The Impact of CEOs' Incentives for Risk-Taking or Risk-Aversion on Corporate Performance: Using CEO Vega and CEO Delta as Incentive Measures

Dr. Samy Garas
Associate Professor of Accounting
School of Business and Economics
State University of New York at Plattsburgh
Office 328, Au Sable Hall, 101 Broad Street
Plattsburgh, NY 12901
Email: sgara002@plattsburgh.edu

Dr. Kienpin Tee

Dr. Chuo-Hsuan Lee

Abstract

This article has a two-fold purpose. First, we investigate whether the CEOs' risk-taking incentives are associated with better concurrent firm performance. Second, we examine the impact of gender on the aforementioned relationship. We find solid empirical evidence that CEOs' risk-aversion incentive, as represented by a higher CEO delta, can be linked to better concurrent firm performance such as return on assets (ROA) and Market-to-Book Value (MTB) ratio. By contrast, we find that the risk-taking incentive, as represented by CEO vega, has no significant impact on ROA, but has a significant impact on MTB ratio only among the group of CEOs with larger share ownerships. Furthermore, we research on the same incentives using only female CEOs in our sample. Our panel-data findings indicate that female CEOs on average possessed a lower CEO delta (low risk aversion) and a lower CEO vega (risk-taking incentive) in their compensation packages when compared with their male counterparts. Taken together, these two risk incentives; are linked to a lower concurrent ROA and MTB value. Our findings also indicate that the aforementioned positive relationship between CEOs' risk-aversion incentive (as measured by CEO delta) and firm performance (as measured by ROA) are less pronounced when a CEO is female. This implies that a female CEO is less likely to increase the firm's ROA relative to a male CEO, given the same sensitivity of personal wealth to stock price change (i.e., the same CEO delta).

1. Introduction

There has been a history of studies investigating the issues surrounding the relationships between CEO compensation and firm performance since 1990s (Jensen and Murphy, 1990; Murphy, 1999; Core and Guay, 1999; Brick et al, 2006; Cheng and Farber, 2008; Matolcsy and Wright, 2011; Ozkan, 2011, Lam et al., 2013). The relationships between CEO compensation and firm performance are intriguing because agency theory suggests that CEOs are only motivated to act in their shareholders' best interests if they are offered incentive contracts that pay for their performance (Jensen and Murphy, 1990).

Indeed, several studies conducted in the past decade have examined CEOs' risk-taking incentives (Cheng and Farber, 2008; Bulan et al., 2010; Wang, 2012; Shen and Zhang, 2013; Phan, 2021; Ikram, Li and MacDonald, 2020). These studies have focused on how such incentives are associated with board firm size (Wang, 2012), firm Productivity (Bulan et al., 2010), investment policy, debt policy and firm risk (Core et al., 2004), and the operating performance of firms after an option-based compensation reduction following the earnings restatements of firms (Cheng and Farber, 2008).

The purpose of this analysis is two-fold. First, we investigate the associations between a CEOs' risk-taking and risk-aversion incentives and firm performance. Second, we research on whether or not female CEOs behave differently from male CEOs in these above relationships. Our approach is different from the previous literature such as Cheng and Farber (2008), in that we use CEO vega and CEO delta as proxies for CEOs' risk-taking incentive and risk-aversion incentive, respectively. We find solid empirical evidence supporting that CEOs' risk-aversion incentive, as measured by CEO delta, can be linked to better firm performance, as measured by return on assets (ROA) and Market-to-Book Value (MTB) ratio. Since CEO delta measures the sensitivity of CEO wealth to stock price changes, our findings imply that a CEO who is rewarded by a compensation package that is more sensitive to stock price changes, as indicated by a higher CEO delta, is more likely to take risk-aversion actions in decision making, improving both the firm's ROA and its MTB ratio.

By contrast, we find that the risk-taking incentive measure, CEO vega, has no significant impact on ROA after controlling for share ownerships. Only by separating out those CEOs with larger share ownership does the same analysis reveal a significant impact on firms' MTB ratio among the group of CEOs with larger share ownerships. CEO vega, representing the sensitivity of CEO wealth to stock price volatility, is associated with stock option value in CEOs' compensation package. Our findings suggest that a CEO who would benefit from a higher stock volatility via stock options-based compensation would not be motivated to produce a higher ROA regardless of the stock ownership, and is only motivated to improve the firm's MTB ratio if the CEO has a larger share ownership.

Furthermore, we examine the risk-taking and risk-aversion incentives of female CEOs. Our findings indicate that on average, female CEOs have received fewer risk-taking and risk-aversion incentives in comparison with their male counterparts, as measured by CEO delta and CEO vega, respectively. Interestingly, the low female CEO delta is associated with a low risk-aversion incentive while the low female CEO vega is associated with a weak risk-taking incentive. The empirical results imply that when the low risk-aversion incentive related to female CEO delta is combined with the low risk-taking incentive related to female CEO vega, this creates a lower ROA and MTB for female CEOs.

Our findings also indicate that the aforementioned positive relationship between CEOs' risk-aversion incentive as measured by CEO delta, and firm performance as measured by ROA, is less pronounced when a CEO is a female. This result implies that a female

CEO is less likely to increase their ROA via risk-aversion conditioning relative to their male CEO counterparts, given the same level of CEO delta.

The contributions of this study to the extant literature are as follows. First, we introduce the use of CEO vega and CEO delta as incentive measures reflecting the relative degree of risk-taking and risk-aversion to evaluate how they are associated with concurrent firm performance. Our findings indicate that both the CEO vega and the CEO delta related to CEO compensation package design have very different implications for concurrent firm performance. Second, we have added additional momentum to the prior research by examining whether female CEOs' risk-taking and risk-aversion incentives are different from their male counterparts, and how these incentives are associated with firm performance.

