long as the chosen incentive structure creates more net shareholder value than the alternatives. The use of incentive mechanisms as an approach to align interests has gathered much interest in the literature (Hayes et al., 2012).

A frequently studied relationship is that between the CEO of a company and its shareholders. There are various ways in which misalignment might occur in such a relationship. One example is the agency problem referred to as empire-building, where the CEO engages in activities for his or her own benefit that can be detrimental to the other stakeholders of the firm.[2] Particularly relevant for this paper is the topic of risk-sharing, where divergent attitudes towards risk between the principal and the agent may result in their preferred actions being conflicting (Eisenhardt, 1989; Jensen, 1986). Incentive mechanisms, such as the use of stock options tied to firm performance, typically aim at impacting the actions

[2]Empire-building often refer to a situation where the size of a company is grown beyond the optimal, or reasonable, size by its managers, with the aim of increasing the resources that they manage as well as strengthening their own personal power and status (Chen et al., 2012; Jensen, 1986).

of risk-averse managers to align with those desired by the shareholders, often through changing firm risk (Williams and Rao, 2006; Hayes et al., 2012).

2.2. Executive incentives, capital structure, and risk

As noted by Berger et al. (1997), the connection between agency theory and firm capital structure is commonly used in the literature, often building upon the work of Jensen and Meckling (1976). A connection can further be extended to firm risk, as managerial risk aversion often leads to levels of risk that are below what is desired by the shareholders, for example through lower than optimal levels of leverage (Williams and Rao, 2006; Berger et al., 1997). An important lever through which a firm can adjust its risk is through capital structure choices. In their original paper, Modigliani and Miller (1958) present a theorem stating that the value of a firm is independent of its choice of capital structure under certain conditions - often referred to as the principle of capital structure irrelevance. While the theorem has later been criticized for its lack of realism, it laid the groundwork for capital structure as a field of study.

While, in general, neither the management of a firm nor its board of directors solely decides on the amount of debt used in the firm, the use of leverage as a mechanism to address the agency problem has received interest in the literature (Berger et al., 1997; Milidonis and Stathopoulos, 2014). Firms can use higher levels of debt than what management would prefer to alleviate, or potentially resolve, the conflicts of interest that might be particularly prominent if the ownership share of management is low. Higher levels of leverage can increase the potential threat of bankruptcy, impacting the wealth and job prospects of the manager (Kim et al., 2017). This is then argued to induce the behaviour of the manager to more closely align with that of the shareholders (Grossman and Hart, 1982). While higher levels of managerial ownership could close the principal-agent alignment gap, it also provides managers more power to influence the level of firm debt to their own liking (Friend and Lang, 1988). From a different perspective, compensation incentives provided to managers may induce capital structure decisions as a way for the managers to adjust firm risk themselves (Milidonis and Stathopoulos, 2014). The interaction between compensation incentives, firm leverage, and risk-taking is of particular interest in this paper. A common concern found in the literature relates to the causal relations and endogenous effects between these topics (Coles et al., 2006; Hayes et al., 2012; Milidonis and Stathopoulos, 2014; Kim et al., 2017).

Studying managerial stock ownership in the context of leverage, Frank and Goyal (2007) argue that CEO ownership is non-linear in nature, where a few CEOs own large stakes while the majority hold relatively small ownership stakes. Furthermore, the impact of the ownership share size itself may vary, incentivising managers at lower levels of ownership and inducing managerial entrenchment at higher ownership levels in the context of firm performance (Frank and Goyal, 2007). CEO ownership can help mitigate agency problems at low ownership levels, whereas entrenchment can discourage risk-taking and therefore cause misalignment between the interests of the principal and the agent (Florackis and Ozkan, 2009). The same effect is generally not expected from stock options, as they do not provide similar stockholder voting rights, and therefore may not provide sufficient comfort for the CEO to take an overly cautious approach to risk (Kim and Lu, 2011; Frank and Goyal, 2007). Examining the relationship between capital structure and managerial self-interest among US listed companies, Friend and Lang (1988) find that increased levels of management ownership led to lower levels of firm leverage, due to the risk of bankruptcy associated with more debt.

Milidonis and Stathopoulos (2014) find that the risk aversion of the CEO might be more important in determining their behaviour than the effects from the use of debt. The incentive effects stemming from CEO compensation elements are expected to differ due to risk preference variability among the CEOs (Devers et al., 2008). Covering an area they argue has received little attention, YU and Luu (2014) examine how the risk-taking incentives arising from compensation elements are affected by CEO attributes, such as age, overconfidence, and tenure. They state that agency costs can be reduced from the firm's perspective by taking such differences in risk preference into consideration when deciding on the incentives provided to the CEO.

Much of the previous research related to CEO compensation incentives and risk-taking is concerned with equity-based compensation, particularly that of stock options (Kim et al., 2017). Two commonly used incentive proxies aimed at capturing the inherent convexity of options are the sensitivities to stock price (delta) and to the volatility of stock returns (vega) (Hayes et al., 2012).[3] Coles et al. (2006) argue that using alternative explanatory variables such as those capturing the size, or value, of the option portfolio provide noisy approximations of the incentives that managers actually face. While strong evidence for a positive relationship between vega and risk-taking is found in previous research, the association between delta and risk-taking is less clear (Armstrong and Vashishtha, 2012; Hayes et al., 2012; Milidonis and Stathopoulos, 2014). Hayes et al. (2012) note that while a higher delta entails a closer relationship between the manager and the stock price (increases) of the firm, the related increase in personal risk for the manager also provides risk-reducing incentives.

It is widely argued that there exists a positive relationship between managerial risk incentives that arise from stock options and firm risk (Coles et al., 2006; Williams and Rao, 2006; Kim and Lu, 2011; Kim et al., 2017). An often-cited reason is that the inherent convexity in options induces managerial risk-taking (Das et al., 2013). Kim and Lu (2011) argue that the direction of the relationship between stock options and risk-taking is more nuanced, pointing to the risk-increasing effect of option grants on the personal wealth of the CEOs. Option grants might therefore induce actions from the CEOs aimed at reducing their personal risk through the means of reducing firm risk (Carpenter, 2000). Lambert et al. (1991) discuss how differences in managerial preferences and risk aversion should be taken into account when valuing options, and that option incentives can be both positively and negatively related to risk. Furthermore, the properties of the options also impact the incentive effects. Lewellen (2006) finds that options can reduce managerial risk-taking, with the effect being most prominent when a large share of the option portfolio consists of in-the-money options.[4]

The literature review alludes to previous research primarily having focused on firms in the United States. Birkeland et al. (2011) and Aas (2019) look at Nordic and Norwegian firms, respectively. The former study the relationship between executive incentives and

[3]The calculation of delta and vega used in the literature is commonly based on the method developed by Core and Guay (2002).

[4]The behaviour of deep in-the-money stock options is expected to be similar to that of owning the underlying stock outright.

capital structure for a randomly drawn sample of listed firms in the Nordic region. Using a dynamic panel data approach, they find a negative impact of options on firm leverage and larger incentive effects from options than from stocks. In a Norwegian context, analyzing the same sample of firms as in this paper, Aas (2019) finds a positive relationship between idiosyncratic risk and firms providing the CEO options as part of the their compensation package.

3. Data

The data section consists of three parts. First is an overview of the sources used to create the sample, followed by a description of the variables used in the empirical analysis. Lastly, descriptive statistics are presented.

3.1. Data sources

The availability of executive compensation data is the main challenge from a data perspective when studying the relationships of interest in this paper. To the knowledge of the author, there do not exist any publicly available databases or data sets containing executive compensation data with sufficient enough detail level for Norwegian firms.[5] There exist relevant databases containing executive compensation data for firms in countries outside of Norway. The Standard & Poor's ExecuComp database is an example, being commonly used for sourcing executive compensation data for firms based in the United States.[6] The lack of such a standardized data source provides a challenge for doing empirical research on related topics in a Norwegian context.

As part of their thesis, Asche and Solberg (2017) approached this challenge by creating their own data set. Through a rigorous manual effort, they collected CEO compensation data for a sample of Norwegian listed companies.[7] Their data set has been used as a foundation in this paper. The structure of the data set is an unbalanced panel, containing compensation data and firm-level data for the years 2012, 2014, and 2016. After excluding selected firms due to poor reporting quality or lack of available information, the resulting data set contains observations for 143 firms across three years.[8] Only having observations from alternating years and the short length of the panel are two drawbacks of this data set. The companies are categorized within 11 different sectors in accordance with the GICS standard.[9] In addition to data on CEO compensation, selected accounting data, firm ownership data, and sector classifications have been sourced from Asche and Solberg.

[5] That is, compensation data split into sub-components such as salary, bonus, stock- and option grants.

[6] See for example Chava and Purnanandam (2010), Coles et al. (2006), and Hayes et al. (2012).

[7] Asche and Solberg (2017) study the relationship between firm performance and top executive compensation for the Norwegian public limited liability companies that were listed on the Oslo Stock Exchange ("Oslo Børs") as of August 15th, 2017.

[8] A complete list of the companies included in the sample can be found in Appendix A.

[9] The Global Industry Classification Standard (GICS) is developed by Standard & Poor Global and MSCI.

Table 3.1 provides an overview of the relevant data sources and accompanying data categories gathered from each source. The various data points have been combined to create the final data set used for the empirical analysis.

Data source	Description
Asche and Solberg (2017)	Compensation data, accounting data, ownership data, sector classification.
TITLON	Stock price data, stock indices price data.
ORBIS	Accounting data, CEO characteristics data.
Annual reports, NewsWeb	CEO characteristics data, option compensation data.[10]

Table 3.1: Data sources used to construct the data set.

The second data source used is TITLON, a database that contains various financial data dating back to 1980 from Oslo Stock Exchange. Stock price data for the relevant firms and price data for the relevant Oslo Stock Exchange stock indices, corresponding to each of the 11 sectors, are sourced from the database. The data was queried by using the programming language Python through a database interface for Microsoft SQL Server ("pymssql").[11] The third data source is the ORBIS database.[12] ORBIS has been used to acquire additional accounting data for the sample firms as well as data on CEO characteristics.

Finally, a manual data collection effort similar to that performed by Asche and Solberg (2017) was needed to acquire sufficiently detailed CEO option compensation data and to supplement the data on CEO characteristics from ORBIS.[13] Option data was collected for the three years 2012, 2014, and 2016, supplementing the existing CEO compensation data already available in the data set.[14] The data is sourced from annual reports and from company filings available through the NewsWeb database.[15] Section 3.2.2 provides

[11] TITLON is available for Norwegian academic institutions. Many thanks to the project team behind the TITLON financial database for their work and to NTNU for providing access to both the TITLON and ORBIS databases. More information on the TITLON database is available at: `https://uit.no/forskning/forskningsgrupper/sub?sub_id=417205&p_document_id=352767`

[12] The ORBIS database is published by the Moody's Analytics company Bureau van Dijk. Access to the database was granted through NTNU.

[13] The option variable available in the data set received from Asche and Solberg captures different incentive effects than what is the aim in this paper. Their option variable aims at capturing the change in value of the option portfolio during the reported year.

[14] Having to collect these data points manually from company filings is time-consuming. A trade-off between time spent collecting data and that spent on other parts of the thesis was therefore needed, resulting in a decision to collect option data for the three years that already had other CEO compensation elements available.

[15] The NewsWeb database is publicly available and provides filings from companies listed at the Oslo Stock Exchange, such as mandatory trade notifications from primary insiders. The database is available at: `https://newsweb.oslobors.no/`

a description of the relevant data points sourced and the resulting variables constructed for the empirical analysis.

3.2. Variable description

Four groups of variables have been constructed from the data set: risk proxies, incentive variables, CEO characteristics, and control variables. A description of the key variables used in the empirical analysis is found below, while a condensed list of all variables can be found in Appendix C.1.

3.2.1. Risk proxies

In line with previous literature, risk-taking is captured through realized stock return volatility for the firms in the sample (Rajgopal and Shevlin, 2002; Coles et al., 2006; Armstrong and Vashishtha, 2012; Hayes et al., 2012; Kim et al., 2017). Specifically, the annualized standard deviation of monthly logarithmic stock price returns is used as a proxy for total firm risk. An alternative approach that is also frequently used in previous research is to decompose firm risk into a systematic and an idiosyncratic component (Belghitar and Clark, 2012). While there seems to exist some evidence of relationship differences between the two risk components and CEO incentives, see for example Jin (2002), the findings from other studies, such as Milidonis and Stathopoulos (2014), are consistent across total firm risk and its sub-components. One potential drawback with this approach is that the idiosyncratic risk component might be misleading if a relevant risk factor is missing from the, often used, factor model that helps decompose total firm risk (Chen and Petkova, 2012). For each firm, the risk proxy mentioned above is then divided by the relevant sector risk over the same time period. The sector risk proxy is calculated in the same way, using log returns of stock index prices. This ratio is referred to as the *Risk Ratio*. The purpose of including sector risk is to isolate the changes in firm risk from those of the sector more broadly. Additional analyses using a proxy for risk without adjusting for sector risk are also performed to validate the findings and for comparing with previous research.

With the sample containing observations for three fiscal years having one year gaps between each year with data, risk proxies have been constructed to contain data for 24-month periods that also include the gap years. A drawback of using monthly data for stock and index prices is the low number of observations per year, which might lead to relatively more noisy and unstable measurements. Doubling the number of observations for each period of interest helps alleviate this issue. The periods captured by the risk proxies start six months prior to, and end six months after, the related year with compensation data. The definition of the three non-overlapping periods and how they map to the three years of compensation data is summarized in Table 3.2.

Period number	Description
Period 1	July 2011 to June 2013 (including), maps to the year 2012.
Period 2	July 2013 to June 2015 (including), maps to the year 2014.
Period 3	July 2015 to June 2017 (including), maps to the year 2016.

