CEO Compensation and Risk Taking:

Evidence from the Pre-Crisis Banking Industry

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Abstract: We study the risk-vega relation for banks and find a significant, negative relationship between firm risk measures and vega conditional on moneyness (proxied by delta, vested options or CEO stock and option related wealth). Further, the negative risk-vega relation is driven by the 1999-2006 subperiod where deltas were generally high and the banks were deregulated. In contrast, the earlier 1993-1998 subperiod actually supports a positive risk-vega relationship. Finally, large banks reliably show a negative risk-vega relationship while the same cannot be said of small banks. Our results inform on two separate debates. First, merely granting stock-options to bank CEOs does not always encourage risk-taking in the banking industry. Option-incentivized risk taking also depends on other characteristics – bank size, CEO's exposure to stock price change (delta), and regulatory and market conditions. Also, option grants are often blamed for the excessive risk taking by the bank CEOs. However, our evidence indicates that risk-taking declined in stock options (as measured by vega) in the period leading to the financial crisis of 2008.

Keywords: CEO compensation, risk taking, compensation sensitivities

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1. **Introduction**

In a December 9, 2009 op-ed article in the *Wall Street Journal*, Gordon Brown and Nicolas Sarkozy opined that " [w]e have found that a huge and opaque global trading network involving complex products, *short-termism and too-often excessive rewards created risks that few people understood*."[1] Excessive CEO compensation of the largest financial firms is blamed as one cause of subprime crisis (Fung, et al., 2011; DeYoung, et al., 2013). Fung el al. (2011) listed three trends that aggravated the moral hazard of excessive risk taking. Overreliance on stock option grants in compensation provided an asymmetric pay-off for executives that encouraged excessive risk-taking. Next, too-big-to-fail also provided a floor to the losses thus exacerbating the moral hazard. Finally, compensation pegged to the size of the bank provided another reason for banks to grow larger. Notwithstanding this perception, there is limited scholarly evidence on the issue of bank CEO compensation and risk-taking, despite the subject's importance (see Mehran, 2004). Also, most evidence in corporate finance is not directly applicable, as it is based on nonfinancial firms (Armstrong and Vashishtha, 2012; Coles et al., 2006; Low, 2009). The present study contributes to the literature by investigating CEO compensation sensitivities and managerial risk taking in banking industry.[2]

In theory, equity based compensation is offered to motivate the CEO to act in the best interest of the stockholders (e.g., Jensen and Meckling, 1976; Haugen and Senbet, 1981). Stock and stock option grants – the two typical components of equity-based compensation – both increase CEO wealth in stock price thus aligning the interests of the CEO with stockholders.

[1] *Global Finance, Global Regulation* was authored by the then prime minister of Great Britain and the president of France. The text is partially italicized for emphasis.

[2] Borrowing from option pricing literature, sensitivity of the executive compensation to changes in the underlying stock price is known as delta. On the other hand, sensitivity of the executive compensation to changes in the stock return volatility is known as vega.

However, convexity[3] of option grants makes the compensation value rise if the underlying stock volatility goes up, thus incentivizing the CEO to undertake positive NPV and high-risk projects that she may otherwise forego (e.g. Amihud and Lev, 1981; Guay, 1999; Smith and Stulz, 1985; Coles et al., 2006).[4] This implication of option pricing theory suggests a positive relation between firm risk and the CEO compensation convexity (vega).

However, in option pricing theory, traded options are priced through arbitrage effectively implying risk neutrality (e.g., Black and Scholes, 1973; Merton, 1973), while a typical option-incented CEO is trading and hedging constrained, and quite likely risk-averse. Significant empirical evidence of early exercise of managerial stock options supports the hypothesis of managerial risk aversion.[5] Indeed, modeling under managerial risk-aversion reveals that the effect of vega on risk-taking may be asymmetric and conditional on the moneyness of the managerial stock options. For example, under constant relative risk aversion (CRRA), Carpenter's (2000) dynamic modeling shows that managers moderates portfolio risk when their asset value grows larger. However they may take excessive risk when options are deep out of the money (see also, Lambert et al., 1991; Ross, 2004; Parrino et al., 2005; and Lewellen, 2006).

[3] If the stock price were to decline, stock grants would lose money while stock option grants would only be out of the money, which gives rise to convexity of option pay-off.

[4] As Guay (1999) indicates, common stock, being options on the firm's asset in the presence of debt, must demonstrate some convexity. For most companies, however, this option is deep in the money, indicating a negligible vega relative to executive stock option grants. Thus, most studies treat the vega of stock option grants as zero.

[5] While option pricing literature recommends holding no or low-dividend options to maturity, early exercise of managerial stock options, driven by moneyness and volatility, is pervasive. Hemmer et al. (1996) find that early exercise is related to high volatility of option returns and is conducted to allow managers to diversify. Huddart and Lang (1996) show that "[E]xercise is strongly associated with recent stock price movements, the market-to-strike ratio, proximity to vesting dates, time to maturity, volatility, and the employee's level within the company." Heath et al. (1999) argue that "[C]ontrolling for economic factors, psychological factors influence exercise." Hall and Murphy (2002) demonstrate early exercise can result from a strong rise in the stock price. Bettis et al. (2005) corroborate the results of prior studies, and show that typical stock option exercise occurs four years before the expiration and about two years after vesting. See also evidence of the propensity of retirement-age CEOs to attract and accept acquisition offers with lower premiums (Jenter and Lewellen, 2011).

Therefore, these theoretical models suggest that one may expect a negative (positive) risk-vega relation when the options are in (out of) the money.

Accordingly, we study the risk-vega relation conditional on moneyness, while correcting for endogeneity through the use of lagged risk measures, firm and year fixed effects, and other control variables. In contrast, the extant literature has typically explored the option pricing motivated unconditional version of the relationship. Further, often the tests have assumed a contemporaneous relationship between vega and risk (Guay, 1999; Low, 2009) while we assume a lead-lag structure on compensation and risk-taking. This also allows us to use longer term view of risk, thus mitigating the endogeneity problem.

We have four key results for the risk-vega relationship for bank CEOs. First, exploring the unconditional risk-vega relation consistent with existing literature, we find total and systematic risk to decline in vega during the sample period (1992-2006). The negative impact of vega on risk lends some support to the arguments of Ross (2004) and Lewellen (2006), and could be motivated by the risk-averse behavior of undiversified CEOs (Lambert et al., 1991; Carpenter, 2000; Hall and Murphy, 2002). Second, consistent with the abovementioned models of CEO risk taking under risk aversion, we find a significant, negative relationship between firm risk measures and vega conditional on moneyness (proxied by delta, vested options or CEO stock and option related wealth). The risk reduction in vega is completely accounted for by the sub-sample of firms where the CEO has more to lose by the downward movement of the stock price (CEOs with higher delta or stock and option related wealth). Next, we decompose the vega into vested, unvested, and new grant components and find that the negative impact is due to the vega of the existing vested option grant (more likely to be high in moneyness and more likely to be early exercised), while the existing unvested grant and current grant vegas have insignificant effect on

risk taking. Third, the negative relationship of the existing vested grant vegas and risk taking is fully accounted for by the 1999-2006 subperiod (a subperiod characterized by high average CEO delta and vega). By contrast, the relationship is actually positive for all three risk measures (and significant for systematic risk) for the earlier 1993-1998 subperiod (characterized by low average CEO delta and vega). Fourth, there is evidence that large banks are more aggressive risk reducers in vega than small banks.

Our first contribution is the study of a conditional risk-vega relation driven by CEO risk aversion, in contrast to the unconditionally positive risk-vega relation motivated by option pricing theory (e.g., Black and Scholes, 1974; Merton, 1973). To our knowledge, this is the first study to empirically explore a conditional specification. The assumption of managerial risk aversion is reasonable, given the pervasive empirical evidence of early exercise of executive stock options, based on the known characteristics like moneyness, vesting, recent price run up and volatility (Heath et al., 1999; Huddart and Lang, 1996; and Bettis et al., 2005).