The rest of the paper is organized as follows. Section 2 presents the related literature. Section 3 presents the development of the research hypotheses. Section 4 describes the data and construction of variables used in the study. The main empirical findings are then provided in Section 5, while Section 6 concludes the paper.

2. Literature Review

2.1 Agency Theory

Agency theory suggests that CEOs are effectively motivated to act in their shareholders' best interests only if they are offered incentive contracts that pay for their desired performance. For example, Jensen and Murphy (1990) use a large sample of compensation contracts to show that CEO wealth changes $3.25 for every $1,000 change in shareholder wealth. Their empirical research suggests that there remains a large gap between the interests of firm managers and shareholders as the pay-for-performance sensitivity is only 0.325%.

A common solution to the agency problem inherent in corporate management has been to create executive compensation packages or equity ownership that enhances a managers' wealth in line with increases in corporate performance and/or a firm's stock value (Baker et al., 1988). Ueng and Wells (2001) suggest that both the manager's equity share holdings and whole compensation package should be properly designed to provide a proper incentive for managers for mitigating agency costs.

Nevertheless, information asymmetry arising from managers' controlling access to corporate information limits shareholders' ability to monitor whether a manager's decisions exhibit an optimal risk level that enhances shareholder value. Thus, it is in the best interest of shareholders to design appropriate corporate control or incentive mechanisms to motivate managers to select only value enhancing projects of appropriate risk. An employment contract that links a portion of compensation to firm performance is a key corporate control device. However, even though the overall compensation package is intended to motivate managers to increase shareholder value, the risk incentives within this package are not uniform across the various components of the package (Huang, 2007). Thus, the agency problem may persist.

2.2 CEO Compensation & Corporate Performance

Following Jensen and Murphy (1990), financial economists have studied the association between executive compensation and corporate performance, investment decisions, capital structure, dividend policies, mergers, and diversification (Mehran, 1995; Murphy, 1999; Girma et al., 2006; Ortiz-Molina, 2007; Mubeen at al., 2020).

By realigning the interests between management and shareholders, executive compensation is traditionally considered the primary solution to address the agency conflict in the modern corporation (Jensen and Murphy, 1990). Academic studies on the relationship between managerial pay and firm performance, especially the relation between equity-based pay and firm performance have not reached a consensus in the literature. However, some research exists that points to a positive relation between pay and performance. Murphy (1986) examines data from 1975-1984 to document a positive relationship between manager salary, bonus, and firm stock returns, as well as a positive relationship between stock-based compensation and stock returns. Mehran (1995) finds that firm value and ROA are both positively related to both the percentage of equity capital held by firm managers and the percentage of equity-based executive compensation. Core and Guay (1999) report that CEOs portfolio of equity incentives in firms guided by agency theory receive greater equity-based compensation, and that these firms also perform relatively better than other firms that have agency problems.

Additionally, Knopf, et al. (2002) find a positive relationship between CEO delta and derivative usage, and a negative relationship between CEO vega and derivative usage. Dennis and Mihov (2003) provide further evidence on managerial incentives and corporate decisions. Graham, et al., (2013) relate managerial traits such as risk-aversion and time preference to corporate decision making. They find these traits are related to CEO's compensation and corporate financial policies. Ittner, et al., (2003) examine accounting and stock returns among the 'new economy' firms during the period 1999-2000. They find that less-than-expected option grants have a negative impact on subsequent performance in both sectors. Denise and Robert (2007) find consistent empirical results suggesting that future firm performance, as reflected by both market-based and income-based performance measures, is unrelated to the level of executive compensation, while is latter is primarily driven by the size of the company.

2.3 Delta and Vega

Early empirical studies in executive compensation utilize the value of different compensation components such as firm performance bonuses, long-term incentive stock or stock options as a measure of manager incentives. According to Core and Guay (2002) and Coles et al. (2006), such direct measures of compensation value are only weak proxies, but delta and vega provide more direct measures of managerial incentives.

Delta is defined as the change in the dollar value of the manager's wealth for a 1% change in stock price. Delta reflects managerial wealth gains from the change in firm value. Vega is defined as the change in the dollar value of the manager's wealth for a 1% change in the annualized standard deviation of stock returns. Vega reflects

managerial wealth gains from an increase in the volatility of the firm's returns. Furthermore, Aggarwal and Samwick (2003) document the trade-off between firm risk and pay-for-performance sensitivity. Since pay-for-performance sensitivity is analogous to delta, an increase in firm risk can be associated with decrease in delta, representing CEO risk-aversion.

Further, Shen and Zhang (2013) research whether CEO delta and vega affect the efficiency of R&D investment decisions. They examine a sample of 843 firms that increase their R&D investments by an economically significant amount over the period of 1995–2006 to find that CEO vega is positively associated with large increases in R&D investments. They also find that high vega firms experience fewer abnormal stock returns and lower operating performance. This suggests that the presence of a high vega motivates managers towards over-investments in R&D activities. Bulan, et al., (2010) find that there is an inverse U-shaped relationship between CEO delta and firm productivity, suggesting that a high delta related to stock incentives in the compensation package results in higher CEO risk-aversion and thereby reduces firm productivity. By contrast, they document a positive relationship between CEO vega and firm productivity, suggesting that a high vega related to stock option grants in the compensation package offsets the aforementioned CEO risk-aversion effect.