Table 3.2: Description of the risk proxy periods.

The choice of periodization for the risk proxies is also motivated by the expectation of a notable presence of longer-term effects from the incentive proxies included in the paper, in particular from options and CEO stock ownership. Alternative volatility periodizations measured over a 12-month and 24-month period after the respective fiscal years have also been used to validate the findings.

The process of creating the risk proxy for the respective firms starts by calculating monthly log returns of the stock prices sourced from the TITLON database. Normalizing the returns to a logarithmic scale (log returns) is a commonly used approach for financial data, as it entails some desired properties such as being interpretable as continuously compounded returns and being time additive (Brooks, 2014, p. 8). This is illustrated in Equation 3.1, taking the natural logarithm of the current month stock price divided by the previous month stock price

$$Log\ returns = ln(\frac{S_t}{S_{t-1}}), \tag{3.1}$$

next, the standard deviation of the sample log returns is calculated

$$\sigma_{monthly} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2}, \tag{3.2}$$

where x_i takes on 24 values, each representing a monthly log return data point. This calculation is performed for each of the three periods as defined above.

The monthly standard deviation of the log returns is then annualized by multiplying with the square root of 12 for easier interpretation and comparison with existing literature.

$$\sigma_{yearly} = \sigma_{monthly} \times \sqrt{12} \tag{3.3}$$

The final metric is obtained by dividing the yearly standard deviation of all the firms with their respective sector standard deviation for the matching time period.

$$Risk\ Ratio = \frac{\sigma_{yearly}\ (firm)}{\sigma_{yearly}\ (sector)} \tag{3.4}$$

3.2.2. Incentive variables

This group of variables aims at capturing CEO incentives provided through compensation elements, referred to as incentive variables. CEO salary and bonus are included to capture compensation components that are not equity-based. Previous research regularly pools the two together as a CEO cash compensation variable, which is also done in this paper (Coles et al., 2006; Armstrong and Vashishtha, 2012; Hayes et al., 2012).

The approach of Core and Guay (2002) is often used in prior studies to calculate delta and vega.[16] These variables appear to have a strong standing in the literature and are viewed as providing a better approximation of the incentives managers face than alternative variables such as those capturing the size, or value, of the CEO's stock or option portfolio (Coles et al., 2006; Milidonis and Stathopoulos, 2014).

In this paper, vega represents the NOK change in value of the CEO's option portfolio for a 0.01 change in the standard deviation of the firm's stock returns, while delta represents the NOK change in value of the CEO's options portfolio for 1% change in the firm's stock price. Similar to Kim et al. (2017), variables are created for the two components of delta and vega, newly granted and the existing portfolio, as well as the sum of the two, measuring the total portfolio effects (referred to only as delta and vega). Furthermore, in line with Coles et al. (2006) and Armstrong and Vashishtha (2012), the logarithmic transformation is applied to delta and vega due to their skewness. A detailed description of delta and vega calculations and their accompanying assumptions can be found in Appendix B.

As noted by Coles et al. (2006), there have been discussions around whether the Black-Scholes option pricing model is an appropriate method for valuing employee stock options. Lambert et al. (1991) argue that managerial risk aversion also should be taken into account when valuing options, due to its potential behavioural impact. Methods such as Black-Scholes may overvalue the options compared to the value assigned by the employee due to factors such as the lack of liquidity and their level of risk aversion. While some studies, such as Jin (2002), aim at addressing this, no such adjustments have been made in this paper.

An alternative option incentive variable is also included. Referred to as *Option Portfolio Ratio*, the variable is constructed by taking the end of year value of the CEO option portfolio, calculated by the Black-Scholes option pricing model, divided by the CEO cash compensation. This is illustrated in Equation 3.5. This variable aims at capturing different incentive effects, looking at the relative size of options to that of cash compensation, supplementing the incentive effects captured by delta and vega. A notable advantage is that more observations are available for this variable.

$$Option\ Portfolio\ Ratio = \frac{Option\ portfolio\ value}{Cash\ compensation} \tag{3.5}$$

[16]See for example Armstrong and Vashishtha (2012), Coles et al. (2006), Frank and Goyal (2007), Brockman et al. (2010), Milidonis and Stathopoulos (2014), and Kim et al. (2017).

Two variables are constructed related to CEO stock ownership. The first variable, *CEO ownership*, measures the ownership percentage of the firm's total outstanding shares held by the CEO. Similar to Milidonis and Stathopoulos (2014), an alternative variable for CEO stock ownership is included. This variable captures the relative size of the CEO's salary to that of her/his stock ownership value, referred to as *Salary-to-Stock ratio*. With the delta variable capturing the sensitivity of the option portfolio value to stock price changes, the two aforementioned variables aim at capturing incentive effects directly connected to stock ownership.

3.2.3. CEO characteristics

It is likely to exist risk preference differences among the CEOs in the sample. The incentive effects from compensation elements are therefore also expected to vary. Selected CEO characteristics are included to explore whether these factors seem to affect the relationships of interest.

CEO age and *CEO tenure* measure in years the age and the time that the CEO has had in the role, respectively. Age and tenure, as well as CEO cash compensation, are all used in previous research as proxies for managerial risk aversion (Coles et al., 2006; Armstrong and Vashishtha, 2012; Milidonis and Stathopoulos, 2014; YU and Luu, 2014). Motivated by studies pointing to both perceived and measurable gender differences in risk aversion, a dummy variable capturing CEO gender is also included (Martin et al., 2009; Charness and Gneezy, 2012; Faccio et al., 2016).

3.2.4. Control variables

Pointing to what has been done in the existing literature appears to be a common starting point when the topic of control variables is addressed.[17] In his assessment of methodological approaches used in the empirical corporate finance literature, Mitton (2020) finds a lack of consistency across groups of control variables.[18] There were, however, some exceptions. Firm size was found to be the most consistently used control variable, included in 84% of the sample regressions, while profitability, leverage, and investments form the second most commonly used group of variables, appearing in approximately half of the sample regressions. Taking the natural logarithm of total assets was found to be the most common proxy for firm size.[19], while total debt divided by total assets was the most common dependent variable in leverage regressions.

Based on data availability, previous research, and the findings from Mitton (2020), the following control variables related to company characteristics are included in this paper: firm leverage (book value of total debt divided by total assets), firm size (logarithm of total assets), market-to-book ratio (market value of equity divided by book value of equity), capital expenditure divided by total assets (CAPEX), and research and development

[17] See for example Coles et al. (2006), Chava and Purnanandam (2010), and Armstrong and Vashishtha (2012).

[18] The sample consists of 954 regressions from 604 articles between the years 2000 and 2018 in three finance journals (*Journal of Finance, Journal of Financial Economics, and Review of Financial Studies*).

[19] Log(total assets) was used in 44% of the regressions.

costs divided by total assets (R&D).[20] Alongside firm size and leverage, MTB (market-to-book), CAPEX, and R&D are also frequently used in previous research studying the topics of incentives, capital structure, and risk due to their potential impact on risk-taking and on the incentives provided to managers (Kim et al., 2017).[21] MTB, CAPEX and R&D are often included as proxies for investment or growth opportunities (Coles et al., 2006; Armstrong and Vashishtha, 2012).

3.2.5. Treatment of outliers

In his review of the empirical finance literature, Mitton (2020) finds that the decisions concerning data outliers can have a significant impact on the results. With the sample size being relatively small, the effects of outliers might be larger than what would be expected for larger samples (Wooldridge, 2013; Brooks, 2014).

Various approaches are available when evaluating the treatment of outliers. Mitton (2020) finds that the three most common approaches used are to winsorize the outliers, keep them, or trim the outliers.[22] The most common cutoff points used for outliers were the 1st and 99th percentiles, occurring in three out of four studies on average. Both the technique of winsorizing and the consistency of cutoff points have increased notably in recent years according to his study. In line with previous studies, the default approach to outlier treatment used in this paper has been to winsorize at the 1st and 99th percentiles. Risk proxies, delta, vega, cash compensation, and MTB have been winsorized. The risk proxies are winsorized based on analyses indicating a potential presence of outliers for these variables, while the choice of winsorizing the remaining four variables is consistent with that of Coles et al. (2006).

[20] Coles et al. (2006) points to the trade-off between using book values or market values for firm leverage, arguing that book debt is more accessible to management, whereas market leverage might be more directly tied to managerial incentives due to its connection with stock price changes.

[21] See for example Coles et al. (2006), Williams and Rao (2006), Frank and Goyal (2007), Hayes et al. (2012), and Im et al. (2020).

[22] The three methods were used in 48%, 43%, and 9% of the studies analyzed, respectively.

3.3. Descriptive statistics

The following section presents selected descriptive statistics for the sample used in the empirical analysis.

The number of observations for the 11 sectors in the sample is illustrated in Figure 3.1. The distribution is quite skewed, with the three largest sectors (Energy, Industrials, and Information Technology) accounting for 59.4% of the total sample observations. Norway is known for its export of oil and gas, being a top seven exporter of crude oil worldwide and noted as the most important source of natural gas to Western Europe by the European Commission (European Commission, 2021). The composition of firms on the Oslo Stock Exchange is reflective of this and is, besides the Energy and Shipping sectors, also known for the strong presence of seafood companies. The sample seems to capture these particularities quite well, with the highest number of observations being within the Energy sector and 80% of the firms in the Consumer Staples sector being related to the seafood industry. The figure further shows that selected sectors have few sample observations, with six observations for Utilities and Communication Services being the lowest. This presents a challenge when performing analyses on sector sub-samples and the distribution of observations across sectors is important to keep in mind when evaluating the results of the analyses and their generalizability.

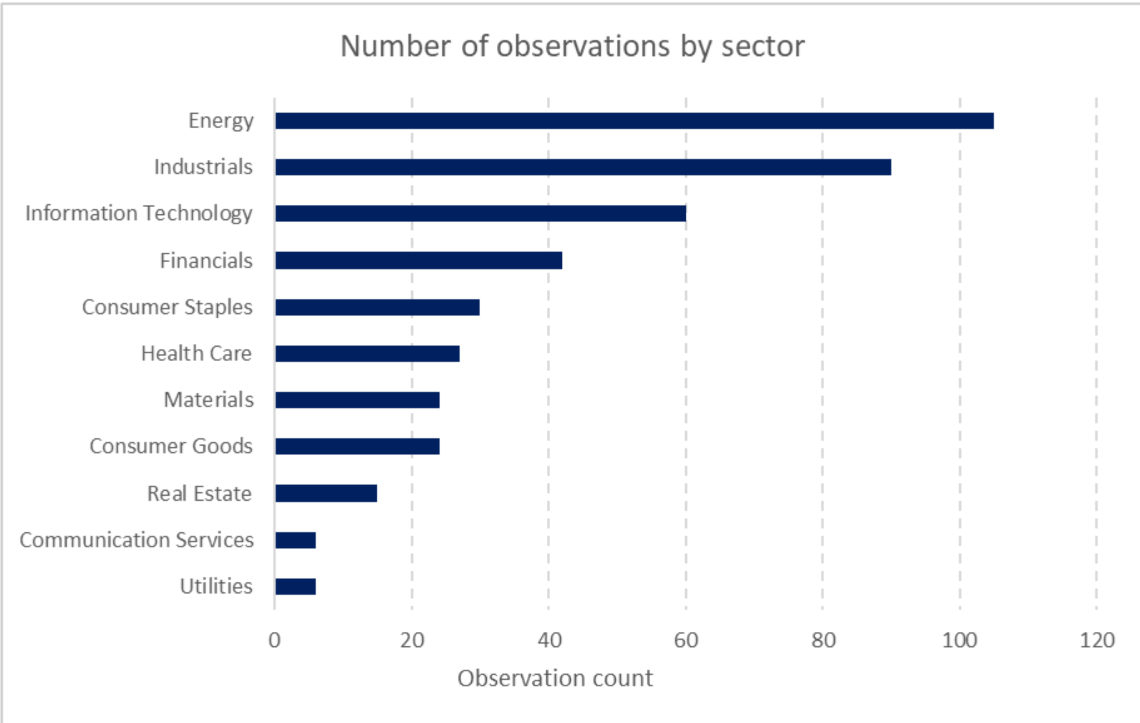

Figure 3.1: Number of observations by sector.

The price development of the 11 sector indices as well as the Oslo Stock Exchange Benchmark Index (*Oslo Børs Benchmark Index_GI*) is shown in Figure 3.2. The graph suggests that there were performance differences across sectors between 2012 and 2016, with the Consumer Staples and Consumer Discretionary (Consumer Goods) sectors showing the best price development during this period. The Real Estate stock index (OSE60) was first introduced in September of 2016, hence overlapping only partly with the time period of the sample used in this paper. Similar to Aas (2019), the Oslo Stock Exchange benchmark index has therefore been used as a proxy for the Real Estate sector volatility for all the three relevant periods.