Our second contribution is on methodology. Himmelberg et al. (1999) and Coles et al. (2011) argue that regression of performance on governance can be problematic, in the absence of clear structural models, due to unobserved heterogeneity and simultaneity. From the methodological perspective, we know that all variables of interest are generally endogenous, and the theory is not a perfect guide in choosing appropriate control variables without structural modeling. This gives rise to the potential problem of omitted variables or not being able to find suitable instruments that are exogenous or truly predetermined. Our conditionally asymmetric risk-vega prediction alleviates these concerns as it is unlikely for the omissions or unobservable firm heterogeneity to induce a negative relationship between vega and firm risk for high delta firms and an insignificant or positive relationship for low delta firms (for a similar reasoning, see Armstrong

and Vashishtha, 2012). Therefore, by virtue of our particular prediction, our study can be viewed as being more robust compared to prior studies.

Our third contribution is in lending clarity to the risk-vega relationship for the banking firms. Note that the evidence on risk-vega relation for banks is limited and mixed, as Fahlenbrach and Stulz (2011) find no support for a positive risk-vega relation while others find some support for the relationship of vega with risk policies, risky acquisition, and the magnitude of the federal financial assistance to the banks during the 2007-2009 period (DeYoung et al., 2009; Hagendorff and Vallascas, 2011; and Gande and Kalpathy, 2011). Also, the generally strong support in corporate finance studies cannot be applied to banking as these studies routinely exclude banks due to their regulation and leverage (Knopf et al., 2002; Rajgopal and Shevlin, 2002; Coles et al., 2006; Low, 2009; Chava and Purnanandam, 2010; and Armstrong and Vashishtha, 2012).

The paper is organized as follows. Section 2 reviews the literature and develops the hypotheses. Section 3 describes our data and methodology. Section 4 presents our results and Section 5 concludes.

2. Literature Review and Hypothesis Development

The practice of equity-based compensation has gained prevalence over time (e.g. Core et al., 2003; Hall and Liebman, 1998; Hall and Murphy, 2002). Accordingly, considerable literature exists in corporate finance with samples excluding banks and utilities, with the first-stage studies focusing on the relationship between various measures of the managerial compensation and firm performance and policies.[6] Core and Guay's (1999, 2002) one-year approximation of

[6] See, for example, the evidence on the relationship of leverage and firm performance and the percentage ownership by the CEO (Mehran, 1992, 1995), risk management and options held by the managers (Tufano, 1996; Rogers, 2002), leverage and the options holdings of the managers (Berger et al., 1997), total risk and managerial options

compensation sensitivities allowed researchers to focus, more directly, on the delta and the vega of the executive compensation packages. Knopf et al. (2002) provide early evidence on firm hedging using Core-Guay delta and vega for nonfinancial firms. They find that hedging is positive related to delta while it is negatively, albeit insignificantly, related to vega. Rajgopal and Shevlin (2002) find vega to be positively related to exploration risk taking for a sample of oil and gas firms.

Coles et al. (2006) demonstrate higher compensation vega leads to riskier firm policies and stock price volatility, for non-financial and non-utility firms. This positive relationship is also supported by international evidence. Based on the sample of nonfinancial firms listed on the Taiwan Stock Exchange and the Gre Tai Securities Market (an over-the-counter market), Wu et al. (2012) show that that managerial risk-taking incentive proxied by managerial option vega to delta ratio is positively to the number of unexercised stock options scaled by total shares outstanding and managerial risk-incentive is negatively related to hedging derivative holding, implying option compensation promotes risk-taking incentive and higher risk-taking. Low (2009) uses the difference-in-difference approach for an exogenous shock to show that lower vega leads to reduced risk-taking by the CEO, but the evidence on delta and risk taking is unclear. Chava and Purnanandam (2010) find that vega is risk enhancing while delta is risk reducing because the CEO vega (delta) is positively (negatively) associated with leverage, but negative (positively) associated with cash levels. Armstrong and Vashishtha (2012) find a positive association between the CEO compensation vega and a measure of firm systematic risk. Therefore, in this

grant for converting thrifts (Schrand and Unal, 1998) and for a general sample (DeFusco et al., 1990), stock return volatility and CEO compensation vega (Guay, 1999; and Cohen et al., 2000), Tobin's Q and managerial equity ownership (Morck et al., 1988), stock repurchases and option based compensation (Jolls, 1998), and risk-enhancing acquisitions and stock and option compensation (Agrawal and Mandelker, 1987), to name a few.

stream of literature with non-banking samples, compensation vega is risk-enhancing while the effect of compensation delta is largely mixed.[7]

The development of the literature in banking on compensation and risk-taking parallels the general stream discussed earlier, with several studies focusing on different measures of compensation: managerial ownership measure (Saunders et al., 1990; Gorton and Rosen, 1995; Anderson and Fraser, 2000; Knopf and Teall, 1996); managerial ownership and ratio of option granted to cash compensation (Houston and James, 1995); equity-based compensation as a fraction of total compensation (Brewer et al., 2003); managerial ownership as a proportion of firm value and option portfolio value as a fraction of total compensation paid (Chen et al., 1998, 2006). Focusing directly on risk-vega relation, DeYoung et al. (2013) find a positive association between some risk policies and vega, but not for the others. Hagendorff and Vallascas (2011) study acquisitions to show that high vega bank CEOs engage in risky acquisitions. Conditioning on the financial crisis of 2008, Gande and Kalpathy (2011) find a positive (negative) association between the vega (delta) and the magnitude of the federal financial assistance to the banks during the 2007-2009 period, while Fahlenbrach and Stulz (2011) find no association between vega and the subsequent stock return and accounting measures of performance during the subprime crisis period. Thus, unlike corporate finance studies, banking studies do not provide strong support for a positive risk (or risk policies) and vega relation. We term the all abovementioned studies – that view risk-vega relationship as monotonically increasing, regardless of other known characteristics – as unconditional risk-vega relationships.

[7] Theoretically, one can expect ambiguity in the effect of delta on risk taking as a higher delta can increases the management exposure to price declines, while on the upside, delta is incentive compatible for risk raking as it increases managerial wealth (Smith and Stulz, 1985; Guay, 1999; John and John, 1993; Coles et al., 2006; Low, 2009; Chava and Purnanandam, 2010; and Armstrong and Vashishtha, 2012).

In contrast, the key point in this study is that the risk-vega relationship is likely asymmetric, conditional on moneyness – as shown in the theoretical work with managerial risk aversion. Under non-increasing absolute risk aversion in wealth, Lambert et al. (1991) demonstrate that manager will turn risk-averse with the increase in the risk of option's payoff when the option is in the money. Ross (2004) similarly finds "conditions under which incentive schedules make agents more or less risk averse." Using a CRRA utility, Parrino et al. (2005) find that in-the-money options make managers more risk averse than do out-of-money options Similarly, Lewellen's (2006) CRRA utility model shows that "options can substantially decrease the executive's preference for risk and debt, particularly if they are in the money." She also found strong empirical support for the above assertion in leverage choices of CEOs. This stream of literature clearly establishes risk-vega relationship to be asymmetric and conditional on the moneyness of the compensation grant.[8]

Additionally, theoretically strong arguments exist why bank risk-taking could be lower compared to non-banks, due to the banking industry's unique regulatory and balance-sheet structures. John et al. (2000) propose that compensation packages, instead of capital ratios, should be the key focus for setting bank regulation and FDIC insurance premium– a potential curb on risk-taking compared to the non-banking firms. Booth et al. (2002) conclude that bank regulation constrains managerial independence and reduces the value of internal monitoring. This can be interpreted as an argument for lower pay-performance sensitivity in banking compared to other industries. John and Qian (2003) argue that regulatory monitoring and

[8] Similarly, Hall and Murphy (2002) employ certainty-equivalent (CE) modeling to explain various stylized facts about CEO compensation. Other studies with similar risk averse modeling include Detemple and Sundaresan (1999), Meulbroek (2001), and Dittmann and Maug (2007).

enhanced incentives for risk-shifting (owing to higher leverage) imply lower pay-performance sensitivity for banks relative to non-banks.

Academic studies typically posit an unconditional risk-vega relation. In contrast, we explore an asymmetric risk-vega relation, conditional on moneyness, which is motivated by managerial risk-aversion based studies. To be consistent with the existing literature, we first test the unconditional risk-vega relation. As we believe the relationship to be positive or negative depending on moneyness, we pose an agnostic null hypothesis for the unconditional test as below. This test will also allow us to compare our results with the existing literature.

H1: Bank risk is unrelated to the vega of the CEO compensation portfolio.