2.4 Female CEOs and firm performance

Historically, there have not been many studies researching on the association between female CEOs and firm performance. Khan and Vieito (2013) found that a female CEO is associated with a lower firm risk level. They state in page 55, "*the boards are not attending to the risk aversion differences between male and female CEOs when they design the compensation packages, especially equity-based compensation, which can be understood as an incentive to female CEOs to take risks*." Peni (2014) found a positive relationship between presence of female CEOs and firm performance as measured by both ROA and Tobin's Q. In recent years, however, articles have increasingly discussed the association between female board members/CEOs/CFOs and firm performance. For example, Sandberg (2019) finds that firms with female CFOs are more profitable and generate more excess profits, and that firms with female CEOs and CFOs are associated with superior stock performance. Eastman (2018) finds that firms with more women on the board of directors showed higher productivity growth. Overall, prior literature has pointed a positive association between female CEOs and firm performance.

3. Hypotheses Development

When a manager has an incentive to increase the firm's risk based on her (his) personal holdings of the firm's stocks and options, S (he) adopts riskier corporate policies. The reverse occurs when (s)he has an incentive to decrease it. To test these predictions, we compute two proxies of risk incentive measures based on the manager's stock and option holdings. Our first proxy, *vega*, measures the sensitivity of the manager's wealth to the firm's stock return volatility. Because managers with a higher vega stand to gain from taking on higher firm risk, *vega* provides a reasonably straightforward measure of the managers' risk-increasing incentives.

Our second proxy, delta, has a relatively less direct relation to risk-taking incentives (Huang, 2007; Ikram, Li and MacDonald, 2020). Delta, computed as the sensitivity of the manager's wealth to the firm's stock price, measures the dollar gain or loss in the manager's wealth as the firm's stock price changes by a certain amount (Huang, 2007; Ikram et al., 2020). While higher delta motivates a corporate manager to work hard for increasing the shareholders' wealth, it also imposes a cost on (her) him. The cost comes in the form of increased exposure to the firm's total risk that an undiversified manager cares about. Unlike a well diversified outside shareholder, managers typically hold a disproportionately higher fraction of their wealth in the firm they manage. In addition, a managers' human capital is closely tied with the firm's performance (Fama, 1980; Stulz, 1984; Smith and Stulz, 1985). Given these considerations, managers with a higher *delta* are likely to prefer financial policies with lower risks to minimize the firm's total risk. Therefore, we consider *delta* as a proxy for the managers' risk-aversion incentives with the important caveat that the relation between *delta* and corporate policies can also be an outcome of the *delta*'s incentive alignment effects.

Bulan, et al., (2010) find that there is an inverse U-shaped relationship between CEO delta and firm productivity, suggesting that a higher delta related to stock incentives in the compensation package results in more CEO risk-aversion and thereby reduces firm productivity. Khan and Vieito (2013) found that a female CEO is associated with a lower firm risk level. If the boards are aware that female CEOs tend to be more risk-averse, we expect the compensation package for female CEOs would be designed to offer a lower risk-aversion incentive (i.e., low CEO delta). As to the vega of female CEOs, Bulan et al. (2010) document a positive relationship between CEO vega and firm productivity. They suggest a *higher* CEO vega related to stock option grants in the compensation package offsets the aforementioned *higher* CEO risk-aversion effect. According to the rationale of Bulan et al. (2010), if the female CEOs are offered a *lower* CEO delta in this compensation packages, we would expect a *lowe*r CEO vega offered in the same packages to balance the risk. This leads to our first hypothesis:

H1: Male CEOs on average have been given larger incentives for their risk behavior (including risk-aversion and risk-taking) than their female counterparts.

Cheng and Farber (2008) find that a decrease in option-based compensation reduces CEOs' incentive to take excessively risky investment and leads to improved firm profitability. Similarly, Bulan, et al., (2010) suggest that a high delta related to stock incentives in the compensation package results in CEO risk-aversion, and thereby reduces firm productivity. Accordingly, we argue that CEOs' incentives for risk-aversion, as indicated by a higher delta in their compensation packages, would lead managers to be more careful when selecting investment projects to avoid taking excessive risks, leading to better firm performance:

H2a: CEOs' incentives for risk-aversion, as measured by a higher delta, are positively associated with their contemporaneous firm performance.

Phan (2021) finds that firm risks are significantly associated with a lower CEO delta and a higher CEO vega. Bulan, et al., (2010) document a positive relationship between the CEO vega and firm productivity, suggesting that a high CEO vega related to stock option grants in the compensation package offsets the CEO risk-aversion effect associated with a high CEO delta. Accordingly, we expect to see a positive relationship between CEO vega and concurrent firm performance:

H2b: CEOs' incentives for risk-taking, as measured by a higher vega, are positively associated with their contemporaneous firm performance.

Prior literature (Peni, 2014) found a positive relationship between presence of female CEOs and firm performance, as measured by both ROA and Tobin's Q. Also, some articles in recent years have discussed the superior market performance of firms by including female CEOs, CFOs, and board members (Eastman, 2018; Taylor, 2019). Accordingly, we expect to see better firm performance associated with firms with female CEOs relative to their male counterparts.

H3: A firm with a female CEO tends to have better firm performance relative to a firm with a male CEO.

Khan and Vieito (2013) found that a female CEO is associated with a lower firm risk level than their male counterparts and the "the boards are not attending to the risk aversion differences between male and female CEOs when they design the compensation packages, especially equity-based compensation, which can be understood as an incentive to female CEOs to take risks (page 55)". Accordingly, we can expect a less pronounced positive association between female CEOs' incentives for risk-aversion and their contemporaneous firm performance.

H4: The positive association between CEOs' incentives for risk-aversion and their contemporaneous firm performance is less pronounced for female CEOs.