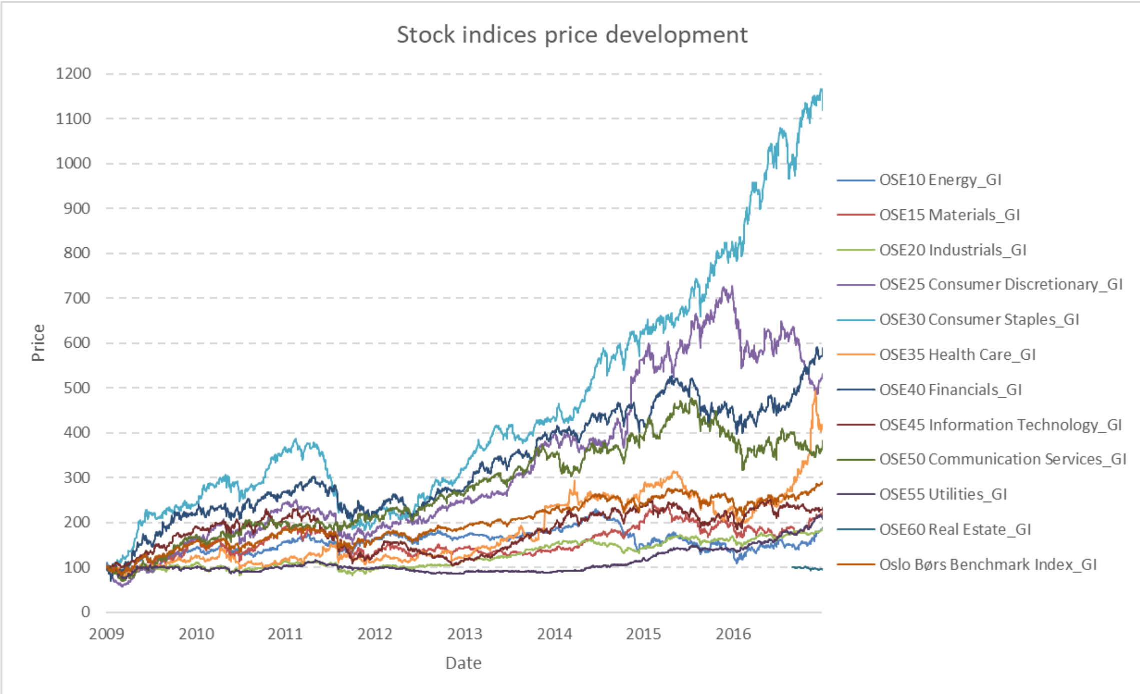

Figure 3.2: Price development for the Oslo Stock Exchange stock indices.

Figure 3.3 presents a box plot of the calculated stock return volatility for the sample firms, grouped together by sector. The horizontal line inside the boxes indicates the median value, while the upper and lower hinges outside of the boxes indicate the 75^{th} and 25^{th} percentiles, respectively. While factors such as the number of observations within each sector impact the results, the distribution ranges appear to be largest for the Energy, Information Technology, and Materials sectors. The figure further indicates that there might be a presence of outliers in the data set, notably at the upper end of the volatility distributions. Tabulated descriptive statistics supplementing this figure can be found in Appendix D.

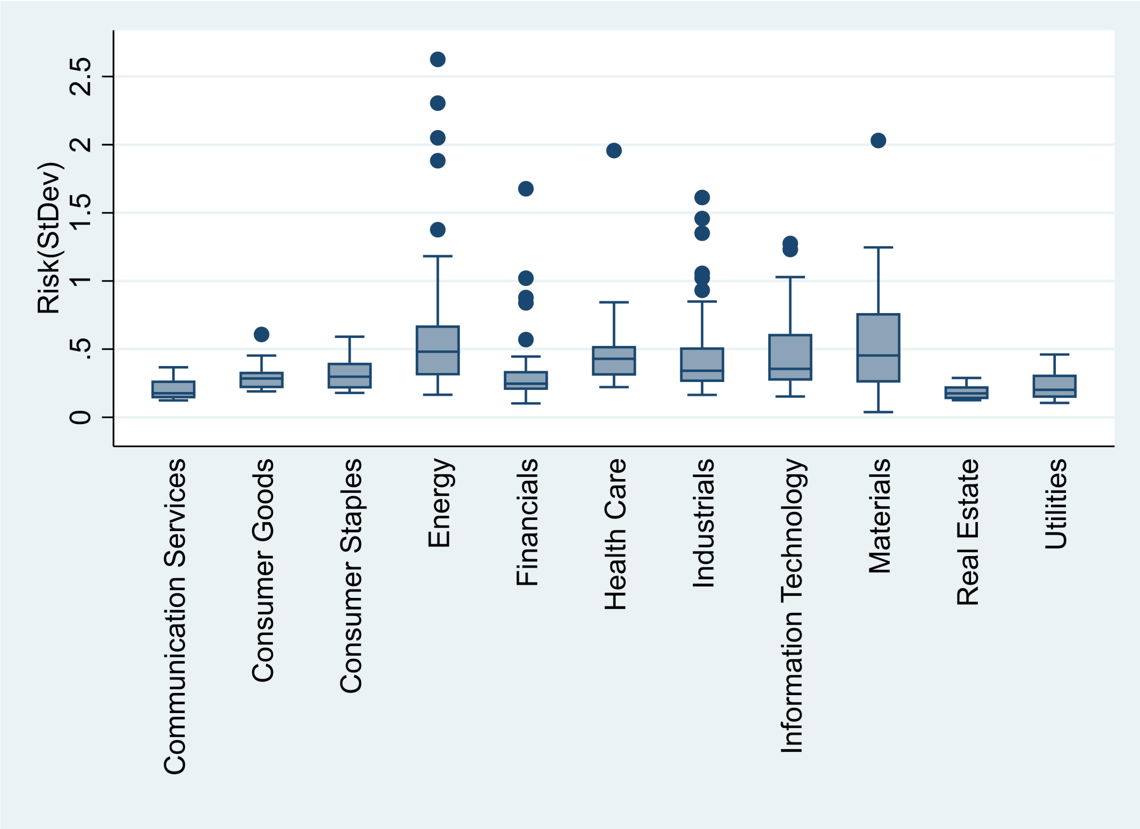

Figure 3.3: Distribution of stock return volatility across sectors.

Summary statistics for the variables used in the empirical analysis are presented in Table 3.3. The stock return volatility of the firms is notably larger than the volatility of their respective stock indices, with a median *Risk Ratio* value of 1.637. Median values for cash compensation (MNOK 3.515), delta (NOK 30,459), and vega (NOK 18,952) are smaller than what is found in previous research on US firms. This is as expected, with managers of Norwegian firms having traditionally had notably lower levels of compensation, particularly for the share of variable pay, compared to US peers (Randøy and Nielsen, 2002; Randøy and Skalpe, 2010). All the equity-based CEO incentives have fairly large distributions of values and accompanying standard errors, suggesting that there are notable differences among the sample firms. The mean value of the *CEO ownership* variable (3.2%) is similar to that of studies on firms in the United States.[23] In line with previous studies, the CEO ownership variable is skewed for the sample with a few CEOs having a large ownership share while many CEOs have small ownership stakes: 77% of the observations have an ownership share below 1%, 13.1% have a value higher than the mean, 5% have a value above 20%, and the max value is 77.5%. The level of ownership is consistently smaller than for previous studies on US firms (Frank and Goyal, 2007; Kim and Lu, 2011; Milidonis and Stathopoulos, 2014).

Female CEOs account for 4.25% of the observations in the sample. In percentage terms, this is higher than for example the study on US firms by Frank and Goyal (2007), where the number is 1.3%. A notable difference is that the 4.25% corresponds to only 18 total

[23]See for example Kim and Lu (2011), Berger et al. (1997), and Frank and Goyal (2007).

observations. The median age and tenure are 52 years and 4.5 years, respectively. This appears to quite similar to the corresponding values found in the literature, with a median tenure of approximately 5-6 years and a median age of around 54-56.[24]

Variable	N	Mean	Min	Max	SD	$25^{th}\%ile$	Median	$75^{th}\%ile$
Dependent variables								
Risk Ratio	373	2.128	0.133	11.731	1.545	1.204	1.637	2.609
Firm risk	373	0.446	0.038	2.626	0.320	0.246	0.337	0.548
Incentive variables								
Salary (NOK 1000)	395	3,298	417	17,444	1,720	2,176	2,948	4,046
Bonus (NOK 1000)	337	1,148	0	17,049	1,850	0	484	1,550
Cash comp. (NOK 1000)	395	4,277	710	21,249	2,771	2,344	3,515	5,369
Delta (NOK 1000)	124	85.6	0	1,745.2	193.6	8.8	30.5	69.2
Vega (NOK 1000)	124	64.4	0	1,468.8	170.7	4.9	19.0	44.8
Option Portfolio Ratio	387	0.474	0.000	16.477	1.901	0.000	0.000	0.105
CEO ownership	343	0.032	0.000	0.775	0.108	0.000	0.001	0.009
Salary-to-Stock	292	3,315	0.038	435,112	29,403	23.2	89.2	408.2
CEO characteristics								
Gender	424	0.958	0	1	0.202	1	1	1
Tenure	424	5.802	0.083	27.500	5.261	1.918	4.500	8.00
Age	412	51.427	30	72	7.391	46	52	57
Firm characteristics								
Debt Ratio	413	0.571	0.005	2.477	0.295	0.400	0.588	0.731
MTB	361	3.020	-282.781	403.574	26.994	0.587	1.327	3.055
CAPEX	405	0.056	0.000	0.957	0.110	0.000	0.019	0.060
R&D	408	0.009	0.000	0.584	0.044	0.000	0.000	0.000
Total assets (MNOK)	425	39,184	0.485	2,653,201	227,655	653	2,462	11,318

Table 3.3: Descriptive statistics for the variables used in the empirical analysis.

[24]Selected studies from US firms: 5 year median tenure and 55 year average age for Frank and Goyal (2007), a 6 year median tenure and 54 year median age for Coles et al. (2006), and a 5 year median tenure and 56 year median age for YU and Luu (2014).

Pairwise Pearson's correlations between the key variables are presented in Table E.1 in Appendix E. A high correlation between delta and vega is estimated, similar to for example Kim et al. (2017). To address the potential issue of multicollinearity between the two, the variance inflation factor (VIF) has been measured for various model specifications (Wooldridge, 2013, p. 98). A fairly high VIF of approximately 7.5 is found for the most simple models that only include delta and vega as explanatory variables and risk as the dependent variable.[25] After including more explanatory variables and estimating the VIF for the model specifications presented in Section 5, a VIF between 1.6 to 2.1 is found for delta and vega. Multicollinearity does not seem to be a large concern for these variables. The *Option Portfolio Ratio* variable is positively correlated to delta and vega, but the coefficient estimates are much lower than the correlation between delta and vega. This may indicate that the variable does not capture the exact same incentive effects as delta and vega.

A positive correlation between *Option Portfolio Ratio* and the two risk proxies is estimated, while cash compensation, delta, and vega show negative correlations with risk. The correlation estimates for vega and *Option Portfolio Ratio* are, however, small compared to the size of their standard errors. Looking at the CEO characteristics, a negative correlation between both tenure and age with the risk proxies is estimated. A significant (at the 5% level) positive correlation between leverage (*Debt Ratio*) and risk as well as a negative correlation between firm size and risk are both as expected based on the existing literature.

[25]While there is no formal cutoff point for which multicollinearity is defined, a VIF that exceeds 5 or 10 is usually an indication that multicollinearity could be a potential problem (Wooldridge, 2013).

4. Methodology

The following section presents methodological considerations. First is an introduction of the econometric methods that have been applied, followed by a discussion of their appropriateness. The structures of the regression models used in the empirical analysis are then presented.

4.1. Econometric methods

The set of econometric methods specialized for data sets with a panel data structure is a natural starting point for studying the sample at hand. Often analyzing a large sample of firms over several years, panel data methods are commonly used in the literature covering the topics of interest in this paper.[26] The two main categories of panel data methods are the fixed-effects model (FE) and random-effects (RE) model. An important assumption for the RE method is that the unobserved effects are not correlated with any of the explanatory variables (Wooldridge, 2013, p. 493). An alternative approach to using panel data methods is to pool all the observations together, removing the time aspect of the data set, and perform an ordinary least squares (OLS) estimation. Referred to as the pooled OLS method, it can be appropriate if there are no significant time-invariant firm-specific effects, such as firm culture, in the data. In general, the RE method is more efficient than pooled OLS which is a desirable property (Wooldridge, 2013, p. 496).

Of particular relevance to the sample studied in this paper is the robustness to outliers, this is due to the relatively low number of observations available, and that analysis suggests the presence of outliers for some of the variables. A technique that is more robust to outliers than OLS and that seems to gather increased interest in the economics and empirical finance literature is that of quantile regressions (QR) (Koenker and Hallock, 2001; Baur et al., 2012).[27]

While OLS minimizes the sum of squared residuals to find the conditional mean value of the dependent variable, median regression instead minimizes the sum of the absolute value of residuals (Brooks, 2014, p. 161). To find different quantiles than the median, the absolute residuals can be weighted differently depending on whether they take on a positive or negative value (Koenker and Hallock, 2001; Brooks, 2014). With QR the effects of explanatory variables can be analyzed across the entire distribution of the dependent variable, instead of just looking at the mean, or median, value (Brooks, 2014). For the sample, this may entail examining whether the relationship between CEO incentives and firm risk differs for firms with different risk profiles. While some previous studies seem to use median regressions as a robustness measure, for example Coles et al. (2006), QR does not appear to be an extensively applied technique for analyzing managerial incentives and risk-taking. Hallock et al. (2010), looking at the CEO pay-performance relationship, note a similar finding for this adjacent field of study. For the purposes of this paper, QR is used as a way of validating the findings from pooled OLS and panel data methods applied to the sample, as well as highlighting the cases where effects seem to differ across

[26] See for example Coles et al. (2006), Chava and Purnanandam (2010), and YU and Luu (2014).

[27] Brooks (2014) argue that the increased interest in the finance space is due to improved availability of statistical software packages targeting econometric purposes and more interest in analyzing tail behaviour of distributions, such as value at risk modeling.

quantiles of the dependent variable.

4.2. Method selection

This paper aims at evaluating whether variations in CEO incentives can explain variations in firm risk. Variations across firms, captured through panel data methods, could therefore be relevant explanatory factors. A concern with using a FE model is that in addition to the removal of firm-specific effects, relevant effects that we aim to capture are also expected to be lost as part of the demeaning process. Furthermore, the sample analyzed covers a relatively short time period, making it less likely that variations within specific firms across time are sufficiently captured. This adds to the hypothesis that a FE model is less suitable.[28] The RE model could therefore be a preferred alternative panel data method to use.