We now proceed to our main hypothesis that the risk-vega relation is conditional on moneyness, in line with the studies cited earlier which argue that risk-averse managers may reduce risk in in-the-money options while increasing risk in out-of-the-money options (Lambert et al., 1991; Carpenter, 2000; Ross, 2004; Parrino et al., 2005; Lewellen, 2006). However, before proceeding further, a brief discussion of how to measure moneyness is in order. While the moneyness of a single option series is relatively easy to compute through the ratio of market to exercise prices, the task become complicated for an executive option portfolio as there is a multiplicity of options maturities and exercise prices granted in the current and previous years and the information on exercise prices, maturities, and past exercises is not fully available (see the assumptions underlying the one-year approximation in Core and Guay (2002)). Further, the average price to strike ratio is not really meaningful when options vary greatly in exercise prices and maturities. Thus we use three alternative proxies for moneyness as discussed below.

Our first proxy for moneyness is the CEO compensation portfolio delta.[9] Option pricing theory shows that delta monotonically increases from zero to one in moneyness with the increase in the stock price (see also the Figure 1 of Core and Guay (2002) for a clear exposition). As Ross (2004) demonstrates, a high delta can motivate a risk-averse CEO to reduce risk. A risk-averse CEO may therefore be less willing to increase risk in response to vega when the portfolio delta is high, compared to the case when the portfolio delta is low (See also Smith and Stulz, 1985).

Our second proxy for moneyness is the vested grant. Typically, a stock option grant is either current or existing (granted in a previous year). Some existing grants, typically older, may be vested while more recent and current grants would generally be unvested. Now, by virtue of being older, a vested grant is extremely likely to be in-the-money (indicating higher delta or moneyness) in comparison to an unvested or new grant, thus indicating that the vested component of the portfolio will typically have high delta. Therefore, in general, vested grant becomes a proxy for the high delta part of the compensation portfolio.[10] Further, another strong behavioral factor may be at play here as a vested grant is practically money in hand because its value can be realized through an exercise.[11] By comparison, an unvested grant would be perceived as something less tangible and riskier. Pervasive evidence exists that investors frequently choose certain gain, which indicates aversion to the risk of holding the position.[12]

[9] Chava and Purnanandam (2010) argue that delta can have two conflicting effects – a positive incentive effect by linking the manager's performance to the firm and a negative risk aversion effect as it exposes the manager to the downside. Their empirical results show that managers reduce risk in delta while they increase it in vega. This view of delta parallels our argument.

[10] Though we are reluctant to preview our findings, indeed the results show it to be the case in summary statistics.

[11] There, though, may be additional bank or regulatory restrictions and tax related concerns on exercise and trading.

[12] There exists considerable evidence of disposition effect among investors (Shefrin and Statman, 1985; Lakonishok and Smidt, 1986; Odean, 1998; and Grinblatt and Keloharju, 2001). This effect suggests that investors quickly sell their winners while they hold on to the losers. The effect is motivated by the prospect theory of Kahneman and Tversky (1979) which defines utility as concave in gains and convex in losses. In this context, an

Indeed, Huddart and Lang (1996) show employees typically exercise vested options years before expiration, commonly sacrificing half of the Black–Scholes value. Further, a CEO's position in options and/or stocks is often far greater than that of a typical investor and the position is quite undiversified as well. In addition, the human capital does not provide diversification to the CEO as it normally does in the case of a typical investor. Besides, bank policies, tax considerations, and regulatory strictures such as insider trading rules, signaling aspects of a sale, and the price impact of large block sales, may further constrain the CEO from exercising options and/or selling stock. Therefore, one might expect the CEO to be more risk-averse with regard to the vested positions that are already in the money.

Our third and last proxy for moneyness is the executive wealth tied to the firm as measured by the value of the CEO's stock and option portfolio. Generally, the larger the CEO wealth tied to the firm, the greater the dollar loss to the CEO if the firm stock price were to decline. Indeed, Sullivan and Spong (2007) demonstrate that earnings volatility declines in managerial wealth concentration in the bank. Therefore, CEO wealth tied to the firm should influence risk-taking through risk aversion.

As discussed, this study resorts to the use of proxies of moneyness, as it is not practically possible to accurately measure moneyness of the executive compensation packages. Accordingly, below, we phrase a less stringent null hypothesis which captures the essence of the abovementioned risk-averse behavior, instead of the rigorous form that argues that executive risk taking will be positive (negatively) related to vega when the options are out of the money (in the money).

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investor would have certain gain if he were to sell the stock or the CEO were to exercise the option immediately to sell the stock, against an uncertain gamble.

H2: Bank risk-vega relation is conditionally asymmetric in moneyness, with an algebraically lower coefficient on vega in moneyness.

3. Methodology, Sampling, and Data Description

In this section, we start with the regression model and the definitions of the variables, then we explain the sample and data, and in the end we present the summary statistics.

3.1. Methodology and variable definition

Following Coles et al. (2006), we adopt the regression model below to test the relationship between risk and CEO compensation sensitivity to volatility (vega):

Equation 1

$$Risk_t = \alpha_0 + \alpha_1 Vega_{t-1} + \alpha_2 Delta_{t-1} + \alpha_3 CashCompensation_t + \alpha_4 CEOownership_t + \alpha_5 Size_t + \alpha_6 Market-to-book_t + \alpha_7 BookLeverage_t + \alpha_8 CEOTenure + \alpha_9 ROA_t + \alpha_{10} Risk_{t-1} + YearDummies + FirmDummies + \varepsilon_t$$

In the above equation, we use all three market based risk measures – total, systematic, and idiosyncratic as dependent variables. We constructed total risk, systematic or market risk, and unique or idiosyncratic risk measures following the methodology of Low (2009).[13] We match these three risk measures for a calendar year with the sensitivities from the previous calendar year. This is consistent with the hypothesis that the board of directors, based on the investment opportunity set of the firm, alters the compensation sensitivities using the new option grant and the CEO responds with risk-taking in the following year.

[13] Total risk is the natural logarithm of the annualized variance of daily returns over the calendar year. Systematic risk is the natural logarithm of the annualized variance of the predicted portion of the market model. Five leads and five lags of market returns are added to the market model regression of stock return on CRSP value-weighted market portfolio return to take in account nonsynchronous trading. Unsystematic risk is the natural logarithm of the annualized variance of the residuals from the market model. Conveniently, all banks in our sample closed their books at calendar year end eliminating the tedious need for distinction between fiscal and calendar years.

Core and Guay (2002) define vega (delta) as CEO wealth sensitivity with respect to a one percent change in volatility (one percent change in stock price). Vega (delta), the CEO compensation sensitivities of volatility (stock price change) is the primary independent variable. We also distinguish between newly granted and existing options. Furthermore, existing options are classified into vested and unvested options. As a result, vega of the CEO portfolio includes vega of newly granted, existing unvested and vested options which are computed using the Core and Guay (2002) one-year approximation. If the coefficient of vega is not significant, Hypothesis 1 is supported. In addition, as explained in last section, vega of existing vested options is used as a proxy of moneyness. If the coefficient of existing vested vega drives the result, it indicates that moneyness matters and Hypothesis 2 is supported.

Vega is of interest here, while we shall include delta, the compensation sensitivity to stock price as a control variable (Coles et al., 2006). Similar to the decomposition of total vega, total delta is composed of unvested and vested. Unvested delta includes that from newly granted option, existing unvested option and restricted stocks. Vested delta consists of that from existing vested option and common stocks. Total delta is used as another proxy of moneyness. If the coefficient of vega is significantly negative and it is driven by the subgroup with higher delta, it shows that a higher delta makes CEO more risk-averse and Hypothesis 2 is supported.

Following Coles et al. (2006), we use CEO tenure and CEO cash compensation to proxy for the CEO's level of risk aversion. CEO tenure is the number of years as the CEO. CEO cash compensation is the sum of salary and bonus earned by a CEO (also available from ExecuComp). CEOs with longer tenure are considered more risk-averse because they are less diversified in terms of wealth and human capital. There are two alternative arguments for the relationship between risk and cash compensation. CEOs with higher cash compensation are perceived as

more entrenched and more risk-averse (Berger et al., 1997). On the other hand, Guay (1999) argues that CEOs with higher cash compensation are less risk-averse because they have more money to invest outside the firm and his/her wealth is more diversified. We also include CEO ownership as a control variable. CEO ownership is defined as the percentage of outstanding common stocks held by the CEO.