4. Data and Methodology

4.1 Sample collection and data description

This study uses year-end data collected from the *Compustat*, *CRSP*, and *Execucomp* databases, for a constructing seventeen-year sample period (1992-2018). The final sample, after removing observations with missing variables (i.e. CEO compensation data and CEO characteristics) and the years of CEO transition, consists of 12,265 firm-year observations. We winsorize all continuous variables at 1% and 99% levels. The variable definitions and the descriptive statistics are reported in Tables 1 and 2, respectively. Average CEO delta and average CFO delta are 117.8 thousand dollars and 722.38 thousand dollars, respectively. These statistics are close to prior research on executive incentives (e.g., Kini and Williams, 2012; Chava and Purnanandam, 2010). We therefore believe that our sample is representative.

Table 1: Data Description

Variable	Explanation
CEO_Vega	Dollar change in the CEO’s option holdings in response to a one-percent change in the firm’s stock return volatility
CEO_Delta	Dollar change in the CEO’s equity and option holdings in response to a one-percent change in the firm’s stock price.
ROA	Return of Asset
MTB	Market to book value
Age	CEO's age
Female	Dummy equal to one if CEO is female, zero if male
Ownership	Percentage of CEO's share ownership excluding stock option
Tenure	Number of years a CEO holds CEO position
Log_Sales	Log of annual sales
Log_SalesSq	Log of square of annual sales
CapitaltoSales	Ratio of net fixed assets over sales
BookLev	Book value of total liability over total asset
RDtoCapital	Ratio of Research and Development Expense over net fixed asset
AdtoCapital	Ratio of Advertising Expense over net fixed asset

Table 2: Statistics Summary

Variable	Mean	Std. Dev.	Min	Max
CEO_Vega	117.812	227.8932	0	2437.886
CEO_Delta	722.3809	2304.561	0	51205.57
ROA	0.046448	0.096022	-1.11137	0.703255
MTB	1.902813	1.240115	0.345266	20.92281
Age	55.097	9.920697	33	80
Female	0.034392	0.182273	0	1
Ownership	2.347149	5.736157	0	52.6
Tenure	9.655644	17.77262	0	115
Log_Sales	7.688473	1.501444	1.365836	12.24216
Log_SalesSq	61.36596	23.53736	1.865509	149.8705
CapitaltoSales	0.549904	0.727548	0	12.09343
BookLev	0.263151	0.215935	0	2.230957
RDtoCapital	0.26156	2.585628	0	68.17466
AdtoCapital	0.033085	0.084745	0	1.102042

Table 3 reports the correlations between any two variables described in Table 1 and 2. Among the independent variables, there do not appear to be any correlations high enough to warrant any concern on multicollinearity. Nonetheless, we checked variance inflation factors (VIFs) for all variables to detect possible presence of multicollinearity. All the VIFs were smaller than 2.0. Therefore, our regression models are assumed to be free from potential multicollinearity problems (Billor, et al., 2006).

Our first hypothesis (*H1*) predicts that male CEOs on average have been given larger incentives for their risk behavior (including both risk-aversion and risk-taking) than their female counterparts. To test *H1*, we will compare the mean difference between male and female CEO vegas and CEO deltas. For *H1* to be supported, we expect to observe significantly higher averages for the male CEOs' delta and vega than those of the female CEOs' delta and vega.

To investigate the effect of the CEOs' risk incentives on firm performance, we adopt the following OLS regression (see Equation (1)) as our baseline model to test the second hypotheses (*H2a and H2b*).

$$Performance_{i,t} = \beta_0 + \beta_1(CEO\ delta)_{i,t} + \beta_2(CEO\ vega)_{i,t} + \beta_3(CEO\ characteristics)_{i,t} + \gamma'\ controls_{i,t} + +\lambda' year_t + \theta' industry_j + \varepsilon_{i,t} \quad (1)$$

Where *i*, *t*, and *j* denote firm *i*, year *t*, and industry (two-digit SIC code) *j*. The dependent variable (*performance*) refers to the measures of ROA and MTB. ROA is used to measure the effectiveness of managers in utilizing the assets for generating accounting returns. MTB is a measure for a firm's market performance relative to its book value. The vector named *controls* refer to a vector of control variables that were selected following Kale, et al., (2009), a study that examines the effect of executive incentives on firm performance. The variables we use to measure the CEO characteristics include Female, Ownership, Age and Tenure. These variables have been used by prior literature. In addition to control for CEO characteristics (*CEO Characteristics),* we also control for year (*Year*) and industry (*Industry*) fixed effects.

H2a and H2b explore whether CEOs' risk-aversion and risk-taking incentives are positively associated with their firm performance. Therefore, we expect to observe positive coefficients on CEO delta and CEO vega ($\beta_1 and \beta_2$), respectively. A positive β_1 indicates that when a CEO's wealth is more sensitive to the firm's stock market price change (i.e., more risk-aversion incentive due to a higher CEO delta), this firm performs better. A positive β_2 designates that when a CEO's wealth benefits more from stock market volatility (i.e., more risk-taking incentive due to a higher CEO vega), this firm also delivers better financial performance.

The third hypothesis (H3) predicts that a firm with a female CEO tends to have a better firm performance. Accordingly, we expect a positive coefficient on the coefficient β_3 on the CEO Characteristic variable (Female) in Equation (1).