Analyzing various data sub-samples, such as those based on the sector of the firms, is also part of the aim of this paper. The key challenge from an analysis perspective is the limited number of observations available for some of these sub-samples, for example for selected sectors (Utilities, Communication Services, and Real Estate in particular). Furthermore, the limited availability of observations for the option incentive variables, specifically for delta and vega, restricts the sample size for several of the relevant analyses. An example is that some firms do not have delta and vega observations for all the three years covered in the sample, which restricts the number of firms available when using panel data methods. For these reasons, pooled OLS is argued to be a preferred method for several of the analyses presented in this paper, such as when performing sub-sample analyses by sector, to obtain the largest possible sample size.[29] While panel data methods appear to be more frequently used in the literature, a large number of previous studies that use panel data methods do so on samples covering a longer time period and usually much larger sample sizes than what is used in this paper. Panel data methods have been applied to the analyses where a low number of observations is not an issue, providing, alongside QR, a robustness measure to validate the estimated relationships from pooled OLS models.

A common test for comparing the appropriateness of a RE model with that of a FE model is the Hausman test (Brooks, 2014). The results from running Hausman tests appear to be in agreement with the qualitative discussion above, with RE being the preferred method for most models. When choosing between a RE regression model and a simple OLS regression model, the Breusch-Pagan Lagrange multiplier (LM) test can helpful. The LM test examines whether a panel effect is present in the data by measuring the variances across firms (entities) (Princeton University, 2007). Results from running LM tests generally indicate that RE is preferred over a pooled OLS model.

[28] The ExecuComp data set provided by Wharton, covering S&P 1000 firms dating back to 1992, is frequently used in the literature. While the methods used and time periods studied varies in previous research, Kim et al. (2017) and Kim and Lu (2011) are examples where fixed-effects models are applied to ExecuComp samples over longer time periods (1995-2011 and 1992-2006, respectively).

[29] As an example, when attempting panel data methods on sector sub-samples, STATA provides an error of insufficient observations for several of the sectors.

To address potential groupwise heteroskedasticity in the residuals, the Modified Wald test is measured for the panel data models. The test results suggest rejecting the null hypothesis of constant variance (homoskedasticity), as the models generally showed the presence of heteroskedasticity. As corrective measures, robust standard errors have therefore been used for the panel data models, while clustered standard errors have been used for the pooled OLS models to account for the panel data structure of the sample (Wooldridge, 2013, pp. 277, 483).

4.3. Presentation of models

This section provides an overview of the regression model structures used to analyze the relationships of interest. A number of variations of the two models have been evaluated, for example through excluding selected control variables when the number of observations available are low and when comparing the effects from alternative incentives variables. Any relevant adjustments will be specified where appropriate when presenting the results.

Equation 4.1 illustrates the general structure of the first regression model.

$$Risk = \beta_0 + \sum_{i=1}^{n} \beta_i Incentive_i + \sum_{j=n+1}^{m} \beta_j Control_j + \epsilon_{it}, \tag{4.1}$$

where the relevant explanatory variables within each category were presented in Section 3.2 and ϵ_{it} represents the error term.

When exploring the existence of a moderating effect from leverage on the incentive-risk relationship, an interaction term between the option incentive variable and firm leverage is included. This is illustrated in Equation 4.2.

$$Risk = \beta_0 + \beta_1(Option \times Leverage) + \sum_{i=2}^{n} \beta_i Incentive_i + \sum_{j=n+1}^{m} \beta_j Control_j + \epsilon_{it} \tag{4.2}$$

The statistical software package Stata has been used to perform the empirical analysis, results are presented and discussed in the following section.

5. Results

Results from the empirical analysis are presented in three parts below. First, the effects of leverage on the relationship between CEO incentives and risk are examined. This is followed by analyses that include CEO characteristics and proxies for risk aversion, before potential differences across sectors are assessed. Lastly, additional robustness measures are discussed.

5.1. Effects of leverage

The effects of financial policies, such as leverage choices, in the context of managerial incentives and risk-taking, do not appear to be as extensively studied as the incentive-risk relationship itself. Firm leverage is often included by introducing it as a control variable or when studying the relationship between incentives and firm leverage directly.[30] Some studies, such as Chava and Purnanandam (2010) and Milidonis and Stathopoulos (2014), focus more specifically on the relationship between managerial incentives, financial policies, and risk. This section aims at examining these topics for the Norwegian firms in the sample.

In the first analysis, the sample has been split into four sub-groups based on the level of firm leverage. The results when using vega as the option incentive variable are presented in Table 5.1, while results when using delta and *Option Portfolio Ratio* are found in Tables F.1 and F.2 in Appendix F, respectively.[31] The results when using vega and *Option Portfolio Ratio* provide indications of a positive relationship between option incentives and risk for lower levels of leverage (below median leverage), with this relationship turning negative for higher levels of leverage (above median). At lower levels of leverage, the positive relationship between option incentives and firm risk aligns with the incentive effects often attributed to options as part of mitigating agency problems (Rajgopal and Shevlin, 2002; Williams and Rao, 2006; Frank and Goyal, 2007). The change in the direction of this relationship for higher levels of firm leverage may suggest that the risk-enhancing effects from the option incentives decrease with leverage (Kim et al., 2017). The results resemble those of Milidonis and Stathopoulos (2014) who find a strong negative relationship between vega and firm risk at above median levered firms and a positive, but not significant, relationship for firms with below median leverage. They characterise this as a non-monotonic connection between compensation incentives inducing CEO risk-taking and firm risk.

There are several possible interpretations for the negative relationship between option incentives and risk at higher leverage levels. One possible explanation could be that CEOs in highly levered firms also have higher levels of risk aversion. Milidonis and Stathopoulos (2014) note that higher leverage can lead to greater career concerns due to

[30] Coles et al. (2006) is an example of the former, while Chava and Purnanandam (2010) is an example of the latter.

[31] The relatively low number of observations in each sub-sample when using vega and delta as option incentive variables prompts a need for simpler regression model specifications using fewer control variables.

added risk of bankruptcy as well as potential reputation-related costs for the CEO.[32] In a recent study of US firms, Lin et al. (2019) find that firms with higher levels of leverage compensate their CEOs more to alleviate the potential bankruptcy cost associated with their capital structure. This could indicate that firms are aware of the added personal distress for CEOs that higher levels of leverage may cause.[33] As noted by Milidonis and Stathopoulos (2014), a potential challenge with this type of analysis is that of managerial self-selection. It could be the case that less risk-averse CEOs choose to work in firms that have higher levels of leverage and that there exist effects that are not captured by the estimated models. The inclusion of risk aversion proxies and CEO characteristics presented in Section 5.2 might help reduce such concerns. Another factor that might influence the incentives-risk relationship for highly levered firms is the increased level of monitoring by debt holders that is expected (Kim et al., 2017).

[32]Milidonis and Stathopoulos (2014) compare firms with above median and below median book leverage values, analyzing a sample of US firms between 1992 to 2005.

[33]Lin et al. (2019) perform OLS regression analysis on a sample of US firms between 2006 and 2013.

	Risk Ratio				
	Sample	Below 25^{th} percentile	Below median	Above median	Above 75^{th} percentile
Vega	0.032	-0.067	0.023	-0.050	-0.484**
	(0.03)	(0.15)	(0.03)	(0.08)	(0.17)
Cash compensation	-0.000	0.000	0.000	-0.000***	-0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
CEO ownership	-2.655	-4.959	-4.002	-3.755*	0.056
	(4.09)	(8.49)	(6.56)	(1.94)	(2.30)
Leverage	0.877	-3.949*	-0.866	4.619***	6.673***
	(0.59)	(2.10)	(1.19)	(1.19)	(1.34)
Firm size	-0.140	-0.192	-0.243	0.110	0.332**
	(0.10)	(0.25)	(0.15)	(0.15)	(0.13)
MTB	0.010	-0.016	-0.035	0.029	0.010
	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
Constant	3.579***	5.970	5.316***	-1.636	-3.014
	(1.32)	(3.82)	(1.89)	(2.56)	(2.05)
Observations	97	28	55	42	23
R^2	0.135	0.226	0.165	0.422	0.613
Adjusted R^2	0.077	0.005	0.061	0.323	0.468
F-statistics	1.243	4.549***	1.711	11.194***	17.466***

* p<0.10, ** p<0.05, *** p<0.010

Table 5.1: Impact of leverage on CEO incentive-risk relationship - Vega. Column one presents the results when using the full sample, while columns two and five look at firms with leverage below and above the 25th and 75th percentiles, respectively. Columns three and four include firms with below and above median leverage levels, respectively. Risk ratio is used as the dependent variable. The regression models are pooled OLS.

5.1.1. Moderating effect of leverage

The findings in the previous section suggest that leverage may be an important factor to take into consideration when evaluating the relationship between managerial incentives and risk. Increasing the amount of leverage is one way to increase risk (Coles et al., 2006; Berger et al., 1997). Still, more leverage might also entail other, potentially counteracting, effects. One area of research that seems to have received less attention is how firm leverage may influence the effects that option incentives have on managerial risk-taking (Kim et al., 2017). The ensuing section aims at examining this topic.

Similar to Kim et al. (2017), an interaction term between the option incentive variable and leverage is used to capture the effects of interest. Table 5.2 presents the results from running pooled OLS models that include this interaction term, varying the use of the option incentive variable. All the regression models suggest a moderating effect from leverage, that is, a negative coefficient estimate for the interaction term, and a positive association between option incentives and firm risk. The size of the coefficient estimates and their accompanying standard errors vary across models. When the *Option Portfolio Ratio* variable is used, the estimated results provide strong indications of a positive relationship between option incentives and firm risk as well the presence of a moderating effect from leverage that affects this relationship. The coefficient estimates are significant at the 5% and 1% levels, respectively. The coefficient estimates for newly granted options, for both vega and delta, are significant at the 10%-level.

The models include control variables commonly used in the literature, with CAPEX and R&D specifically added to improve comparability with analyses performed by Kim et al. (2017). The coefficient estimates for the control variables are generally in line with prior studies, with a strong positive relationship between firm leverage and risk across models, similar findings for R&D, and firm size negatively associated with risk (Coles et al., 2006; Armstrong and Vashishtha, 2012; Kim et al., 2017). For the market-to-book ratio and capital expenditures, the results are more mixed and not significant.

Splitting the effects of delta and vega into those from newly granted and the existing option portfolio provides improved comparability with for example the study done by Kim et al. (2017). The drawback for the sample used in this paper, however, is that the number of observations decreases from an already fairly low starting point for delta and vega. A clear trend across analyses is that using an alternative option incentive variable that has more observations, such as the *Option Portfolio Ratio* variable, improves the robustness of the results. The *Option Portfolio Ratio* variable is also interesting in that it captures the relative size of the CEOs' option portfolio value to that of their cash compensation. YU and Luu (2014) argue that the relative size of the compensation elements is important to understand the incentive dynamics at play, as the compensation elements provide incentives that can be working in opposite directions.

Comparing the findings to a study with closer geographic proximity, the results are also in alignment with Aas (2019). Using the same sample of firms as in this paper, he finds that including options as part of the CEO compensation package has a positive effect on idiosyncratic and total firm risk, with the relationship to idiosyncratic risk being significant. The findings from analyses that include the interaction term provide further support for a positive relationship between option incentives and firm risk, and for leverage seemingly having an impact on this relationship. The indications of a moderating effect from leverage are in line with those of Kim et al. (2017). They argue that the observed effect from leverage illustrates that there are other factors impacting how option incentives influence CEO risk-taking that need to be taken into account. As noted by several authors in the literature, the incentive effects of options on risk-averse managers can be nuanced, and options can in some instances also discourage risk-taking (Lambert et al., 1991; Carpenter, 2000; Lewellen, 2006).

	Risk Ratio						
	Vega NG	Vega EP	Vega	Delta NG	Delta EP	Delta	Option Portfolio Ratio
Option incentive	0.436*	0.056	0.105	0.219*	0.045	0.092	0.165**
	(0.25)	(0.2)	(0.18)	(0.12)	(0.20)	(0.14)	(0.08)
Option × Leverage	-0.768*	-0.119	-1.65	-0.618*	-0.220	-0.290	-0.366**
	(0.43)	(0.36)	(0.32)	(0.31)	(0.41)	(0.32)	(0.16)
Cash compensation	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	0.000*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Leverage	9.188**	1.789	2.619	7.819**	2.785	3.913	1.827***
	(4.40)	(3.51)	(3.26)	(3.27)	(4.10)	(3.36)	(0.40)
Firm size	-0.087	-0.135	-0.131	-0.062	-0.122	-0.120	-0.291***
	(0.09)	(0.11)	(0.09)	(0.10)	(0.11)	(0.09)	(0.05)
MTB	-0.003	0.000	-0.000	-0.003	0.001	0.00	-0.027
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
CAPEX	-0.739	0.624	0.433	-0.781	0.640	0.494	0.722
	(2.19)	(1.36)	(1.27)	(1.99)	(1.35)	(1.27)	(0.63)
R&D	9.438***	3.628*	5.140**	7.353***	3.460**	4.941***	-1.484
	(1.93)	(2.11)	(1.93)	(1.58)	(1.64)	(1.74)	(3.12)
Constant	-1.701	3.143	2.467	-0.083	3.014	2.317	5.171***
	(2.67)	(3.00)	(2.61)	(1.79)	(3.02)	(2.29)	(0.74)
Observations	56	86	104	56	86	104	336
R^2	0.332	0.123	0.152	0.330	0.134	0.162	0.171
Adjusted R^2	0.219	0.032	0.081	0.216	0.044	0.092	0.151
F-statistics	5.423***	1.943*	2.459**	6.753***	2.116*	2.525**	10.317***

* p<0.10, ** p<0.05, *** p<0.010

Table 5.2: Moderating effect of leverage.
Variables for the newly granted options (columns one and four), the existing option portfolio (columns two and five), and the total option portfolio of the CEO (newly granted plus existing portfolio, columns three and six), are included for both vega and delta. The results from using the *Option Portfolio Ratio* variable are shown in column seven. *Risk Ratio* is the dependent variable. The regression models are pooled OLS.