Following Coles et al. (2006), we also include market to book ratio of equity, book leverage ratio and firm size as additional control variables. Market-to-book is the market capitalization of the equity divided by the book value of equity. Higher market to book ratio indicates more growth opportunities and is expected to be positively related to firm risk. Book Leverage is the book value of the leverage ratio of the bank. ROA is the net income before extraordinary items and discontinued operations divided by total assets. Size is the market capitalization of the equity.

In all regressions of risk measures on sensitivities, we take the following approach. To control for the endogeneity between risk measure and CEO compensation sensitivities, we include the lagged measure of risk, conventional control variables, and firm and year fixed effects – common remedies employed in the literature (Himmelberg et al., 1999). The subscript t-1 indicates that the lagged value of the variable is being used. As Coles et al. (2011) note, including the firm fixed effects captures constant (or slow-moving) components of variation in data for each firm leaving less variation for the model to explain, thus potentially compromising the power of the test by diminishing the ability to reject the null hypothesis of no relationship. A similar statement can be made for year fixed effects. Nevertheless, if we do find a rejection, the result would still be valid and perhaps even more significant as it surmounts a bias towards the

null hypothesis.[14] Also, by positing an asymmetric relation conditional on moneyness, we impart further methodological robustness to our analysis as discussed in the introduction (Armstrong and Vashishtha, 2012). Cash compensation and CEO tenure are included to capture the risk preference of CEO. Following Saunders et al. (1990), we include CEO ownership variable to control for the incentive alignment effect on risk taking. As motivated by Guay (1999), market-to-book equity captures the investment opportunities. The bank size and leverage are expected to affect risk and compensation and are included as controls as well. As used by Coles et al. (2006), a high ROA may also signal growth opportunities. Standard errors are clustered by firms in order to adjust the correlation across years for a given firm.

3.2. Data and sampling

Information on CEO compensation is obtained from Standard and Poor's ExecuComp database. First, we retrieve all commercial banks and saving institutions from ExecuComp database during 1992 and 2005. Therefore, the last year we compute the vegas and deltas for is 2005. We choose to cut off the sample in 2005 to avoid the financial crisis years. We seek to study the relationship between a bank's risk measures – total, systematic or market, and unique or idiosyncratic risks – in a given calendar year in the light of the compensation package offered in the previous calendar year, under the assumption that the compensation package is first revealed to the CEO and then the CEO sets about finding and implementing new projects and activities. Therefore, the last year we use the stock return data to compute risk measures is 2006, as including later years would risk contamination from the financial crisis. There are 1385 firm-

[14] Coles et al. (2011) investigate the effect of endogeneity on common empirical methodologies. Table 10 of their study demonstrates that, while lacking power, fixed effects regressions (with or without control variables) "adequately controls for the endogeneity problem." On the other hand, the simultaneous equations model is found to be very sensitive to the choice of instruments, even while using model-generated dependent variable (not actual empirical values though, Table 11 of their paper).

year observations for 190 banks with available CEO compensation data. We merge these observations with risk measures constructed from CRSP and other firm-specific variables from COMPUSTAT during 1993-2006. While the risk measures are our dependent variables, we include the lagged value of the risk measure as an independent variable to address endogeneity between risk and CEO compensation sensitivity (Coles et al., 2006). After deleting the observations with missing variables, we have 1097 firm-year observations from 177 banks with complete data for both CEO compensation sensitivity measures, risk measures and the other firm specific variables.

3.3. Sample descriptive statistics

We constructed four sets of variables: CEO compensation sensitivities, other CEO-related variables, risk measures, and firm-specific control variables. Table 1 presents the sample statistics for the variables in our analysis. Panel A describes all CEO compensation and other CEO related variables. The mean of vega (delta) is $154,000 ($446,000), which is much larger than the median value of $55,000 ($228,000). It suggests that some CEOs in the sample have much larger vegas and deltas than others. We find that the delta of unrestricted common stocks is the largest component with mean (median) of $190,000 ($88,000). To better appreciate the magnitudes of delta and vega relative to cash compensation, we find that a 3.5 percent increase in stock price would provide the CEO with nearly the same wealth as cash compensation going by the mean, though the applicable increase would be nearly 4.6 percent in the median. For vega, the stock would have to add about 10 percent to its volatility to make the CEO nearly as much wealth as cash compensation in the mean. One must bear in mind the caveat that we are making linear projections to gain some preliminary understanding.

Table 1: Descriptive Statistics of the Sample

This table reports summary statistics for our sample during 1993-2006. Panel A-C present summary statistics on CEO related variables, bank risk measures, and other firm-specific variables, respectively. Panel D presents the correlation matrix of primary variables. In Panel A, Delta is CEO option and stock holding value sensitivity with respect to a 1% change in stock price. Delta can be divided into two components: Unvested delta is the value sensitivity of all unvested stocks and options including newly granted options (Delta, newly granted options), existing unvested option (Delta, existing unvested options) and restricted stock (Delta, restricted stock); Vested delta is the value sensitivity of all exercisable stocks and options including that of existing vested option (Delta, existing vested option) and common stock (Delta, common stock). Vega is CEO option value sensitivity with respect to a 1% change in stock-return volatility. Vega has two components: Unvested vega is the value sensitivity to stock return volatility of all unexercisable options including that of newly granted option (Vega, newly granted option) and existing unvested option(Vega, existing unvested option); Vested vega is the value sensitivity to stock return volatility of all exercisable options which are existing vested options. Cash compensation is the sum of the base salary and bonus earned by CEO. CEO stock and option wealth is defined as the sum of the estimated value of CEO options and stocks compensation. CEO ownership is the shareholding proportion of CEO relative to the number of common shares outstanding of the bank. CEO tenure is the number of years of being CEO. Panel B reports the sample statistics of risk measures. Total risk is the natural logarithm of the annualized variance of daily returns over the fiscal year. Systematic risk is the natural logarithm of the annualized variance of the predicted portion of the market model. To adjust for non-synchronous trading, five leads and five lags of market returns are added to the market model regression of stock return on CRSP value-weighted market portfolio return. Unsystematic risk or unique risk is the natural logarithm of the annualized variance of the residuals from the market model. Panel C presents the sample statistics of key firm specific control variables. Market to book ratio is the ratio of market value of equity to book value of equity. Book leverage ratio is the ratio of total debt to total assets. ROA is the net income before extraordinary items and discontinued operations divided by total assets. This quotient is then multiplied by 100. The book value of assets is used to proxy for firm size. In Panel D, ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Panel A: CEO related variables								
Variable	N	Mean	Dev	Min	25^{th}	50^{th}	75^{th}	Max
Total Delta ($millions)	1097	0.446	0.574	0.008	0.101	0.228	0.555	4.931
Delta, unvested	1097	0.115	0.181	0.000	0.017	0.047	0.144	1.575
- newly granted option	1097	0.029	0.056	0.000	0.003	0.011	0.033	0.775
- existing unvested option	1097	0.065	0.106	0.000	0.008	0.025	0.079	1.183
- restricted stock	1097	0.021	0.059	0.000	0.000	0.000	0.015	0.667
Delta, vested	1097	0.331	0.446	0.000	0.068	0.167	0.392	3.442
- existing vested option	1097	0.141	0.244	0.000	0.021	0.056	0.145	2.952
- common stock	1097	0.190	0.284	0.000	0.031	0.088	0.221	2.758
Total Vega ($millions)	1097	0.154	0.269	0.000	0.021	0.055	0.158	2.078
Vega, unvested	1097	0.092	0.154	0.000	0.012	0.032	0.100	1.358

- newly granted option	1097	0.036	0.068	0.000	0.004	0.013	0.041	0.849
- existing unvested option	1097	0.056	0.099	0.000	0.005	0.018	0.061	0.798
Vega, vested	1097	0.063	0.140	0.000	0.004	0.014	0.054	1.198
Cash Compensation (Salary + Bonus, $ milllions)	1097	1.558	1.565	0.000	0.703	1.049	1.820	14.000
CEO stock and option wealth ($ millions)	1097	32.060	42.163	0.146	6.866	16.264	39.151	354.714
CEO Ownership (%)	1097	9.516	13.850	0.000	1.684	3.944	12.170	89.230
CEO tenure (years)	1097	7.097	5.397	0.000	3.000	6.000	11.000	29.000
Panel B: Risk Measures								
Total Risk	1097	6.516	0.656	4.658	6.04	6.488	6.949	9.522
Systematic risk	1097	5.128	0.901	2.138	4.544	5.164	5.75	8.2
Unsystematic risk	1097	6.129	0.718	4.299	5.662	6.096	6.625	9.401
Panel C: Firm Control Variables								
Market to book ratio	1097	2.303	1.069	0.529	1.600	2.080	2.724	14.360
Book leverage ratio	1097	0.915	0.0283	0.602	0.906	0.919	0.93	0.967
ROA	1097	1.192	0.446	-1.664	0.957	1.184	1.419	4.315
Book Value of Total Assets($Millions)	1097	49803	127155	567.4	5595	13287	40571	1460000