Table 3: Correlation Table

	CEO_Vega	CEO_Delta	ROA	MTB	Age	Female	Ownership	Tenure	Log_Sales	Log_SalesSq	CapitaltoSales	BookLev	RDtoCapital	AdtoCapital
CEO_Vega	1													
CEO_Delta	0.2807	1												
ROA	0.1243	0.0763	1											
MTB	0.1291	0.066	0.2755	1										
Age	0.0761	0.1632	0.0547	-0.0185	1									
Female	-0.0794	-0.0534	-0.0433	-0.0079	-0.0214	1								
Ownership	-0.1091	0.2769	0.0776	0.0421	0.1158	-0.0638	1							
Tenure	-0.0275	0.1134	0.0292	-0.0311	0.1614	-0.0171	0.2143	1						
Log_Sales	0.4273	0.1921	0.1478	-0.1084	0.0966	-0.1043	-0.2529	-0.0997	1					
Log_SalesSq	0.4485	0.2076	0.1124	-0.0959	0.1012	-0.1087	-0.2495	-0.1013	0.9902	1				
CapitaltoSales	0.0175	-0.0226	-0.064	-0.1624	0.0066	-0.0622	-0.0381	0.0272	0.007	0.0145	1			
BookLev	0.0765	-0.0577	-0.1803	-0.0336	0.0475	-0.0034	-0.1621	-0.0186	0.1225	0.1292	0.1491	1		
RDtoCapital	0.0062	-0.0191	-0.3106	0.1631	0.0481	-0.014	-0.0311	-0.0136	-0.2165	-0.1502	-0.0437	0.1389	1	
AdtoCapital	0.0963	-0.0049	0.1174	0.1534	-0.0354	0.115	-0.0038	-0.0077	0.0215	0.0149	-0.1446	-0.0304	-0.0312	1

In the fourth hypothesis (*H4)* we expect to see a less pronounced positive association between CEOs' incentive for risk-aversion and their contemporaneous firm performance for female CEOs. To investigate whether the CEOs' risk-aversion incentives on firm performance is weakened or strengthened when the CEO is a female, we revise our baseline model as follows:

$$Performance_{i,t} = \beta_0 + \beta_1(CEO\ delta)_{i,t} + \beta_2(CEO\ vega)_{i,t} + \beta_3(CEO\ characteristics)_{i,t} + \beta_4(CEO\ delta * female)_{i,t} + \beta_5(CEO\ vega * female)_{i,t} + \gamma' controls_{i,t} + +\lambda' year_t + \theta' industry_j + \varepsilon_{i,t} \quad (2)$$

where *female* is a dummy equal to one if the CEO is a female, otherwise zero. According to H4, we expect to observe a negative coefficient on the interaction variable CEO delta*Female (β_4) in Equation (2).

5. Results & Discussion

Table 4: Mean Difference of key variables between male and female CEOs

Variable	Mean		Difference (t-test)
	Male	Female	
CEO_Vega	121.2206	22.10951	99.11108***
CEO_Delta	745.566	71.41361	674.1524***
ROA	0.047171	0.026157	0.021013**
MTB	1.904649	1.851292	0.053357
Age	55.13562	54.01282	1.122796
Ownership	2.416091	0.411462	2.00463***
Tenure	9.712785	8.051282	1.661503
Log_Sales	7.71798	6.860775	0.857205***
Log_SalesSq	61.84815	47.83972	14.00844***
CapitaltoSales	0.55843	0.310735	0.247695***
BookLev	0.263278	0.259562	0.003717
RDtoCapital	0.268828	0.057592	0.211236
AdtoCapital	0.031244	0.08474	-0.0535***

We run a mean difference test to compare the difference of the incentive to take risk between male and female CEO. Table 4 shows that male CEOs have significantly higher vega (99.11) and higher delta (674.15) than the vega (22.1) and delta (71.4) of female CEOs. This finding supports our first hypothesis (H1) that male CEOs on average have larger risk-taking and risk-aversion incentives provided by their compensation package than their female counterparts.

Table 5: Impact of CEOs' risk incentives to firm performance

Dependent Variables	ROA	MTB
Incentive of risk taking		
CEO_Vega	0.00003**	0.000205*
	(0.0000)	(0.0001)
CEO_Delta	0.00001*	0.00008***
	(0.0000)	(0.0000)
CEO Characteristics		
Female	-0.04913***	-0.107***
	(0.0147)	(0.0480)
Ownership	0.00046	0.0136**
	(0.0006)	(0.0064)
Age	0.00073***	-0.00357
	(0.0002)	(0.0022)
Tenure	-0.00004	-0.000324
	(0.0001)	(0.0015)
Control Variables		
Log _Sales	0.08334***	0.920***
	(0.0165)	(0.1740)
Log_SalesSq	-0.00479***	-0.0680***
	(0.0011)	(0.0118)
CapitaltoSales	-0.02259***	-0.309***
	(0.0073)	(0.0769)
BookLev	-0.12671***	-0.301**
	(0.0142)	(0.1510)
RDtoCapital	-0.00131	-0.0725***
	(0.0011)	(0.0116)
AdtoCapital	-0.05567	-0.398
	(0.0376)	(0.3980)
Industry Dummy	Included	Included
Constant	-0.29598***	-0.631
	(0.0626)	(0.6630)
Observations	12,265	12,265
R-Square	0.1065	0.0039
Wu-Hausman (p-value)	0.0366	0.0026
Hansen-J (p-value)	0.0000	0.0000

Our baseline regression results (panel data regressions with industry and year fixed effect) is reported in Table 5. The baseline results indicate that for every dollar increase in CEO delta, ROA and MTB increase by 0.00003 and 0.00001, respectively. Further, for every dollar increase in CEO vega, ROA and MTB increase by 0.00003 and

0.00001, respectively. This presents an strong evidence of positive relationship between CEO risk-aversion and risk-taking incentives and concurrent firm performance. Therefore, our findings support our second hypothesis (H2a and H2b) that CEOs' risk-aversion and risk-taking incentives, as proxied by CEO delta and CEO vega, are positively associated with their firm performance.

One potential concern with our regression results is the low adjusted R square when firm performance is measured by MTB in Table 5. Later, in Table 7 we will demonstrate how the adjusted R square can be largely improved after we group the sample into two subgroups based on share ownership.