5.1.2. Impact of CEO stock ownership

There is literature pointing to managerial stock ownership having non-linear effects on risk-taking, where high levels of ownership can lead to managerial entrenchment while incentive effects inducing risk-taking can be present at lower levels of ownership (Frank and Goyal, 2007; Kim and Lu, 2011). Various analyses have been performed to explore whether indications of such effects might be present for the sample firms. No clear indications were found when analyzing sub-samples varying the level of the *CEO ownership* variable.

Supplemental analyses have been performed with an alternative variable, *Salary-to-Stock ratio*, aimed at capturing incentive effects from CEO stock ownership.[34] This variable captures the relative size of the CEO's salary to that of her/his stock ownership value. Results from regression models where firm leverage is used as dependent variable are presented in Table F.4 in Appendix F. A significant positive association between the *Salary-to-Stock ratio* and firm leverage is found for CEOs with high levels of salary compensation to stock ownership (above median and above 75th percentiles). The results are, however, not clear for CEOs with a lower value for the *Salary-to-Stock ratio* (below median and below 25th percentile). This may indicate some support for leverage being used as a lever for risk-taking among CEOs that are less likely to be entrenched. However, it might be the case that firms with higher levels of leverage adjust the compensation package, for example by increasing salary, to induce CEO behaviour, as suggested by Lin et al. (2019). Gray and Cannella (1997) note that having a large equity ownership stake entails greater personal risk for a CEO and that this can impact the effects from other compensation incentives. A parallel could be drawn to the moderating effect found from leverage on option incentives. The findings also provide some evidence that CEO option incentives seem to have a stronger effect on firm leverage than those of CEO stock ownership for the sample firms. This is what Birkeland et al. (2011) found to be the case when studying the incentives effects from stocks and options on capital structure choices for Nordic firms. Further research on how CEO stock ownership influences other risk-taking incentives could be interesting and help provide a more clear picture of the relationships in a Norwegian context.

5.1.3. Robustness measures

A series of robustness tests have been performed for the analyses presented. Across analyses, using panel data methods provide similar directional results. The coefficient estimates and standard errors vary somewhat in magnitude, and the results when using *Option Portfolio Ratio* as the option incentive variable provide more robust results than those using delta in particular. Table F.3 in Appendix F shows an example of running quantile regressions, using *Option Portfolio Ratio* as the option incentive variable. Strong support for a positive relationship between options and risk as well as a moderating effect of leverage is found for the 25th, 50th, and 75th percentiles. The results for the two most extreme quantiles (10th and 90th) are showing the same coefficient signs but are weaker in strength.

An important finding across the various analyses performed on the sample is that vega

[34]Inspiration for using this variable is taken from Milidonis and Stathopoulos (2014).

appears to yield more robust coefficient estimations and indications of a positive association with risk, compared to that of delta. This is consistent with previous research (Chava and Purnanandam, 2010; Hayes et al., 2012; Milidonis and Stathopoulos, 2014). Being tied to stock return volatility, vega provides a more direct way of capturing firm risk. It also appears to be the preferred variable used in the literature to capture such effects (Coles et al., 2006; Milidonis and Stathopoulos, 2014). Some studies analyze delta and vega separately, while others look at their joint effect or explore both of these alternative approaches. While the tables presented in this paper mainly look at the variables separately, analyses have also been performed looking at delta and vega jointly. Column three of Table 5.3, covered in Section 5.2, provides an example. The findings illustrate the coefficient sensitivity for the delta variable that appears in some models, with the coefficient sign for delta turning negative when vega is included in the same model. Note that for this model, the interaction term between options and leverage is excluded. The coefficient estimates are not significant at any level.

The coefficient estimates for vega and delta show higher sensitivities to model specifications (including choice of control variables), compared to that of incentive variables with more observations. This is particularly prominent when splitting the effects into those from newly granted options and the existing portfolio, that is, when reducing the sample sizes. When using alternative periodization of stock return volatility, the results for both vega and delta show some inconsistencies for the magnitude of the standard errors and coefficient estimates, as well as the coefficient signs. Consistent results across models are found when using *Option Portfolio Ratio*. Winsorizing outliers at the 5th and 95th percentiles instead of the 1st and 99th percentiles does not materially impact the results.

5.2. CEO characteristics and risk aversion

The various incentives awarded to CEOs aimed at influencing risk-taking are not expected to have the same effect for every manager. Differences in risk preferences among the CEOs is one important factor as to why this might be the case (Chava and Purnanandam, 2010; Lefebvre and Vieider, 2014). An interesting area of research focuses on managerial characteristics, aimed at helping understand why the behaviour and choices made differ amongst managers (Frank and Goyal, 2007; YU and Luu, 2014). CEO characteristics such as gender, age, and tenure may affect risk preferences and arguments have been made that the compensation package should take this into account to reduce agency costs between the owners and managers of the firm (YU and Luu, 2014). In this section, the effects of selected CEO characteristics are analyzed for the sample in an attempt to explore whether they can support the understanding of the relationship between incentives provided to the CEOs and risk-taking.

5.2.1. Gender

Table 5.3 presents the results from running regression models that include the CEO characteristics gender, tenure, and age. Looking at the effects of CEO gender, a positive relationship with risk is the main finding across models, although not significant, suggesting that firms led by male CEOs may be associated with higher risk.[35] Using vega as the option incentive variable, untabulated quantile regression results show an increasingly negative (positive) relationship between CEO gender and risk for lower (higher) percentiles of the dependent variable. For the 10th and 90th percentiles, the coefficient estimates are significant at the 10% level and 5% level respectively, supporting the results of female CEOs being associated with lower risk firms in the sample.

Studies suggest that females appear to be, and are perceived as, more risk-averse than males (Martin et al., 2009; Charness and Gneezy, 2012). One way in which this appears in a corporate setting is that female-led firms tend to have lower levels of leverage than male-led firms (Faccio et al., 2016). This also seems to be the case for the sample. In untabulated results, using leverage as the dependent variable, a significant positive relationship between male CEOs and leverage is found.[36] Khan and Vieito (2013) find, however, that gender differences in risk aversion do not seem to be taken into account by the board of directors when designing compensation packages. As noted in Section 3.3, the gender distribution in the sample is highly skewed, with female CEOs accounting for only 4.25% of the observations. While this is higher than some studies performed on US firms, a key difference and notable challenge is that the 4.25% is low in absolute terms, only amounting to 18 total observations. The findings need to be interpreted with this in mind.

5.2.2. Tenure

One characteristic that is commonly used in the literature as a proxy for CEO risk aversion is tenure.[37] From Table 5.3, a negative association between CEO tenure and risk is estimated. This is in line with much of the previous research (Coles et al., 2006; Armstrong and Vashishtha, 2012; Belghitar and Clark, 2012). The findings are strengthened across robustness measures and stands out as the CEO characteristic with the most robust findings for the sample. The effects of tenure might not be unambiguous, however, with Chen and Zheng (2014) finding a positive association between tenure and risk-taking, seemingly caused by a decline in CEO career concerns outweighing the effects of additional experience.

Frank and Goyal (2007) find that CEOs with longer tenures are associated with lower firm leverage. Berger et al. (1997) present similar findings when using the market value of leverage, but emphasize that there might be several interpretations available. It might for example be due to managerial entrenchment, where CEOs try to avoid the associated costs of a higher levered capital structure. YU and Luu (2014) propose that stock options are more commonly granted to CEOs with low tenure than for CEOs with higher tenures, where the CEOs have had more time to prove their abilities. In untabulated results, indications of a non-linear relationship between CEO option incentives and tenure is found, in line with YU and Luu (2014).[38] The estimated coefficients are relatively small and the results only seem to hold when using *Option Portfolio Ratio* to capture option incentive effects.

[35] The *CEO gender* variable is a dummy variable, when *CEO gender* = 1 the CEO is a male.
[36] Quantile regressions provide significant results at the 1% level for all but the 10th (lowest) percentile.
[37] See for example Coles et al. (2006), Frank and Goyal (2007), and Armstrong and Vashishtha (2012).
[38] Similar to YU and Luu (2014) a squared term for CEO tenure has been used to capture nonlinearities.

5.2.3. Age

CEO age is another characteristic that is used as a risk aversion proxy in the literature, where older CEOs often are assumed to take less risk than younger CEOs (Milidonis and Stathopoulos, 2014; Serfling, 2014; YU and Luu, 2014). The main finding across analyses examining CEO age is that adding a squared term, aimed at capturing nonlinearities, improves the robustness of the coefficient estimates. Table F.5 in Appendix F shows a significant negatively estimated relationship between CEO age and risk, seemingly consistent with previous studies.

Several possible explanations of the effects of CEO age are discussed in the literature. Anderson et al. (2000) point out that for older executives, more time has passed to learn about their performance and abilities, which could reduce the agency costs and thus lead to less use of equity-based incentives than for younger managers. It could be the case that firms adjust the compensation package of older CEOs to account for the higher levels of risk aversion. Another explanation could be, as Gray and Cannella (1997) point out, that more senior CEOs have a larger influence on the firm's board of directors, and hence are able to impact the decisions concerning their compensation to match their own preference.

5.2.4. Cash compensation as a risk proxy

In addition to variables capturing CEO characteristics directly, CEO cash compensation is frequently used as a proxy for risk aversion (Coles et al., 2006; Armstrong and Vashishtha, 2012; Milidonis and Stathopoulos, 2014). The proxy is also used in this paper to supplement CEO characteristics as a potential factor impacting risk-taking dynamics for the sample firms. Managerial entrenchment is an often cited reason for including cash compensation and CEO tenure, where CEOs having a higher share of cash compensation and a longer tenure with the firm expected to more be entrenched, and hence, more risk-averse (Berger et al., 1997; Coles et al., 2006; Milidonis and Stathopoulos, 2014).

Mixed evidence is found for the cash compensation variable. The coefficient estimates are small across models and the direction of the coefficient signs are inconclusive. The literature points to effects in different directions and highlights that alternative interpretations can be made (Coles et al., 2006). The negatively estimated association with risk when using delta and vega as option incentive variables, reported in Table 5.3, is similar to Milidonis and Stathopoulos (2014) and YU and Luu (2014). The latter find that CEOs with a high share of cash- to total compensation tend to invest in projects that are less risky. On the other hand, Armstrong and Vashishtha (2012) present the perspective that CEOs have more opportunities to diversify their portfolio with higher cash compensation, which could lead to them being less risk-averse.

The main findings related to the relationship between option incentives and firm risk as well as the moderating effect from leverage do not appear to change after including CEO characteristics and risk aversion proxies to the regression models. The inclusion of these variables might help reduce the potential for omitted variables or relationships not captured by the models, such as that of managerial self-selection (Milidonis and Stathopoulos, 2014).

	Risk Ratio			
	Vega	Delta	Vega and delta	Option Portf. Ratio
CEO gender	0.369	0.237	0.781	0.571
	(1.13)	(1.19)	(1.16)	(0.40)
CEO tenure	-0.052*	-0.055*	-0.050*	-0.041**
	(0.03)	(0.03)	(0.03)	(0.02)
CEO age	0.015	0.015	0.012	0.011
	(0.02)	(0.02)	(0.02)	(0.02)
Cash compensation	-0.000	-0.000	-0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)
CEO ownership	-0.931	-0.407	-1.062	1.024
	(2.77)	(2.76)	(2.70)	(0.78)
Vega	0.107		0.062	
	(0.17)		(0.05)	
Delta		0.182	-0.083	
		(0.18)	(0.09)	
Option Portf. Ratio				0.117*
				(0.06)
Option × Leverage	-0.129	-0.394		-0.303**
	(0.29)	(0.32)		(0.14)
Leverage	2.377	5.075	1.065**	1.636***
	(2.88)	(3.28)	(0.45)	(0.39)
Firm size	-0.155**	-0.140*	-0.145*	-0.243***
	(0.07)	(0.08)	(0.07)	(0.05)
Constant	2.118	1.177	2.968*	3.713***
	(2.22)	(2.20)	(1.60)	(1.01)
Observations	96	96	96	312
R^2	0.163	0.170	0.169	0.163
Adjusted R^2	0.075	0.083	0.082	0.138
F-statistics	1.859*	1.953*	1.940*	6.064***

* p<0.10, ** p<0.05, *** p<0.010

Table 5.3: CEO characteristics and risk aversion proxies.
Vega and delta are used as option incentive variables in columns one and two, respectively. In column three, they are both included in the same model. *Option Portfolio Ratio* is used as the option incentive variable in column four. *Risk Ratio* is the dependent variable for all the models. The regression models are pooled OLS.

5.3. Sector analyses

To assess potential differences across the sectors in the sample, analyses have been performed separating the sample firms into their respective sectors from the 11 possibilities presented in Section 3. The number of observations available for the vega and delta variables are constraining factors when performing these sub-sample analyses. It has therefore been necessary to primarily use alternative variables aimed at capturing option incentives.[39]

Table 5.4 presents the results from running a pooled OLS model with *Option Portfolio Ratio* as the option incentive variable.[40] The signs and magnitudes for both the option variable and the interaction term between option incentive and leverage vary across sectors. Health Care, Finance, and Consumer Goods all show significant negative associations between option incentives and risk, whereas the Information Technology sector is the only sector providing a significant positive estimated relationship.