Our sample period covers 14 years during which banking industry has gone through two major regulatory changes. Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994 permitted bank holding companies to acquire bank in other states and convert out-of-state subsidiary banks into branches. Financial Services Modernization Act of 1999 eliminated restrictions on banks, insurance companies, and security firms entering into each other's areas of business. We plot the cross-sectional means of all CEO vegas and deltas over the years in Figures 1 and 2, respectively. Consistent with the literature, both figures show that CEO compensation sensitivities rose rapidly after 1994. Total vega increases from less than $50,000 in 1994 to peak around $280,000 in 2002 while the total delta started from a base of $109,940 to peak around $716,000 in 2004. Vega of existing vested options increased more than other component of vegas, from $14,880 in 1992 to $138,470 in 2004. There is an interesting pattern at work. After the first deregulation of 1994, new grant vegas gradually increased until 2000. However, after the year 2000, the new grant vegas roughly remain unchanged or slightly decreased. If boards calibrate vegas to encourage risk taking, it would appear that while boards seemed to encourage risk taking through interstate banking after the first deregulation in 1994, they did not similarly react to the second deregulation of activities restriction in 2000. It is likely, though, that the boards could be raising the sensitivities in anticipation of the second deregulation.

We compared our sample statistics to those in Coles et al. (2006) whose sample includes all firms excluding finance companies and utilities during 1992-2002. Our mean banking sample delta ($446,000) is comparable in level to Coles et al. (2006) delta of $600,000, and this equality of order holds for the median delta as well. However, our mean sample vega of $154,000 is nearly twice the vega of $80,000 presented in Coles et al (2006), with a similar ratio for the

medians as well ($55,000 against $34,000). Therefore, compensation policies for the banking industry appear to rely more heavily on incentivizing risk-taking compared to non-banking industries.[15] An average bank CEO earns about 37 percent more than her non-banking counterpart in cash compensation ($1,558,000 against $1,140,000). Also, an average bank CEO owns about 9.52 percent of the bank while the median is 3.94 percent. The ownership and tenure figures appear to provide some *prima facie* evidence of entrenchment, and the mean tenure of seven years equals that of Coles et al. (2006). While other authors do not provide figures on the break-down of mean total vega and delta, we find that deltas of existing vested options and common stock comprise about 74 percent of total mean delta, while vegas of existing unvested and newly granted options are nearly 60 percent of the mean total vega. The seeming contradiction in the magnitudes of vested and unvested sensitivities is reasonable as delta increases in moneyness (typically higher for vested or older options) while vega is high near the money (for the new grant and the unvested or newer grant) (see, for example, Core and Guay (2002) for empirical evidence). Also, this corroborates our earlier assertion that the vested grant can be used as a proxy for the high-moneyness or high-delta grant.

We also present measures of total, market, and unsystematic risk (natural logarithms of the annualized variance based on daily return) in Panel B of Table 1. Control variables for the firm include market to book ratio, book leverage ratio, return on assets, and book value of total assets, and their statistics are presented in Panel C of Table 1. Expectedly, the leverage ratio for

[15] These banking mean total delta, vega, and current compensation also approximate those presented by DeYoung et al. (2009).

banks has a mean of 92% which is significantly higher than their non-banking peers, while the average market to book ratio of 2.3 is comparable to the value of 2.24 in Coles et al. (2006).[16]

Panel D of Table 1 presents the correlation coefficients between the various variables. Predictably, the risk measures are strongly correlated with one another. Also, the correlation between total vega and total delta is 0.78 which implies that they strongly tend to move together. This would make sense as both measures largely depend on the size of the new and existing option grants (in value or number). Generally, the correlations between the firm control variables, and the risk measures and the compensation sensitivities are strong and significant. This once again is expected as the control variables are included to proxy for the investment opportunity of the firm – crucial to endogenous determination of the compensation sensitivities and the subsequent risk.

[16] We reviewed the Bank Holding Company database from Federal Reserve Bank of Chicago to ensure that the banks in our sample are not excessively burdened with regulatory constraints which may limit the manager from implementing the desired policy. The mean (median) leverage ratio is 8.5% (8.2%). According to FDIC Improvement Act in 1991, a bank's capital adequacy is assessed by its capital ratio. If a bank's leverage ratio is 5% or more, and the total risk-based and Tier 1 risk-based ratios are above 10% and 6% respectively, it is well capitalized and is placed in the highest capital adequacy zone. Generally banks in this zone are free from intervention by regulators. A vast majority of banks in the sample are well-capitalized and are not affected by Prompt Corrective Action Provisions of the FDIC Improvement Act of 1991. Their asset growth, acquisition, branching, and dividend policy and financing policy are not under the monitoring of regulators, thus leaving the CEO free to implement the desired policy.

Table 1 cont. Panel D. Correlation Matrix of Sensitivities, Risk Measures and Control Variables

	Market Risk	Unique Risk	Delta	Vega	Cash Comp.	CEO ownership	Tenure	Book Value of Assets	Market to Book ratio	Leverage	ROA
Total Risk	0.673***	0.934***	-0.013	-0.130**	0.001	0.054*	-0.019	-0.103**	0.215***	0.203***	-0.090**
Market Risk	1	0.397***	0.213***	0.135***	0.242***	-0.051*	0.011	0.094***	0.300***	0.117***	0.037**
Unique Risk		1	-0.112**	-0.251**	-0.122**	0.093***	-0.017	-0.182**	0.137***	0.201***	-0.143**
Delta			1	0.776***	0.527***	0.142***	0.113***	0.524***	0.212***	0.011	0.188***
Vega				1	0.613***	-0.133***	0.007	0.709***	0.059*	-0.010	0.161***
Cash Comp.					1	-0.155***	-0.037	0.635***	0.140***	0.099***	0.115***
CEO ownership						1	0.273***	-0.183***	0.029	0.035	-0.040
Tenure							1	-0.071**	-0.034	-0.109**	0.033
Book Value of								1	-0.067**	0.077**	-0.049
Market to Book ratio									1	0.128***	0.412***
Leverage										1	-0.226**

4. Empirical Results

The results of our unconditional and conditional tests of the risk-vega relation are below.

4.1. Unconditional test of managerial risk taking and vega

Before we proceed with our key conditional tests of risk-vega relationship, we first perform unconditional tests of the same, in accordance with the existing literature for the purpose of comparison. Table 2 presents unconditional regressions of the risk measures on the lagged values of total vega, total delta, and the cash compensation of the CEO. The vega and delta calculations include all stock and option ownership, vested and unvested, at the end of the previous year. The regressions show negative coefficients on vega implying that an increase in

the risk sensitivity of the compensation package of the CEO leads to a reduction in all three measures of risk in the coming year, with significance level at 95% (99%) for total (systematic) risks. This result is different from what Guay (1999), Low (2009), and Coles et al. (2006) observed in their sample of nonfinancial firms.[17] Nevertheless, there is similarity here with the evidence of Fahlenbrach and Stulz (2011) in that the vega is not found to be unequivocally risk increasing.[18] Further it may be consistent with the prediction of Lewellen (2006) that risk-averse CEOs may reduce risk in vega and the effect of convexity on risk may not be construed as unequivocally positive. There is another key methodological reason that may have bearing on why our results differ from those in extant literature. While we study the risk in the year following the grant year, Guay (1999) studies the risk measure in the 240 day period surrounding the grant while Low (2009) and DeYoung et al. (2013) employ risk measures from the contemporaneous fiscal year. Employing non-financial firms, Coles et al. (2006) do test the relationship between total risk and the lagged values of the compensation sensitivities and find a positive relationship.