Table 6: Moderation of female CEO to CEO's Incentive of risk taking and firm performance

Dependent Variables	ROA	MTB
Incentive of risk taking		
CEO_Vega	0.000027***	0.000213*
	(0.0000)	(0.0001)
CEO_Delta	0.000002*	0.00008***
	(0.0000)	(0.0000)
CEO Characteristics		
Female	-0.0960***	-0.595***
	(0.0200)	(0.2110)
Ownership	0.000395	0.0126**
	(0.0006)	(0.0063)
Age	0.000749***	-0.00332
	(0.0002)	(0.0022)
Tenure	-0.0000142	-0.00001
	(0.0001)	(0.0015)
Control Variables		
Log _Sales	0.0815***	0.897***
	(0.0164)	(0.1730)
Log_SalesSq	-0.00474***	-0.0674***
	(0.0011)	(0.0118)
CapitaltoSales	-0.0227***	-0.308***
	(0.0072)	(0.0764)
BookLev	-0.122***	-0.258*
	(0.0142)	(0.1510)
RDtoCapital	-0.00146	-0.0741***
	(0.0011)	(0.0115)
AdtoCapital	-0.0578	-0.455
	(0.0375)	(0.3960)
Moderation variables		
Female*CEO_Vega	**-0.000294**	**-0.00829****
	(0.0003)	**(0.0036)**
Female*CEO_Delta	**-0.000730*****	**-0.00977*****
	(0.0002)	**(0.0020)**
Industry Dummy	Included	Included
Constant	-0.286***	-0.514

	(0.0624)	(0.6600)
Observations	12,265	12,265
R-Square	0.1126	0.0067
Wu-Hausman (p-value)	0.0317	0.0025
Hansen-J (p-value)	0.0000	0.0000

H3 predicts that a firm with a female CEO tends to have a higher firm performance. Surprisingly, after controlling for other variables, Table 5 reveals that male CEOs in our sample have a relatively higher ROA and MTB. However, the mean difference on MTB is statistically insignificant. In Table 6, we further test this hypothesis by controlling other variables in the regression results. Our analysis reveals a significant decrease in ROA by 0.096, and a significant decrease in MTB of 0.595 for firms with a female CEO. Taken together, our results in Table 5 and 6 contradict with our hypothesis H3.

Herein, we need to note that in our study we are examining the *concurrent* ROA and MTB related to female CEOs. Our empirical results do not imply that female CEOs will experience worse firm performance in the future. Since the previous literature supports the notion that female CEOs on average perform better in the future (Khan and Vieito, 2013; Peni, 2014; Eastman, 2018, Taylor, 2019), struggling companies may have tended to promote women as CEOs (Stewart, 2018). Further, more female CEOs have replaced male CEOs since the great recession (Fottrell, 2019). This implies that it is very likely that poor existing firm performance created a situation where the CEO chosen was more likely a woman. In other words, the worse concurrent performance associated with female CEOs might be the *cause* for hiring a female CEO, not the *effect* of hiring a female CEO (Stewart, 2018; Fottrell, 2019).

Our fourth hypothesis H4 argues that the positive association between CEOs' incentives for risk-aversion and their contemporaneous firm performance is less pronounced for female CEOs. Table 6 reveals a significantly negative coefficient on the interaction term CEO delta*Female (β_4), regardless of whether firm performance is measured by ROA or MTB. The negative coefficient of both interactive terms show that when a firm has a female CEO, the positive impact of CEO delta on ROA is reduced by 0.00073, and the impact on MTB is reduced by 0.00977. Our regression results in Table 6 strongly support the hypothesis H4. Again, similar to the results discussed in Table 5, Table 6 presents a low adjusted R square when firm performance is measured by MTB.

Table 7: Comparison of moderation impact of female CEO between high and low share ownership of CEO

Dependent Variables	ROA		MTB	
Group	High	Low	High	Low
Incentive of risk taking				
CEO_Vega	0.000023	0.0000186	0.000416**	-0.0000379
	(0.0000)	(0.0000)	(0.0002)	(0.0002)
CEO_Delta	0.000004***	0.00001*	0.00007***	0.000263***
	(0.0000)	(0.0000)	(0.0000)	(0.0001)
CEO Characteristics				
Female	-0.121***	-0.0554*	-0.663**	-0.494
	(0.0267)	(0.0315)	(0.2800)	(0.3360)
Ownership	0.000664	0.0808*	0.0105	0.557
	(0.0006)	(0.0486)	(0.0067)	(0.5190)
Age	-0.000384	0.000915***	-0.00529	-0.00296
	(0.0005)	(0.0003)	(0.0052)	(0.0027)
Tenure	-0.000412*	-0.0000293	-0.000855	0.00236
	(0.0002)	(0.0002)	(0.0025)	(0.0026)
Control Variables				
Log _Sales	0.124***	0.0935***	-0.682**	2.163***
	(0.0265)	(0.0231)	(0.2780)	(0.2470)
Log_SalesSq	-0.00845***	-0.00430***	0.0269	-0.127***
	(0.0019)	(0.0015)	(0.0194)	(0.0162)
CapitaltoSales	-0.0142*	-0.0235	-0.128	-0.474***
	(0.0075)	(0.0150)	(0.0791)	(0.1600)
BookLev	-0.130***	-0.131***	-0.779***	0.542**
	(0.0201)	(0.0219)	(0.2110)	(0.2340)
RDtoCapital	0.00266	-0.00144	-0.107**	-0.0413***
	(0.0048)	(0.0013)	(0.0500)	(0.0143)
AdtoCapital	0.0598	-0.0545	2.633***	-0.417
	(0.0761)	(0.0465)	(0.7980)	(0.4970)
Moderation variables				
Female*CEO_Vega	**-0.000898**	**-0.00044**	**-0.0109**	**-0.004**
	(0.0006)	**(0.0007)**	**(0.0068)**	**(0.0071)**
Female*CEO_Delta	**-0.000854*****	**-0.000514**	**-0.0113*****	**-0.00349**
	(0.0002)	**(0.0005)**	**(0.0021)**	**(0.0056)**
Industry Dummy	Included	Included	Included	Included
Constant	-0.336***	-0.432***	5.658***	-6.773***
	(0.0972)	(0.0970)	(1.0200)	(1.0350)
Observations	6,133	6,132	6,133	6,132
R-Square	0.0877	0.183	0.0815	0.182
Wu-Hausman (p-value)	0.1771	0.0588	0.0034	0.0034
Hansen-J (p-value)	0.0000	0.0000	0.0000	0.0000