As discussed in Section 3.3, the distribution of observations across sectors is fairly imbalanced. Energy, Industrials, and Information Technology are the three largest sectors, measured by the number of observations, and the estimated effects from these sectors are expected to have a relatively large impact on the results for the full sample. Of the three, only the Industrials sector has a negative coefficient estimate for the option variable. The standard error exceeds the option variable coefficient estimate in magnitude for both the Industrials and the Energy sector. With the analyses presented earlier in the paper pointing to a positive association between option incentives and firm risk, it is not unexpected that the main effect from these three sectors would be in directional alignment with those analyses.

Sub-sample sector or industry analyses covering the topics of interest in this paper do not seem to be extensively studied in the literature. That being said, the study by Rajgopal and Shevlin (2002) targeting a sample of oil and gas producers is one such example. They point out that managerial self-selection issues might be less prominent for this type of analysis, as managers with comparable risk preferences might also choose to work in the same industries. A potential drawback of focusing on a single industry is that the generalizability of the findings can be more limited. This could be one reason why a number of previous studies focus on larger samples of firms across industries. Managerial incentives and the use of specific compensation elements likely differ across sectors (Kim et al., 2017). To account for this, a common approach is to control for industry fixed effects in panel estimations. Some studies include indicator variables targeting selected industries, such as technology firms (Hayes et al., 2012; Kim et al., 2017) or separate firms into high- or low-risk industries (Milidonis and Stathopoulos, 2014), while some exclude selected sectors, such as utilities and financial services firms (Coles et al., 2006).

[39] Furthermore, for selected sectors where the number of observations is particularly constraining, there is a need for simpler models using fewer explanatory variables. Trade-offs related to model complexity have been important for this set of analyses.

[40] The Communication Services, Real Estate, and Utilities sectors are excluded due to having an insufficient number of observations.

It is interesting to note that the Information Technology sector provides the strongest estimated results. A positive coefficient estimate for the option variable is shown in Table 5.4, significant at the 5% level. The sector is known for its considerable use of equity-based incentives to managers, in particular for firms in the United States (Anderson et al., 2000). The Information Technology sector has the largest number of delta and vega observations in the sample, indicating relatively more extensive use of options as an incentive mechanism also for Norwegian IT firms. Lambert et al. (1991) and Anderson et al. (2000) discuss how the perspective of managerial self-selection could also be relevant in this context, where CEOs choose which sectors to work in based on their risk preferences. It could be the case that less risk-averse managers want to work in sectors that are riskier or that are known for more extensive use of equity-based incentives, such as the IT sector.

The three largest sectors in the sample (Energy, Industrials, and IT) have a sufficient number of observations for the delta and vega incentive variables to perform analyses using these. No notable new insights were found. For both vega and delta, a positive coefficient for the option incentive variable and a negative coefficient for the interaction term between option incentive and leverage are estimated. However, the coefficient estimates vary in magnitude and relative size compared to their standard errors, with the Information Technology sector showing the most robust results also here.

The results presented in this section could help highlight some particularities with the Norwegian context. The firms in the sample are fairly concentrated within the three largest sectors, of which one is particularly known for the use of equity-based incentives (Information Technology) and one has the highest firm risk measured in the sample (Energy). It is important to keep in mind the size of the sector sub-samples when interpreting the results presented in this section, with some sectors having relatively low sample sizes.

	Risk Ratio							
	Cons. Goods	Cons. Staples	Energy	Finance	Health Care	Industri.	Info. Tech.	Materials
Option Portf. Ratio	-7.890***	-1.216	0.236	-2.478*	-0.422*	-2.235	0.233**	6.030
	(2.00)	(3.69)	(0.49)	(1.40)	(0.20)	(2.37)	(0.09)	(6.96)
Option × Leverage	11.646***	2.135	-1.151	4.005	5.818**	3.328	-0.488**	-11.782
	(2.86)	(6.53)	(1.32)	(2.31)	(2.47)	(2.85)	(0.21)	(13.14)
Cash compensation	-0.000**	-0.000	-0.000	0.000	0.000***	0.000***	0.000*	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
CEO ownership	0.055	-0.560	1.148	-3.310	59.987	-2.189**	-4.143*	-1.526
	(5.84)	(0.52)	(1.87)	(14.23)	(38.94)	(0.91)	(2.40)	(2.91)
CEO tenure	-0.015	0.003	-0.051*	-0.018	-0.007	-0.028	-0.056	-0.199*
	(0.02)	(0.02)	(0.03)	(0.03)	(0.04)	(0.04)	(0.06)	(0.10)
Leverage	-0.313	0.718	1.753**	-0.082	0.182	3.874***	1.405	2.314*
	(0.54)	(2.63)	(0.79)	(0.68)	(0.82)	(1.42)	(1.16)	(1.28)
Firm size	0.512***	-0.041	-0.275***	-0.016	-0.520**	-0.883***	-0.266**	-0.408*
	(0.15)	(0.14)	(0.10)	(0.08)	(0.17)	(0.25)	(0.12)	(0.22)
MTB	-0.180**	-0.095	-0.026	0.134***	-0.143**	-0.389***	-0.002	0.219
	(0.06)	(0.12)	(0.02)	(0.02)	(0.06)	(0.13)	(0.03)	0.36
Constant	-5.448**	2.238	6.073***	1.483	6.463**	13.785***	4.773***	8.061**
	(1.97)	(2.77)	(1.55)	(0.95)	(2.00)	(3.57)	(1.64)	(2.91)
Observations	19	22	73	25	18	71	44	20
R^2	0.827	0.452	0.241	0.830	0.875	0.318	0.277	0.668
Adjusted R^2	0.689	0.115	0.146	0.745	0.764	0.230	0.111	0.427
F-statistics	14.285***	2.329*	8.884***	9.786**	7.866***	3.159***	2.762**	4.471***

* p<0.10, ** p<0.05, *** p<0.010

Table 5.4: Sector sub-samples.
The following sectors are included, listed in their respective order: Consumer Goods, Consumer Staples, Energy, Finance, Health Care, Industrials, Information Technology, and Materials. All models use *Risk Ratio* as the dependent variable and *Option Portfolio Ratio* as the option incentive variable. The regression models are pooled OLS.

5.4. Additional robustness measures

To conclude this section, selected additional robustness measures are addressed, supplementing those discussed when presenting the results. The aim is to further discuss potential weaknesses and the validity of the results. Specifically, the topics covered are the choice of risk proxies and the periodization of stock return volatility.

Two main risk proxies have been analyzed on the sample. First is the *Risk Ratio* variable that includes the effect of sector risk. The other is the annualized standard deviation of log returns (*Firm risk)*, that is, the numerator of the *Risk Ratio* variable. The use of historical stock return volatility as a proxy for risk can be limiting, as this measure is likely to also capture risk factors not directly related to that of the CEO's actions (Kim et al., 2017). Further research may include other risk proxies that are used in the literature, such as asset volatility, earnings volatility, or R&D expenditure (Im et al., 2020; Hayes et al., 2012; YU and Luu, 2014; Kim et al., 2017). Firm volatility could also be decomposed, using for example factor models, as discussed in Section 3.2.1.

The main choice of periodization for the risk proxies is presented in Section 3.2.1. Both historical volatility and volatility of future returns appear to be used when constructing risk proxies in the literature (Williams and Rao, 2006; Armstrong and Vashishtha, 2012; Hayes et al., 2012; Kim et al., 2017). Similar to for example (Kim et al., 2017), different periodizations have been tested to improve the robustness of the findings. Specifically, one- and two year periods following the fiscal years analyzed in the sample are tested in addition to the main 24-month periodization.[41]

Table F.6 in Appendix F shows the results from running the same regression model as in column one of Table 5.1 from Section 5.1. Using vega as the incentive variable, the main volatility periodization is compared with using the one- and two-year alternatives. Furthermore, *Firm risk* is used as risk proxy instead of *Risk Ratio*, excluding the effects from sector volatility. The results from running a random-effects regression model using the main periodization are also included for reference and as an example of assessing robustness along several dimensions, by varying the volatility periodization, risk proxy, and regression method used for the analysis. The results indicate that the estimated relationship between vega and risk for this model is not clear. For all the alternative periodization and for the random-effects model, the size of the coefficients is small and the standard errors are relatively large. Similar results are found when using delta as the incentive variable. This provides an example of how regression models using delta and vega show higher sensitivities to model specifications for the simpler models analyzed, as discussed in Section 5.1.3. The simpler model specifications tested, such as those that exclude the effects of leverage, the interaction term between leverage and options, and CEO characteristics, do not seem to do as good of a job in capturing the relationships of interest when using vega and delta.

[41] The data set contains incentives data until 2016, and stock price data was available until 2018 in TITLON (inclusive), hence restricting periodizations of more than two years after the fiscal year in which incentives data are available.

6. Conclusion

This thesis explores the topics of executive incentives, capital structure, and risk. The topics have received notable interest in the literature, there are, however, fewer studies that look at the Norwegian context while also including the two well-known proxies for CEO risk-taking incentives, vega and delta. Particular emphasis is placed on how firm leverage impacts the relationship between option incentives and risk, which is an area of the literature that seems to have received less attention.

Econometric methods are applied to a sample of Norwegian listed firms structured as a panel, covering the years 2012, 2014, and 2016. In line with previous research, the findings suggest a positive relationship between option incentives and risk for the sample. The most robust results are found when using the *Option Portfolio Ratio* variable, capturing the relative size of the option portfolio value to cash compensation. The results further indicate that leverage could be an important factor affecting the relationship between CEO incentives and risk-taking. Notably, a moderating effect of leverage on risk-taking incentives provided by option incentives is found for the sample firms, suggesting a weaker incentive effect from options for higher levels of firm leverage.

Differences in CEO risk preferences are an important factor expected to influence the incentive effects arising from compensation elements provided to the CEOs. Analyses that include CEO characteristics and risk aversion proxies are performed, aimed at understanding why the behaviour and choices of CEOs may differ. Tenure is the characteristic with the most robust results, showing a negative relationship with risk. Some support is found for firms led by male CEOs being associated with higher risk.

The sample reflects some of the particularities with the Norwegian context, where the three largest sectors (Energy, Industrials, and Information Technology) account for 59.4% of the sample observations. Sub-sample analyses indicate that there exist differences across sectors for the relationships of interest. The Information Technology sector, known for its use of equity-based incentives, provides the strongest results, and they are in line with those of the sample as a whole. The findings in this paper are not interpreted as causal effects, however, they provide a foundation for further research in a Norwegian context.

A concern when studying the topics of executive incentives, capital structure, and risk is that of endogeneity. One way in which the issue may arise is the expectation that capital structure decisions and the compensation incentives granted to the CEO are related and not determined independently from each other (Chava and Purnanandam, 2010; Armstrong and Vashishtha, 2012; Kim et al., 2017).[42] Endogeneity is a recurring topic covered in related literature and several possible approaches are used in attempts of addressing endogeneity issues and estimate causal relationships (Chava and Purnanandam, 2010). Approaches include utilizing exogenous shocks (Kim et al., 2017) or changes in regulation (Chava and Purnanandam, 2010) as well as applying methods such as the instrumental variable approach and simultaneous equations models.[43] The use of lagged values for the

[42]It could, for example, be the case that CEOs make debt-related choices on behalf of the firm taking into consideration the structure of their own compensation package (Kim et al., 2017).

[43]For examples of the two latter methods, see for example: Coles et al. (2006), Armstrong and Vashishtha (2012), and Rajgopal and Shevlin (2002).

incentive variables as well as firm fixed effects and year effects are also used (Coles et al., 2006; Milidonis and Stathopoulos, 2014). For the analyses presented in this paper, endogeneity issues could cause the parameter estimates to become biased and inconsistent (Wooldridge, 2013). While the availability of CEO option data and the limited sample size provide some challenges for using certain approaches, exploring this topic in more detail will likely provide further insights.

There are several potentially interesting areas for further research. The empirical methods applied in this paper are relatively simple, in parts due to the size of the sample. There could be alternative model specifications and estimation methods available that might do a better job of capturing the relationships of interest. Furthermore, methods such as the aforementioned simultaneous equations models and instrumental variable approach could potentially help address endogeneity-related concerns. Including alternative proxies for risk and increasing the size of the sample by collecting additional compensation data could also help validate the findings. In terms of focus, exploring the topics of risk preferences and CEO characteristics as well as looking at alternative levers to financial policies for risk-taking, such as investment decisions, both appear compelling.