The coefficients on delta are always significantly positive for all three risk measures. Theoretically, the effect of delta on risk is not unequivocal and it is included in the regression as control variables, along with cash compensation and CEO ownership.[19] Also, note that we do not hypothesize on the direct role of delta in risk-taking. Instead we posit a conditional relationship between risk-vega contingent upon moneyness (delta being a proxy for the

[17] Also, see Hagendorff and Vallascas (2011), DeYoung et al. (2009), and Gande and Kalpathy (2011), among others.

[18] Anderson and Fraser (2000) have a parallel result that shows risk taking to be negatively related to managerial stockholding in early 1990s.

[19] Guay (1999) argues that higher cash compensation could indicate a more diversified manager with lower risk aversion. Higher delta yields a less diversified manager as the wealth become more subject to stock price movement. However, John and John (1993) indicate that higher delta may encourage risk-taking. Therefore, Coles et al. (2006) employ delta merely as a control since the "effects, however, are unclear." Similarly, cash compensation is treated as a control variable.

moneyness). In summary, from the entire sample, there is strong evidence that vega motivates managers to reduce risk, irrespective of which risk measure is employed.

4.2. Robustness checks on the unconditional test of managerial risk taking and vega

The evidence in the previous section shows that vega negatively affects subsequent risk taking by the bank CEO. However, collinearity may be obfuscating our regression, and those of the previous studies, as total vega and delta have a correlation of 0.78. This correlation is to be expected as both are related to the number of stocks and options granted to the manager. Indeed, to check this intuition, we calculated the correlation between delta, vega, and managerial stock and option related wealth (defined as the sum of all option and stock values held by the CEO). Delta and managerial stock and option related wealth have a correlation of 0.96. The correlation between vega and managerial stock and option related wealth is 0.60. While the variance inflation factors associated with the regressors, in Table 2, were moderate indicating that collinearity may not be severe (near but not above the value of 10), we choose an alternative specification to test the robustness of the results in Table 2.

Table 2: Stock Return Based Risk Measures and Vega

We regresses the risk measures for individual banks on the lagged values of risk sensitivities – delta and vega. Cash compensation, CEO ownership, book value of total assets, market to book ratio, book value of leverage, CEO tenure, and return on assets are included as control variable. The lagged value of the dependent variable, firm fixed effects, year dummies are also included. See Equation 1 for specification. Standard errors are clustered by firms. T-statistics are reported below coefficient estimates. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Type of Risk Measure		
VARIABLES	Total Risk	Market Risk	Unique Risk
Vega	-0.246**	-0.577***	-0.182
	(-1.98)	(-4.47)	(-1.23)
Delta	0.167***	0.132**	0.176***
	(2.68)	(2.21)	(2.64)
Cash Compensation	-0.006	0.006	-0.023
	(-0.37)	(0.29)	(-1.41)
CEO ownership	-0.003	-0.006**	-0.002
	(-0.90)	(-2.15)	(-0.65)
Assets/1,000,000	-0.394**	-0.708**	-0.299
	(-2.06)	(-2.34)	(-1.18)
Market to Book Ratio	-0.026	0.013	-0.041*
	(-1.15)	(0.42)	(-1.67)
Leverage	2.547**	2.350	2.090*
	(2.47)	(1.49)	(1.82)
CEO tenure	-0.001	0.002	0.000
	(-0.40)	(0.32)	(0.11)
ROA	-0.056	-0.036	-0.068
	(-0.99)	(-0.39)	(-1.24)
Dependent variable at lag 1	0.289***	0.225***	0.258***
	(8.13)	(5.99)	(7.43)
Intercept	2.506**	1.533	3.080***
	(2.55)	(1.07)	(2.72)
Year and firm dummies	Yes	Yes	Yes
Observations	1,097	1,097	1,097
R-squared	0.846	0.820	0.848

In this robustness test, we include managerial stock and option related wealth as a regressor and employ the orthogonalized values of vega and delta. We admit that the above wealth is definitely not the entire wealth of the manager as she may have outside investments and holding. However, the data on manager's outside wealth are not available and some components such as deferred compensation, pension, and other retirement benefits, though relevant, are equally hard to determine in a large sample and/or suffer from limited disclosure (Sundaram and Yermack, 2007). Nevertheless, we include this wealth variable as it is closely related to the delta and the vega. Further, it is indeed worth asking – in the presence of near-perfect correlation between wealth and delta, and a high correlation between wealth and vega – whether significant coefficients on vega and delta, largely if not totally, owe their explanatory power to the not-included managerial stock and option related wealth variable.

Table 3 contains the results for a regression which is nearly identical to Table 2, but with two key differences. First managerial stock and option related wealth is an additional regressor. Next, given the high correlation of 0.78 between vega and delta and the further high correlations of managerial stock and option related wealth with vega and delta, we use wealth as a primitive and orthogonalize delta to wealth (by obtaining the residual of delta regressed on wealth) and orthogonalize vega to delta and wealth (by obtaining the residual of vega regressed on delta and wealth). This specification ensures that we shall only be interpreting the effect of the unique information in vega and delta, without any confounding collinearity. All other explanatory variables of Table 2 are maintained in their exact form.

Table 3: Stock Return Based Risk Measures and Orthogonalized Vega

This table reports the estimation results of regressing 3 risk measures on orthogonalized vega and delta relative to managerial stock and option –related wealth. stock and option wealth is defined as 1 year lagged value of the sum of all option and stock values held by the CEO. Delta residual relative to wealth is the 1 year lagged value of the residual from the regression of total delta on CEO stock and option related wealth. vega residual relative to delta and wealth is the one year lagged value of the residual from the regression of total vega on total delta and CEO stock and option related wealth. Other control variables are as defined in Table I. Standard errors are clustered by firms ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level..

VARIABLES	Type of Risk Measure		
	Total Risk	Market Risk	Unique Risk
Vega residual relative to Delta and Wealth	-0.462**	-0.696**	-0.398**
	(-2.27)	(-2.40)	(-2.04)
Delta residual relative to Wealth	-0.126	-0.610***	-0.032
	(-0.78)	(-4.00)	(-0.17)
Stock and Option Wealth	1.128*	-0.539	1.491**
	(1.73)	(-0.78)	(2.17)
Cash Compensation	-0.004	0.007	-0.021
	(-0.24)	(0.34)	(-1.25)
CEO Ownership	-0.003	-0.006**	-0.002
	(-0.89)	(-2.16)	(-0.64)
Assets/1,000,000	-0.368*	-0.693**	-0.274
	(-1.97)	(-2.24)	(-1.11)
Market to Book Ratio	-0.026	0.013	-0.040
	(-1.13)	(0.42)	(-1.65)
Leverage	2.520**	2.337	2.060*
	(2.44)	(1.48)	(1.78)
CEO tenure	-0.002	0.002	0.000
	(-0.51)	(0.28)	(0.02)
ROA	-0.056	-0.035	-0.067
	(-0.98)	(-0.38)	(-1.24)
Dependent variable at lag 1	0.287***	0.225***	0.255***
	(8.02)	(6.00)	(7.21)
Constant	2.542**	1.532	3.131***
	(2.57)	(1.07)	(2.74)
Year and firm dummies	Yes	Yes	Yes
Observations	1,097	1,097	1,097
R-squared	0.847	0.820	0.848

The result in Table 3 support the result from Table 2, as vega is still strongly negative and significant at the conventional 95% level of confidence for not only total and systematic risk, but also for idiosyncratic risk. Interestingly, delta is no longer positive but negative for all three cases – total, systematic and idiosyncratic risks – and significant for systematic risk. Clearly, once the underlying correlation structure between delta and vega is removed, results have further clarity and vega emerges as the key variable affecting the risk choices. Wealth has a significant, positive effect on total risk (at 90% confidence level) and on idiosyncratic risk (at 95% confidence level). What is clear is that the significant and positive coefficient on delta in Table 2 largely owed its existence to the fact that it was a wealth proxy, and also to the strong correlation between vega and delta. In that sense, the results of Table 3 clearly establish vega to be the key variable, consistent with the focus of the academic research. We now move to our conditional tests to see if risk-vega relationship is indeed conditional on moneyness.

4.3. Conditional tests of risk-vega relationship

We have found strong evidence of an unconditional, negative relationship between lagged vega and the bank risk measures, that may be consistent with Carpenter (2000) and Lewellen (2006), among others. We now proceed to the direct test of an asymmetric risk-vega relationship, contingent upon moneyness. As discussed earlier, Carpenter (2000) and Lewellen (2006) show that in-the-money options would discourage risk taking, while out-of-the-money options will encourage it.