CEO vega and delta are both affected by the composition of the CEO compensation package. That is, the higher the share ownership of a CEO, by nature, the higher the value of the CEO vega and CEO delta one possesses. To verify whether the CEO share

ownership matters in affecting the relationship between the CEO's incentive to take risks, the CEO's gender and the firm's performance, we divide our sample of firms into two groups: high CEO share ownership and low CEO share ownership. We then rerun the regression from the previous test conducted in Table 6. The new results are recorded in Table 7.

As demonstrated by Table 7, the adjusted R square statistic has been largely improved as we divide the samples into high and low ownership groups. Indeed, dividing the sample firms into these two groups reveals some interesting results. First, the associations between CEOs' risk-aversion incentives, as measured by *CEO delta,* and firm performance are consistently positive across all columns, regardless of the CEO ownership and the selection of firm performance measure (ROA versus MTB). By contrast, the risk-taking incentive, as measured by *CEO vega* is only positively associated with MTB in the group with large CEO share ownership. Second, across all columns on Table 7, a female CEO is still associated with a lower firm performance. Lastly, the less pronounced positive association between female CEOs' risk-aversion incentives and ROA is still well-supported among CEOs with larger share ownerships.

6. Conclusions and limitations

In this article, we find solid evidence supporting that CEOs' risk-aversion incentive, as represented by a higher CEO delta, can be linked to better concurrent firm performance, as measured by both ROA and MTB ratios. By contrast, we find that the risk-taking incentive measure, as represented by CEO vega, has no significant impact on ROA, but has a significant impact on MTB ratio only among the group of CEOs with relatively larger share ownerships. Furthermore, we examine these same incentives for female CEOs. Our panel-data findings indicate that the average female CEOs possessed a lower CEO delta and CEO vega in their compensation packages when compared to their male counterparts. For female CEOs, the low CEO delta is associated with a low risk-aversion incentive, and the low CEO vega is associated with a weak risk-taking incentive. We find that these two risk incentives, when taken together, are linked to a lower concurrent ROA and MTB.

At a glance, these findings appear to be inconsistent with the findings from the previous literature, which indicates that the presence of a female CEO leads to a better firm performance in the future. However, since we use concurrent firm performance rather than future firm performance in this research, our results are indeed consistent with previous literature indicating that firms in crisis tend to replace male CEOs with female CEOs. Our findings also indicate that the aforementioned positive relationship between CEOs' risk-aversion incentive, as measured by CEO delta, and firm performance, as measured by ROA, is less pronounced when a CEO is a female. This implies that a female CEO is relatively less likely to increase the firm's ROA, given the same sensitivity of personal wealth to stock price change (i.e., CEO delta).

The contributions of this study are as follows. First, we make contributions to the previous literature by introducing the use of CEO vega and CEO delta as the risk-taking and risk-aversion incentive measures to evaluate how they are associated with concurrent firm performance. Our findings indicate that CEO vega and CEO delta

related to CEO compensation package design have very different implications for concurrent firm performance. Second, we have added additional momentum to the prior research by examining whether or not female CEOs' risk-taking and risk-aversion incentives are different from their male counterparts, and how these risk-taking and risk-aversion incentives are associate with their firm performance.

Nevertheless, this study has several limitations. First, the scope of our research cannot identify the cause-and-effect relationships among our key variables. Although our results indicate that a female CEO is associated with a lower "concurrent" firm performance, our data cannot tell whether hiring a female CEO is the cause or the effect of the lower firm performance. In other words, hiring a female CEO might actually be the result of the poor firm performance in the past years. Second, our research focuses on the concurrent firm performance. Future studies should explore how the male and female CEOs' risk-aversion and risk-taking incentives affect prospective firm performance. For example, it may take several years for CEO stock options in the incentive packages to be vested and it makes sense to investigate the association between the CEO risk-taking incentives and future firm performance.

References

Aggarwal, R., & Samwick, A. (2003). Performance incentives within firms: The effect of managerial responsibility. *The Journal of Finance*, 58(4), 1613-1650.

Baker, G., Jensen, M., & Murphy, K. (1988). Compensation and incentives: Practice vs. theory. *The journal of Finance*, 43(3), 593-616.

Billor, N., Chatterjee, S., & Hadi, A. S. (2006). A re-weighted least squares method for robust regression estimation. *American Journal of Mathematical and Management Sciences*, 26(3-4), 229-252.

Brick, I., Palmon, O., & Wald, J. (2006). CEO compensation, director compensation, and firm performance: Evidence of cronyism? *Journal of Corporate Finance*, 12(3), 403-423.

Bulan, L., Sanyal, P., & Yan, Z. (2010). A few bad apples: An analysis of CEO performance pay and firm productivity. *Journal of Economics and Business*, 62(4), 273-306.

Chava, S., & Purnanandam, A. (2010). CEOs versus CFOs: Incentives and corporate policies*. Journal of financial Economics*, 97(2), 263-278.

Cheng, Q., & Farber, D. (2008). Earnings restatements, changes in CEO compensation, and firm performance. *The Accounting Review*, 83(5), 1217-1250.