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A. List of sample firms

Ticker	Company name	Ticker	Company name	Ticker	Company name
AFG	AF Gruppen	GSF	Grieg Seafood	PLCS	Polarcus
AFK	Arendals Fossekompani	GYL	Gyldendal	POL	Polaris Media
AKA	Akastor	HAVI	Havila Shipping	PROTCT	Protector Forsikring
AKERBP	Aker BP	HEX	Hexagon Composites	PRS	Prosafe SE
AKSO	Aker Solutions	HYARD	Havyard Group	QFR	Q-Free
AKVA	AKVA Group	IMSK	I.M. Skaugen	REACH	Reach Subsea
AMSC	American Shipping Company	INSR	Insr Insurance Group	REC	REC Silicon
APP	Apptix	IOX	Interoil Exploration and	RENO	RenoNorden
AQUA	AqualisBraemar	ITE	Itera	RISH	GC Rieber Shipping
ARCUS	Arcus	JIN	Jinhui Shipping and Transportation	SAFE	Saferoad Holding
ASC	ABG Sundal Collier	KID	KID	SALM	SalMar
ATEA	Atea	KIT	Kitron	SAS NOK	SAS NOK
ATLA NOK	Atlantic Petroleum	KOA	Kongsberg Automotive	SBANK	Sbanken (Formerly: Skandiabanken)
AUSS	Austevoll Seafood	KOG	Kongsberg Gruppen	SBO	Selvaag Bolig
AVM	Avocet Mining	KVAER	Kværner	SCANA	Scana (Formerly: Incus Investor)
AXA	Axactor SE	LINK	Link Mobility Group	SCH	Schibsted
B2H	B2Holding	LSG	Lerøy Seafood Group	SDSD	S.D. Standard Drilling
BAKKA	Bakkafrost	MGN	Magnora (Formerly: Sevan Marine)	SEVDR	Sevan Drilling
BEL	Belships	MEDI	Medistim	SIOFF	Siem Offshore
BERGEN	Bergen Group	MHG	Mowi	SKI	Skiens Aktiemølle
BGBIO	BerGenBio	MULTI	Multiconsult	SOFF	Solstad Offshore
BIOTEC	Biotec Pharmacon	NANO	Nordic Nanovector	SOLON	Solon Eiendom
BLO	NRC Group (Formerly: Blom)	NAPA	Napatech	SOLV	Solvang
BMA	Byggma	NAS	Norwegian Air Shuttle	SONG	Songa Offshore
BOR	Borgestad	NAVA	Navamedic	SPU	Spectrum
BOUVET	Bouvet	NEL	NEL	SRBANK	SpareBank 1 SR-Bank
BRG	Borregaard	NEXT	Next Biometrics Group	SSC	The Scottish Salmon Company
COV	ContextVision	NGT	NextGenTel Holding	SSO	Scatec Solar
CXENSE	Cxense	NHY	Norsk Hydro	STB	Storebrand
DAT	Data Respons	NKR	Nekkar (Formerly: TTS Group)	STRONG	StrongPoint
DNB	DNB	NOD	Nordic Semiconductor	SUBC	Subsea 7 SA
DNO	DNO	NOFI	Norwegian Finans Holding	TEAM	Team Tankers International
DOF	DOF	NOR	Norwegian Energy Company	TECH	Techstep
EIOF	Eidesvik Offshore	NPRO	Norwegian Property	TEL	Telenor
EKO	Ekornes	NRS	Norway Royal Salmon	TGS	TGS-NOPEC Geophysical Company
ELE	Element (Formerly: Intex Resources)	NSG	Norske Skog	THIN	Thin Film Electronics
EMGS	Electromagnetic Geoservices	NTS	NTS	TOM	Tomra Systems
ENTRA	Entra	OCY	Ocean Yield	TRVX	Targovax
EPR	Europris	ODF	Odfjell	VEI	Veidekke
EQNR	Equinor (Formerly: Statoil)	ODL	Odfjell Drilling Ltd	VVL	Voss Veksel- og Landmandsbank
EVRY	EVRY	OLT	Olav Thon Eiendomsselskap	WALWIL	Wallenius Wilhelmsen Logistics
FJORD	Fjord1	OPERA	Otello (Formerly: Opera Software)	WEIFA	Weifa
FLNG	FLEX LNG	ORK	Orkla	WILS	Wilson
FOE	Fred. Olsen Energy	OTS	Oceanteam	WWI	Wilh. Wilhelmsen Holding
FUNCOM	Funcom	PARB	Pareto Bank	XXL	XXL
GIG	Gaming Innovation Group	PEN	Panoro Energy	YAR	Yara International
GJF	Gjensidige Forsikring	PGS	PGS	ZAL	Zalaris
GOD	Goodtech	PHO	Photocure		

Figure A.1: Sample firms.

B. Calculation of delta and vega

In their paper, Core and Guay (2002) presents a method to estimate the sensitivities of CEO wealth to changes in stock price (delta) and stock volatility (vega). The method is based upon the Black and Scholes (1973) option pricing model, with adjustments made for dividends as presented by Merton (1973). The option value is then given by Equation B.1.

$$Option\ value = Se^{-dT}N(d1) - Ke^{-rT}N(d2), \tag{B.1}$$

where d1 and d2 are defined as

$$d1 = \frac{(ln(S/K) + T(r - d + \sigma^2/2)}{\sigma\sqrt{T}},$$

$$and\ d2 = d1 - \sigma\sqrt{T}$$

The parameter notation, taken from Hull (2012), is the following:
C = Option value.
S = Stock price of the underlying.
N = Function for the cumulative probability distribution of a standardized normal distribution.[44]
N' = Normal density function.
K = Option strike price.
σ = Stock return volatility.
r = Risk-free interest rate.
T = Time to maturity for the option, measured in years.
d = Dividend yield.

Delta is then defined by Core and Guay (2002) as:

$$\frac{\partial C}{S} \times \frac{S}{100} = e^{-dT}N(d1) \times \frac{S}{100} \tag{B.2}$$

While vega is defined as:

$$\frac{\partial C}{\sigma} \times (0.01) = e^{-dT}N'(d1)S\sqrt{T} \times (0.01) \tag{B.3}$$

The final delta and vega variables used in the empirical analysis are then constructed by scaling the obtained values from Equations B.2 and B.3 with the size of the CEO's option portfolio. That is, by multiplying with the number of options in the CEO's portfolio. A separation between newly granted options, the existing option portfolio, and the sum of the two (total option portfolio) is made, and variables for all these three categories are

[44] As part of calculating delta and vega, the cumulative normal distribution function is needed. In Microsoft Excel this can be implemented with the NORMDIST function Hull (2012, p. 315).

created for both delta and vega. Vega represents the NOK change in value of the CEO's option portfolio for a 0.01 change in the standard deviation of the firm's stock returns, while delta represents the NOK change in value of the CEO's option portfolio for 1% change in the firm's stock price.

It is common to use the change in equity portfolio value, combining stocks and options, for delta, while for vega only the change in option portfolio values is measured. This is argued by stock vega usually being much lower than option vega (Coles et al., 2006). This paper uses the change in option portfolio value for both delta and vega. For the delta variable, this differs from previous research and is due to the manual data collection effort being focused on option data as well as the primary focus being on the vega variable.

The option portfolio can be divided into two components, the first is newly granted options during the year and the second is the existing portfolio of unexercised options that are held by the CEO. Data for newly granted options is usually readily available in company filings for that fiscal year, while an approximation method presented by Core and Guay (2002) is used in the literature for estimating selected parameters for the existing portfolio. The motivation for the latter is that delta and vega variables can be constructed much easier than having to go through many years of data to get all information on the CEOs' option portfolios, while still providing accurate estimations of the incentive variables (Core and Guay, 2002). Not all of their assumptions were easily replicated or as applicable to the sample used in this paper. In particular, the time to maturity and exercise price for the existing portfolio of unexercised options are the two core parameters to be estimated. The remaining parameters (stock price, volatility, risk-free interest, and dividend yield) are similar for both the newly granted and unexercised options.

For the assumptions related to exercise price approximation, the data granularity needed to replicate the method of Core and Guay (2002) was not as easily available for the sample used in this paper (hand-collected data). For the ExecuComp database often used in previous studies, variables are defined separating unexercised unexercisable options and unexercised exercisable options. After a trade-off between the accessibility of data, and the manual effort needed to collect the data, with that of additional value added, a decision was made to make a simplifying assumption. The alternative would be to spend significant time manually collecting the necessary data to get a detailed breakdown of the existing option portfolios for each of the years. The simplification made was to compute a value-weighted exercise price for the existing option portfolio based on the number of options granted and their respective exercise prices of newly granted options during the sample period. A drawback is that not all exercise prices for earlier (newly) granted options of the CEOs were collected, only for the years fiscal years 2012, 2014, and 2016. In some cases, a complete overview of the CEO option portfolio was reported by the firm.

Core and Guay (2002) found that most firms granted new options with a time-to-maturity of ten years. The average time-to-maturity for the options granted in this paper is 5.65 years. Therefore, some of the assumptions related to time-to-maturity were found to be less applicable. If newly granted options were awarded during the year, half of the time to maturity of these was used for the existing portfolio. With two-year gaps between fiscal years analyzed and an average time to maturity of 5.65 for the sample, this was deemed to be a better approximation than using the six (or nine) years of Core and Guay (2002) for exercisable (and unexercisable) unexercised options respectively. If no newly granted options were awarded during the year, the time-to-maturity of newly granted options from a previous period was used (adjusted for the time since that period).[45]

When collecting the option parameters used for the delta, vega, or Black-Scholes option pricing calculations, the parameters reported by the firms were used when available. The parameters used in the Black-Scholes model, and potentially other assumptions, were often available and sometimes accompanied with a fair value valuation of the CEO stock options. In cases where some of, or none, of the parameters were reported, the following data sources were used: historical volatility from the stock price data source TITLON (previous three years), stock price and dividend yield from company filings, risk-free interest rate from Norges Bank based on the maturity of the options (government bonds). Currency exchange rates were also sourced from Norges Bank when needed for companies operating with other currencies than NOK.

[45]For reference, Frank and Goyal (2007) provide a concise overview of the assumptions of the approximation method from Core and Guay (2002) for unexercised options.

C. Variable descriptions

Table C.1 presents a description of the variables used in the empirical analysis.

Variable	Description
Risk Ratio	Risk proxy. Stock return volatility divided by the relevant sector volatility, both measured as standard deviations of monthly logarithmic returns.
Firm risk	Risk proxy. Stock return volatility measured as standard deviations of monthly logarithmic returns.
Cash compensation	The sum of CEO salary and CEO bonus (NOK 1000).
(Option) Delta	Change in value (NOK) of the CEO's option portfolio from a 1% change in the underlying firm's stock price.
(Option) Vega	Change in value (NOK) of the CEO's option portfolio from a 0.01 change in the annualized standard deviation of the underlying firm's stock returns.
Option Portfolio Ratio	The end of year option portfolio value divided by cash compensation. The Black-Scholes option pricing model is applied to value the option portfolio.
CEO ownership	Stock ownership share of the CEO, measured by the number of shares owned by the CEO divided by the total number of outstanding shares.
Salary-to-Stock Ratio	CEO salary divided by the value of CEO stock holding at the end of the year.
CEO gender	Dummy variable capturing CEO gender. If CEO gender = 1, the gender is male.
CEO tenure	The number of years the CEO has had in the role.
CEO age	The age of the CEO measured in years.
Debt Ratio	Leverage proxy. Total debt divided by total assets (book values).
Firm size	Natural logarithm of the book value of total assets.
MTB	Market-to-book ratio. The market value of firm equity divided by the book value of equity.
CAPEX	Capital expenditures divided by total assets.
R&D	Research and development expenditures divided by total assets.
Total assets	Book value of total assets.

Table C.1: Variable descriptions.

D. Descriptive statistics - Risk proxies

Descriptive statistics for the two risk proxies, grouped by sector, are tabulated below. In Table D.1, annualized standard deviation of monthly log returns of the sample firms is used (*Firm risk)*, while Table D.2 uses the *Risk Ratio* variable.

Sector	N	Mean	Min	Max	SD	$25^{th}\%ile$	Median	$75^{th}\%ile$
Communication Services	6	0.209	0.124	0.367	0.093	0.139	0.176	0.270
Consumer Goods	19	0.294	0.190	0.608	0.100	0.213	0.285	0.334
Consumer Staples	27	0.307	0.179	0.591	0.115	0.211	0.298	0.400
Energy	99	0.579	0.165	2.626	0.410	0.304	0.478	0.663
Financials	33	0.360	0.102	1.677	0.320	0.201	0.247	0.340
Health Care	22	0.508	0.222	1.957	0.366	0.305	0.429	0.524
Industrials	77	0.439	0.164	1.613	0.288	0.259	0.341	0.513
Information Technology	51	0.457	0.153	1.275	0.270	0.268	0.355	0.612
Materials	23	0.496	0.038	1.247	0.304	0.238	0.368	0.746
Real Estate	11	0.190	0.125	0.288	0.059	0.133	0.175	0.228
Utilities	5	0.245	0.105	0.461	0.144	0.143	0.202	0.313
Total	373	0.446	0.038	2.626	0.320	0.246	0.337	0.548

Table D.1: Descriptive statistics for annualized stock return volatility of the firms in the sample (grouped by sector).

Sector	N	Mean	Min	Max	SD	$25^{th}\%ile$	Median	$75^{th}\%ile$
Communication Services	6	0.949	0.552	1.553	0.408	0.588	0.831	1.341
Consumer Goods	19	1.296	0.870	2.480	0.407	0.986	1.267	1.393
Consumer Staples	27	1.490	0.738	2.438	0.434	1.132	1.376	1.702
Energy	99	2.335	0.681	11.731	1.680	1.325	1.911	2.951
Financials	33	1.779	0.492	8.102	1.599	0.971	1.189	1.731
Health Care	22	1.724	0.733	6.789	1.270	1.010	1.434	1.817
Industrials	77	2.990	1.170	11.273	1.963	1.643	2.371	3.544
Information Technology	51	1.948	0.682	5.504	1.147	1.193	1.496	2.685
Materials	23	2.174	0.133	5.104	1.379	1.112	1.888	3.204
Real Estate	11	0.571	2.089	0.466	0.466	0.726	1.213	1.317
Utilities	5	1.773	0.720	3.617	1.142	1.120	1.335	2.073
Total	373	2.128	0.133	11.731	1.545	1.204	1.637	2.609

Table D.2: Descriptive statistics for the *Risk Ratio* variable (grouped by sector).