4.3.1. Moneyness proxied through delta and risk choices

The first proxy of moneyness is delta. For a single option, it is easy to find that delta goes from zero to one as the stock price tends from zero to infinity. In the present context of a

portfolio, we have a reasonable approximation of aggregate moneyness in the delta of the CEOs portfolio as moneyness directly affects wealth and, from presented correlations, we know that delta and wealth are near perfect in correlation.[20] Also, one can view delta as a mapping of stock price moves on managerial wealth; and a higher delta translates into larger changes in managerial wealth for the same $1 change in the underlying stock price (Ross, 2004). For a risk-averse CEO, this reduces the certainty-equivalent wealth.[21] Consistent with the above discussion, we sort our sample each year by the total delta of the CEO portfolio and split the annual data into two equal groups – the high delta group and the low delta group. Now, we run by-group regressions of the risk measures on vega, along with the customary control variables and present the results in Table 4.[22] Our prediction, based on the cited literature above, is that high-delta group CEO, due to the higher moneyness of their holdings, will tend to reduce risk more (or increase risk less) compared to the low-delta group. The results in Table 4 indeed bear out our prediction. High delta group has a negative sign on total vega and there is significance for market risk at the 99% confidence level, and for total risk at the 90% confidence level. By contrast, the sign on the vega for the low delta group is never significant. Thus, clearly in-the money options tend to motivate the CEOs to reduce risk. Interestingly, in the low delta group, we do not observe CEOs increasing risk in vega but this may be a consequence of using firm and year dummies that bias towards non-rejection (see Coles et al., 2011).

[20] Ross (2004) notes, in a similar context, that raising the higher delta will temper the risk-taking behavior, for CEOs who are risk-averse enough.

[21] Note that delta and vega are partial derivatives, obtained under the Black-Scholes assumption of risk neutrality.

[22] If there are material differences between the high and low delta groups that are unaccounted for by the control variables, the two subsample approach should capture the economic environment better than a single regression with dummies. Besides, we found the single sample regression to be beset with collinearity when using a delta dummy in addition to the interaction term between delta dummy and vega. Further, to better address the issue of endogeneity, the two subsample approach provided more flexibility as low and high deltas are bound to be related to control variables. Therefore, the separation into two subsamples provides a cleaner picture. See Low (2009) for detailed justifications of this approach.

Table 4: Delta Level and Its Impact on Risk Taking

The full sample is divided into two subgroups according to the annual median value of total delta: total delta is lower (higher) than annual median for Low(High) Delta Group.. Standard errors are clustered by firms.. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively

	Type of Risk Measure					
VARIABLES	Total Risk		Market Risk		Unique Risk	
	Low Delta Group	High Delta Group	Low Delta Group	High Delta Group	Low Delta Group	High Delta Group
	(1)	(2)	(3)	(4)	(5)	(6)
Vega	-0.181	-0.283*	-1.139	-0.470***	-0.277	-0.250
	(-0.26)	(-1.93)	(-1.05)	(-3.83)	(-0.33)	(-1.45)
Delta	0.649	0.169**	1.075	0.148**	0.652	0.168**
	(1.57)	(2.44)	(1.64)	(2.40)	(1.40)	(2.24)
Cash Compensation	-0.036	-0.015	-0.052	0.013	-0.080	-0.032
	(-0.42)	(-0.80)	(-0.38)	(0.69)	(-0.83)	(-1.62)
CEO ownership	0.003	-0.004	-0.005	-0.006	0.005	-0.005
	(0.64)	(-1.15)	(-1.08)	(-1.32)	(1.18)	(-1.18)
Assets/1,000,000	2.628	-0.393**	-10.430**	-0.641**	6.385	-0.375
	(0.50)	(-2.32)	(-2.10)	(-2.52)	(0.98)	(-1.66)
Market to Book Ratio	-0.045	-0.019	-0.145	0.042	-0.025	-0.039
	(-0.75)	(-0.97)	(-1.59)	(1.65)	(-0.40)	(-1.64)
Leverage	1.798	3.061**	3.046	1.210	1.097	3.247*
	(1.08)	(2.02)	(1.18)	(0.74)	(0.66)	(1.86)
CEO tenure	0.000	-0.002	-0.001	0.007	0.005	-0.004
	(0.04)	(-0.39)	(-0.09)	(0.95)	(0.59)	(-0.60)
ROA	0.065	-0.162**	0.225	-0.261***	0.005	-0.146
	(0.85)	(-2.17)	(1.56)	(-3.30)	(0.07)	(-1.61)
Dependent variable at lag 1	0.175***	0.282***	0.112**	0.200***	0.167***	0.245***
	(2.85)	(5.76)	(2.06)	(3.42)	(3.08)	(4.70)
Intercept	3.963**	2.867**	1.558	3.213**	4.555***	3.078*
	(2.30)	(2.06)	(0.66)	(2.14)	(2.69)	(1.87)
Year and firm dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	547	550	547	550	547	550
R-squared	0.841	0.884	0.836	0.863	0.856	0.865

4.3.2. Stock and option related CEO wealth in the company and risk choices

CEO wealth tied to the company is considered to be one of the key reasons for managerial risk aversion. As Carpenter (2000) demonstrates, "[A]s asset value grows large, … , the manager moderates asset risk." Ross (2004) similarly argues that due to a (risk) magnification effect (similar to the volatility cost in Lewellen (2006)), despite a wealth increase due to an option grant, "an agent can have a very different attitude toward risk at a higher level of wealth than at a lower level." Likewise, Lambert et al. (1991) suggest "if managers exhibit substantial differences in their levels of wealth, degrees of personal diversification, and degrees of risk aversion," Black-Scholes based valuations and comparative statistics can lead to improper conclusions.

Thus, managerial wealth tied to the company can be viewed as a second proxy for the moneyness. A high delta or a large quantity of wealth tied to the company indicates that the CEO has a great deal to lose if the stock price declines. Recall that wealth and delta have a very high correlation of 0.96. Therefore, we conduct a similar analysis as in the previous section by separating the companies in the high and low CEO stock and option related wealth groups, based on the CEO wealth tied to the company (measured as the market value of stocks and options). Again, regressions are run separately for the high and low CEO wealth groups and the results are presented in Table 5.

Table 5: CEO Stock and Option Wealth and the Risk-Vega Relationship

The full sample is divided into two subgroups according to the annual median value of CEO stock and option wealth: lower (higher) than annual median for Low (High) Wealth Group. We conduct the same tests as in Table 2 for each of these two subsamples. The results for Low Wealth Group are reported in Columns (1), (3), and (5) and those for Low Wealth Group are reported in Columns (2), (4), and (6). Standard errors are clustered by firms. T-statistics are reported below coefficient estimates. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Type of Risk Measure					
VARIABLES	Total Risk		Market Risk		Unique Risk	
	Low Wealth	High Wealth	Low Wealth	High Wealth	Low Wealth	High Wealth
	(1)	(2)	(3)	(4)	(5)	(6)
Vega	-0.074	-0.309*	-0.910	-0.547***	-0.012	-0.271
	(-0.17)	(-1.95)	(-0.88)	(-3.82)	(-0.02)	(-1.32)
Delta	0.534	0.159**	0.963	0.137*	0.491	0.176*
	(1.64)	(2.10)	(1.50)	(1.77)	(1.07)	(1.92)
Cash Compensation	-0.041	-0.014	-0.042	0.015	-0.101	-0.034
	(-0.76)	(-0.75)	(-0.35)	(0.81)	(-1.23)	(-1.63)
CEO ownership	0.003	-0.004	-0.006	-0.005	0.007	-0.005
	(0.87)	(-1.02)	(-1.16)	(-1.11)	(1.46)	(-1.06)
Assets/1,000,000	-0.880	-0.349*	-15.858***	-0.569**	6.101	-0.422
	(-0.23)	(-1.98)	(-2.89)	(-2.34)	(1.16)	(-1.54)
Market to Book Ratio	-0.048	-0.018	-0.151	0.038	-0.004	-0.038
	(-1.06)	(-0.97)	(-1.55)	(1.59)	(-0.05)	(-1.58)
Leverage	2.444*	3.189**	3.453	1.618	1.508	2.911*
	(1.81)	(2.09)	(1.45)	(1.00)	(0.76)	(1.71)
CEO tenure	-0.002	-0.001	-0.001	0.013*	0.003	-0.005
	(-0.38)	(-0.11)	(-0.18)	(1.70)	(0.31)	(-0.72)
ROA	0.061	-0.189**	0.230	-0.282***	-0.008	-0.177**
	(1.08)	(-2.41)	(1.63)	(-3.32)	(-0.11)	(-2.03)
Dependent variable at lag 1	0.166***	0.240***	0.123**	0.143***	0.021	0.054
	(3.55)	(4.27)	(2.27)	(2.69)	(0.47)	(1.12)
Intercept	3.442***	2.999**	1.109	2.904*	5.296***	4.910***
	(2.60)	(2.06)	(0.50)	(1.84)	(2.79)	(3.07)
Year and firm dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	549	548	549	548	549	548
R-squared	0.849	0.880	0.829	0.865	0.861	0.856