Coles, J., Daniel, N., & Naveen, L. (2006). Managerial incentives and risk-taking. *Journal of financial Economics*, 79(2), 431-468.

Core, J., & Guay, W. (1999). The use of equity grants to manage optimal equity incentive levels. *Journal of accounting and economics*, 28(2), 151-184.

Core, J., & Guay, W. (2002). Estimating the value of employee stock option portfolios and their sensitivities to price and volatility. *Journal of accounting research*, 40(3), 613-630.

Dennis, D., & Mihov, V. (2003). The choice among bank debt, non-bank private debt, and public debt: evidence from new corporate borrowings. *Journal of financial Economics*, 70(1), 3-28.

Denise, D., & Robert, H. (2007). Executive compensation: Much ado about nothing? *Financial analysts journal*, 63(5), 1-12.

Eastman, M. (6 March 2018). Women on boards: One piece of a bigger puzzle [Web page]. Retrieved from https://www.msci.com/www/blog-posts/women-on-boards-one-piece-of-a/0872932779

Fama, E. (1980). Agency problems and the theory of the firm. *Journal of political economy*, 88(2), 288-307.

Fottrell, Q. (29 July 2019). The controversial theory why more women have replaced male CEOs since the Great Recession [Web page]. Retrieved from https://www.marketwatch.com/story/the-number-of-new-female-ceos-has-almost-doubled-since-2010-heres-whats-behind-that-dramatic-growth-2019-07-18

Girma, S., Thompson, S., & Wright, P. (2006). The impact of merger activity on executive pay in the United Kingdom. *Economica*, 73(290), 321-339.

Graham, J., Harvey, C., & Puri, M. (2013). Managerial attitudes and corporate actions. *Journal of financial economics*, 109(1), 103-121.

Huang, J. (2007). *Executive compensation and takeovers: impact of CEO's psychological and biological characteristics on risk-taking and performance*. PhD Thesis, Cranfield School of Management, UK.

Ikram, A., Li, Z., & MacDonald, T. (2020). CEO Pay Sensitivity (Delta and Vega) and Corporate Social Responsibility. *Sustainability*, 12(19), 7941.

Ittner, C., Lambert, R., & Larcker, D. (2003). The structure and performance consequences of equity grants to employees of new economy firms. *Journal of Accounting and Economics*, 34(1-3), 89-127.

Jensen, M., & Murphy, K. (1990). Performance pay and top-management incentives. *Journal of political economy*, *98*(2), 225-264.

Kale, J., Reis, E., & Venkateswaran, A. (2009). Rank-order tournaments and incentive alignment: The effect on firm performance. *The Journal of Finance*, 64(3), 1479-1512.

Khan, W., & Vieito, J. (2013). CEO gender and firm performance. *Journal of Economics and Business*, 67, 55-66.

Knopf, J., Nam, J., & Thornton, J. (2002). The volatility and price sensitivities of managerial stock option portfolios and corporate hedging. *The Journal of Finance*, 57(2), 801-813.

Lam, K., McGuinness, P., & Vieito, J. (2013). CEO gender, executive compensation and firm performance in Chinese-listed enterprises. *Pacific-Basin Finance Journal*, 21(1), 1136-1159.

Matolcsy, Z., & Wright, A. (2011). CEO compensation structure and firm performance. *Accounting & Finance*, 51(3), 745-763.

Mehran, H. (1995). Executive compensation structure, ownership, and firm performance. *Journal of financial economics*, 38(2), 163-184.

Mubeen, R., Han, D., Abbas, J., & Hussain, I. (2020). The effects of market competition, capital structure, and CEO duality on firm performance: A mediation analysis by incorporating the GMM model technique. *Sustainability*, 12(8), 3480.

Murphy, K. (1986). Top executives are worth every nickel they get. Harvard Business Review, 64(2), 125-132.

Murphy, K. (1999). Executive compensation. *Handbook of labor economics*, *3*, 2485-2563.

Kini, O., & Williams, R. (2012). Tournament incentives, firm risk, and corporate policies. *Journal of Financial Economics*, 103(2), 350-376.

Ortiz-Molina, H. (2007). Executive compensation and capital structure: The effects of convertible debt and straight debt on CEO pay. *Journal of Accounting and Economics*, 43(1), 69-93.

Ozkan, N. (2011). CEO compensation and firm performance: An empirical investigation of UK panel data. *European Financial Management*, 17(2), 260-285.

Peni, E. (2014). CEO and Chairperson characteristics and firm performance. *Journal of Management & Governance*, 18(1), 185-205.

Phan, N. (2021). Managerial Ability, Managerial Incentives and Firm Performance: Empirical Evidence from Vietnam. *The Journal of Asian Finance, Economics and Business*, 8(4), 193-200.

Sandberg, D. (16 October 2019). When women lead, firms win [Web page]. Retrieved from https://www.spglobal.com/en/research-insights/featured/when-women-lead-firms-win

Shen, C., & Zhang, H. (2013). CEO risk incentives and firm performance following R&D increases. *Journal of Banking & Finance*, 37(4), 1176-1194.

Smith, C. & Stulz, R. (1985). The determinants of firms' hedging policies. *Journal of financial and quantitative analysis*, 20(4), 391-405.

Stewart, E. (31 October 2018). Why struggling companies promote women: the glass cliff, explained [Web page]. Retrieved from https://www.vox.com/2018/10/31/17960156/what-is-the-glass-cliff-women-ceos

Stulz, R. (1984). Optimal hedging policies. *Journal of Financial and Quantitative analysis*, 127-140.

Ueng, C., & Wells, D. (2001). Corporate diversification, manager's incentive, and shareholder wealth. *,* 17(3), 13-22.

Wang, C., (2012). Board size and firm risk-taking. *Review of Quantitative Finance and Accounting*, 38(4), 519-542.