E. Correlations

Table E.1 shows the pairwise Pearson's correlations between the variables used in the empirical analysis. Correlations significant at a 5% level are marked with bold text.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Dependent variables																
(1) Risk Ratio	1															
(2) Firm risk	**0.891***	1														
	(0.000)															
Incentive variables																
(3) Cash compensation	-0.091	**-0.116***	1													
	(0.088)	(0.028)														
(4) Delta	-0.116	**-0.187***	**0.417***	1												
	(0.218)	(0.046)	(0.000)													
(5) Vega	-0.081	-0.143	**0.268***	**0.931***	1											
	(0.391)	(0.129)	(0.004)	(0.000)												
(6) Option Portfolio Ratio	0.005	0.042	-0.025	**0.454***	**0.214***	1										
	(0.927)	(0.435)	(0.626)	(0.000)	(0.021)											
(7) CEO ownership	0.063	-0.005	0.086	-0.050	0.012	-0.037	1									
	(0.258)	(0.930)	(0.114)	(0.611)	(0.905)	(0.497)										
(8) Salary-to-Stock	**0.181***	**0.194***	-0.022	-0.001	-0.045	-0.029	-0.035	1								
	(0.002)	(0.001)	(0.704)	(0.994)	(0.670)	(0.629)	(0.552)									
CEO characteristics																
(9) CEO gender	0.016	-0.008	**0.121***	0.064	0.039	0.040	0.047	-0.073	1							
	(0.761)	(0.885)	(0.016)	(0.486)	(0.673)	(0.435)	(0.385)	(0.216)								
(10) CEO tenure	**-0.119***	**-0.128***	-0.003	0.001	0.061	-0.010	**0.263***	-0.086	0.094	1						
	(0.022)	(0.014)	(0.951)	(0.994)	(0.508)	(0.846)	(0.000)	(0.145)	(0.053)							
(11) CEO age	-0.075	**-0.116***	0.079	0.132	0.149	0.027	-0.004	0.056	**0.117***	**0.287***	1					
	(0.157)	(0.027)	(0.122)	(0.163)	(0.113)	(0.602)	(0.948)	(0.345)	(0.018)	(0.000)						
Firm characteristics																
(12) Debt Ratio	**0.163***	**0.112***	0.059	-0.038	-0.025	**-0.167***	0.007	**0.152***	0.009	0.029	-0.040	1				
	(0.002)	(0.032)	(0.244)	(0.688)	(0.793)	(0.001)	(0.894)	(0.009)	(0.851)	(0.564)	(0.423)					
(13) Market-to-Book	-0.022	-0.022	0.009	0.089	0.055	**0.118***	-0.061	-0.052	0.009	0.063	0.036	-0.098	1			
	(0.684)	(0.680)	(0.859)	(0.355)	(0.567)	(0.028)	(0.268)	(0.376)	(0.862)	(0.234)	(0.502)	(0.063)				
(14) CAPEX	0.083	0.032	0.027	0.058	0.086	-0.050	0.073	0.045	0.035	-0.007	-0.008	**0.175***	-0.020	1		
	(0.110)	(0.546)	(0.595)	(0.531)	(0.352)	(0.340)	(0.178)	(0.448)	(0.486)	(0.888)	(0.880)	(0.000)	(0.708)			
(15) R&D	-0.022	0.014	-0.084	0.074	0.063	**0.418***	-0.028	-0.022	0.039	0.041	-0.008	**-0.219***	0.070	-0.055	1	
	(0.673)	(0.786)	(0.101)	(0.425)	(0.498)	(0.000)	(0.601)	(0.714)	(0.438)	(0.406)	(0.878)	(0.000)	(0.186)	(0.272)		
(16) Firm size	**-0.267***	**-0.321***	**0.514***	0.166	0.131	-0.091	-0.042	0.003	**0.128***	0.054	**0.120***	**0.267***	**-0.228***	0.054	**-0.192***	1
	(0.000)	(0.000)	(0.000)	(0.069)	(0.153)	(0.074)	(0.432)	(0.965)	(0.008)	(0.271)	(0.015)	(0.000)	(0.000)	(0.276)	(0.000)	

Table E.1: Pairwise Pearson's correlations.

F. Additional regressions

This section of the Appendix includes the supplemental regression tables referenced in Section 5.

In Tables F.1 and F.2, the results from running sub-sample regressions based on firm leverage are provided using delta and *Option Portfolio Ratio* as option incentive variables, respectively. The tables present Pooled OLS models using *Risk Ratio* as the dependent variable. In both tables, column one presents the results when using the full sample, while columns two and five looks at firms with leverage below and above the 25th and 75th percentiles, respectively. Columns three and four include firms with below and above median leverage levels, respectively.

	Risk Ratio				
	Sample	Below 25^{th} percentile	Below median	Above median	Above 75^{th} percentile
Delta	0.003	-0.029	0.058	-0.078	-0.424*
	(0.07)	(0.08)	(0.06)	(0.13)	(0.21)
Cash compensation	-0.000	0.000	0.000	-0.000***	-0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
CEO ownership	-2.499	-4.330	-4.071	-3.741*	-0.462
	(4.22)	(8.38)	(6.37)	(2.04)	(2.30)
Leverage	0.864	-4.010*	-0.925	4.613***	6.777***
	(0.58)	(2.15)	(1.15)	(1.18)	(1.45)
Firm size	-0.140	-0.183	-0.258*	0.116	0.321**
	(0.10)	(0.25)	(0.15)	(0.16)	(0.13)
MTB	0.010	-0.018	-0.040	0.029	0.017
	(0.02)	(0.04)	(0.02)	(0.03)	(0.02)
Constant	3.801***	5.593	5.182***	-1.478	-3.399
	(1.41)	(3.50)	(1.83)	(2.49)	(2.20)
Observations	97	28	55	42	23
R^2	0.129	0.221	0.168	0.425	0.607
Adjusted R^2	0.071	-0.002	0.064	0.326	0.460
F-statistics	0.983	5.157***	1.236	11.458***	10.159***

* p<0.10, ** p<0.05, *** p<0.010

Table F.1: Impact of leverage on CEO incentive-risk relationship - Delta.

	Risk Ratio				
	Sample	Below 25^{th} percentile	Below median	Above median	Above 75^{th} percentile
Option Portf. Ratio	0.027	0.064**	0.037	-0.085**	-0.119
	(0.03)	(0.03)	(0.03)	(0.04)	(0.36)
Cash compensation	0.000*	0.000	0.000***	-0.000	-0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
CEO ownership	0.335	7.238**	0.829	-0.374	-1.734
	(0.60)	(3.57)	(0.66)	(0.79)	(1.60)
Leverage	1.623***	-1.597	0.078	3.441***	3.039**
	(0.44)	(1.17)	(0.76)	(0.99)	(1.33)
Firm size	-0.278***	-0.149	-0.273***	-0.197***	-0.218**
	(0.05)	(0.10)	(0.08)	(0.06)	(0.09)
MTB	-0.025	-0.024	-0.034**	-0.016	-0.013
	(0.02)	(0.02)	(0.01)	(0.03)	(0.03)
Constant	5.101***	4.258***	5.473***	2.859***	3.620*
	(0.77)	(1.31)	(1.21)	(1.06)	(2.06)
Observations	312	76	162	150	67
R^2	0.135	0.234	0.116	0.216	0.195
Adjusted R^2	0.118	0.168	0.081	0.183	0.115
F-statistics	6.227***	9.756***	4.664***	5.226***	3.859***

* p<0.10, ** p<0.05, *** p<0.010

Table F.2: Impact of leverage on CEO incentive-risk relationship - Option Portfolio Ratio.

Table F.3 shows the results from a robustness test for the moderating effect of leverage using quantile regression. The 10th, 25th, 50th (median), 75th, and 90th percentiles are used. The dependent variable is *Risk Ratio* and *Option Portfolio Ratio* is used as the option incentive variable.

	Risk Ratio				
	10^{th} percentile	25^{th} percentile	50^{th} percentile	75^{th} percentile	90^{th} percentile
Option Portf. Ratio	0.015	0.060***	0.050**	0.038***	0.021
	(0.02)	(0.01)	(0.02)	(0.01)	(0.03)
Option × Leverage	-0.027	-0.107***	-0.096***	-0.085***	-0.075*
	(0.04)	(0.03)	(0.04)	(0.03)	(0.04)
Cash compensation	0.000	0.000	0.000***	0.000**	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Leverage	0.008	0.078*	0.159*	0.333***	0.682***
	(0.05)	(0.04)	(0.09)	(0.12)	(0.16)
Firm size	-0.019***	-0.026***	-0.042***	-0.069***	-0.126***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
MTB	-0.006	-0.003	-0.006**	-0.005	-0.007
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
CAPEX	0.139	0.255**	0.323**	0.357***	0.049
	(0.17)	(0.12)	(0.15)	(0.12)	(0.17)
R&D	-0.505	-1.190	-0.543	0.485	0.513
	(0.66)	(0.72)	(1.31)	(1.11)	(1.40)
Constant	0.473***	0.578***	0.841***	1.296***	2.171***
	(0.07)	(0.07)	(0.08)	(0.13)	(0.19)
Observations	336	336	336	336	336

* p<0.10, ** p<0.05, *** p<0.010

Table F.3: Quantile regression - Moderating effect of leverage.

Table F.4 presents the results from running sub-sample pooled OLS regressions based on the *Salary-to-Stock ratio* variable. Leverage (book value of total debt to assets) is used as the dependent variable. Columns one and four looks at firms with a Salary-to-Stock ratio below and above the 25th and 75th percentiles, respectively. Columns two and three include firms with below and above median Salary-to-Stock ratios, respectively.

	Leverage			
	Below 25^{th} percentile	Below median	Above median	Above 75^{th} percentile
Salary-to-Stock	0.006	-0.000	0.000***	0.000***
	(0.00)	(0.00)	(0.00)	(0.00)
Option Portf. Ratio	-0.050***	-0.043***	-0.333***	-0.423**
	(0.01)	(0.01)	(0.11)	(0.18)
Option $\times$ Leverage	0.096***	0.082***	0.754***	0.885**
	(0.02)	(0.02)	(0.22)	(0.38)
Cash compensation	-0.000**	-0.000**	-0.000	-0.000
	(0.00)	(0.00)	(0.00)	(0.00)
CEO tenure	0.002	-0.000	0.010*	0.014**
	(0.00)	(0.00)	(0.01)	(0.01)
Firm size	0.039*	0.048***	0.043**	0.045
	(0.02)	(0.02)	(0.02)	(0.03)
MTB	0.001	0.000	0.007	-0.004
	(0.00)	(0.01)	(0.01)	(0.01)
Constant	-0.015	-0.087	-0.142	-0.116
	(0.32)	(0.23)	(0.28)	(0.47)
Observations	70	143	143	71
R^2	0.396	0.299	0.268	0.251
Adjusted R^2	0.328	0.262	0.230	0.168
F-statistics	6.593***	12.555***	4.677***	11.037***

* p<0.10, ** p<0.05, *** p<0.010

Table F.4: Impact of Salary-to-Stock ratio on firm leverage.

Table F.5 shows the results from running pooled OLS regression models that include a squared term for tenure, age, and both age and tenure, in columns one, two, and three, respectively. *Option Portfolio Ratio* is used as the option incentive variables, while the dependent variable is *Risk Ratio*.

	Risk Ratio		
	Tenure squared	Age squared	Age sqrd. and Tenure sqrd.
CEO gender	0.563	0.560	0.554
	(0.39)	(0.41)	(0.40)
CEO tenure	-0.110**	-0.042**	-0.098**
	(0.05)	(0.02)	(0.05)
CEO age	0.013	-0.382***	-0.363**
	(0.02)	(0.14)	(0.14)
Tenure × Tenure	0.003*		0.003
	(0.00)		(0.00)
Age × Age		0.004***	0.004**
		(0.00)	(0.00)
Cash compensation	0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)
CEO ownership	1.131	1.005	1.094
	(0.74)	(0.73)	(0.70)
Option Portf. Ratio	0.131**	0.165***	0.174***
	(0.06)	(0.05)	(0.05)
Option × Leverage	-0.319**	-0.388***	-0.398***
	(0.14)	(0.11)	(0.11)
Leverage	1.650***	1.731***	1.738***
	(0.38)	(0.38)	(0.38)
Firm size	-0.241***	-0.240***	-0.239***
	(0.05)	(0.05)	(0.05)
Constant	3.784***	13.434***	13.069***
	(1.00)	(3.52)	(3.47)
Observations	312	312	312
R^2	0.172	0.196	0.202
Adjusted R^2	0.145	0.169	0.173
F-statistics	5.595***	7.394***	6.891***

* p<0.10, ** p<0.05, *** p<0.010

Table F.5: CEO characteristics and risk aversion proxies - Non-linear terms.

Table F.6 presents the results from running pooled OLS regression models using vega as the option incentive variable and *Firm risk* as the dependent variable. In column one, the main 24-month stock return volatility is used, while columns two and three use one- and two year periods following the fiscal years analyzed in the sample, respectively. Column four includes a random-effects model using the main stock return volatility periodization. *Firm risk* (annualized standard deviation of stock returns) is used as dependent variable.

	Firm risk			
	Main periodization	1-year	2-year	Random-effects model
Vega	0.008	-0.010	0.006	0.007
	(0.01)	(0.02)	(0.01)	(0.04)
Cash compensation	-0.000	0.000	0.000	-0.000
	(0.00)	(0.00)	(0.00)	(0.00)
CEO ownership	-0.905	-0.711	-0.389	-1.572
	(0.65)	(0.68)	(0.95)	(3.87)
Leverage	0.100	0.102	0.117	0.572
	(0.13)	(0.20)	(0.15)	(0.44)
Firm size	-0.051***	-0.029	-0.057**	-0.099
	(0.02)	(0.03)	(0.02)	(0.09)
MTB	-0.000	0.000	-0.003	0.019
	(0.00)	(0.00)	(0.00)	(0.03)
Constant	1.085***	0.937**	1.166***	3.249**
	(0.24)	(0.42)	(0.29)	(1.35)
Observations	97	96	99	97
R^2	0.172	0.039	0.121	0.122
Adjusted R^2	0.117	-0.026	0.064	
F-statistics	2.215*	0.706	1.547	

* $p<0.10$, ** $p<0.05$, *** $p<0.010$

Table F.6: Additional robustness measures - Example analysis.

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