The results fall in line with the earlier results seen for the high and low delta cases that were laid out in Table 4. For the high wealth CEOs, there is a negative relationship between risk and vega and this relationship is significant for systematic risk (at 99% confidence level) and total risk (at 90% confidence level). Now, while the relationship is also negative for the low wealth CEOs, it is nowhere close to being significant at any conventional level.

Our results with the two proxies of moneyness (compensation package delta and CEO stock and option related wealth) are consistent with the behaviors noted in the studies of executive risk policy choices as well as with the executive early exercise behavior (Huddart and Lang, 1996; Heath et al., 1999; Bettis et al., 2005). Also, this negative relationship between vega and firm risk is driven entirely by the moneyness of the CEO option grants. This would appear to bear out the intuition of risk-aversion based studies of managerial behavior that a greater potential of downside loss may curb risk taking.

4.3.3. Moneyness proxied through vested grants

More recently granted options are generally unvested while the older options are typically vested; and vested grants will typically have high deltas as vested grants are older and a common practice is to set the exercise price equal to the stock price on the grant date (see Carow et al. (2009) on conventions in option grants). Therefore, the vested grants are generally deep-in-the-money or have high delta, while unvested and currents grants will be close-to-the-money with lower delta. Therefore, extending the logic made earlier, the vega of vested grant should cause the risk-averse CEO to reduce risk in vega, given the grant's high delta. Indeed, as presented in Table 1, vested delta (options and stocks) accounts for nearly three-quarters of the total delta, both in the mean and the median. By contrast, vested vega is only 40% (25%) of the total vega

in the mean (median). Also, consistent with the evidence cited for disposition effect among stock and option holders, CEOs may choose to think of their vested grants being as good as cash, which cannot be said of the unvested portion by virtue of not being exercisable (leaving the issue of moneyness aside). As noted earlier, Huddart and Lang (1996) find an unusually high exercise activity in the three months following vesting." This evidence supports the CEOs being risk-averse in vested options. Furthermore, due to a variety of restrictions such as corporate policy, regulatory constraints, and insider trading rules, CEOs cannot dispose of their entire vested grant immediately. Besides, there are market impact and signaling issues to consider when a CEO chooses to sell a very large segment of his vested stock and option grant. Due to this difficulty in converting the grant into cash as desired, the CEO may instead choose to run the firm more conservatively which should result in a negative risk-vega relation for vested vega (e.g., Sullivan and Spong, 2007). So, consistent with the second hypothesis, algebraically lower coefficients should be evident on vested grants compared to their unvested and current counterparts.

To contrast the predicted asymmetry between vested grants against its unvested counterparts, we next decompose total CEO vega into its three components – new grant, unvested grant, and vested grant. The regression of the three risk measures on the decomposition of vega along with the usual controls and fixed effects is presented in Table 6. The results in Table 6 provide strong support for our prediction of a stronger negative relationship between vested vega and the risk measures, compared to its unvested counterparts (consistent with our second hypothesis). All risk measures significantly decline in the vested vega component of the CEO option portfolio. On the other side, the new and existing grant (unvested) vegas have no significances and carry mixed signage. Delta, a control variable in our study, predictably shows up significantly postive signs, as in Table 2.

Table 6: Impact of Component Vegas on Risk Measures

We regress risk measures on the three components of vega – newly granted option vega, existing unvested and vested vega. Other control variables are as defined in Table 1. The lagged value of the dependent variable, firm fixed effects, year dummies are also included. Standard errors are clustered by firms. T-statistics are reported below coefficient estimates. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

VARIABLES	Total Risk	Systematic Risk	Idiosyncratic Risk
	(1)	(2)	(3)
Vega, newly granted	-0.282	-0.614	-0.239
	(-0.98)	(-1.39)	(-0.92)
Vega, existing unvested	0.149	-0.199	0.154
	(0.80)	(-0.71)	(0.66)
Vega, existing vested	-0.584***	-0.908***	-0.451**
	(-3.97)	(-4.55)	(-2.34)
Delta	0.166***	0.132**	0.175***
	(2.66)	(2.21)	(2.62)
Cash Compensation	-0.006	0.006	-0.023
	(-0.35)	(0.28)	(-1.37)
CEO Ownership	-0.002	-0.006**	-0.002
	(-0.83)	(-2.18)	(-0.60)
Assets/1,000,000	-0.260	-0.578	-0.195
	(-1.46)	(-1.39)	(-0.86)
Market to Book Ratio	-0.030	0.010	-0.043*
	(-1.27)	(0.30)	(-1.75)
Leverage	2.544**	2.364	2.084*
	(2.50)	(1.49)	(1.82)
CEO tenure	-0.001	0.002	0.001
	(-0.25)	(0.40)	(0.21)
ROA	-0.051	-0.030	-0.063
	(-0.90)	(-0.33)	(-1.15)
Dependent variable at lag 1	0.278***	0.218***	0.253***
	(7.77)	(5.82)	(7.29)
Constant	2.583***	1.545	3.118***
	(2.66)	(1.08)	(2.76)
Year and firm dummies	Yes	Yes	Yes
Observations	1,097	1,097	1,097
R-squared	0.848	0.820	0.849

Therefore, managers as a group mostly respond to the vega of the vested component and their impulse is to reduce risk in it. These results strongly support the Lewellen (2006) argument of managerial risk aversion as vested options will typically be in the money (thus reducing the desire for risk). It also is consistent with the early exercise behavior of the executives noted above.

We also checked the robustness of our results by specifying the component vegas differently. Instead of computing each component vega as the effect on managerial wealth in dollars if the underlying stock volatility were to go up by 1% (Core and Guay, 2002), we compute the mean Black-Scholes vega per option for each component and ignore the number of options under each component of the grant. This removes the number of options from vega which essentially is a wealth effect. Our results, though not presented here for brevity, show that the Black-Scholes vega of existing vested options (which is essentially Core-Guay vega without number of options included) negatively affects all three risk choices consistent with the results presented above. However Black-Scholes vegas of new and existing grants are not significantly related to risk measures. This is truly a strong result that managers seem to react to the existing, vested vega negatively even when the number of options is excluded from vega calculations.

4.4. Risk-vega relation across subperiods

From the results presented so far, the conclusion appears to be firmly for a negative risk-vega relation which is induced by the high levels of moneyness of the CEO compensation portfolio. Though the results are strong and consistent with the models of the risk-averse CEO, they are somewhat puzzling as traditionally there is strong evidence for a positive risk-vega relationship in non-banking literature. Of course, as demonstrated earlier, this negative effect

largely stems from the "high moneyness" half of the sample. Still, the "low moneyness" half of the sample also carries a negative, albeit insignificant coefficient (though for new and unvested grants we do see insignificant but mixed signage), instead of the typically predicted positive sign.

Figures 1 and 2 show that average CEO compensation delta rose at a near-exponential rate from 1992 through 1998. The vega continues to grow at an exponential rate until 2002. As the moneyness (represented here by delta) is of interest, we split the data into nearly equal two sub-periods (1993-98 and 1999-2006). This choice of subperiods (with a slightly longer second subperiod) contains any effects of Gramm-Leach-Bliley Financial Services Modernization Act of 1999 entirely in the second period. This Act is important as it permitted banks to enter traditionally non-banking product markets such as brokerage and fund management, investment banking, insurance etc.

Figure 1. Time Trend of Delta and Its Components

(unit: millions)

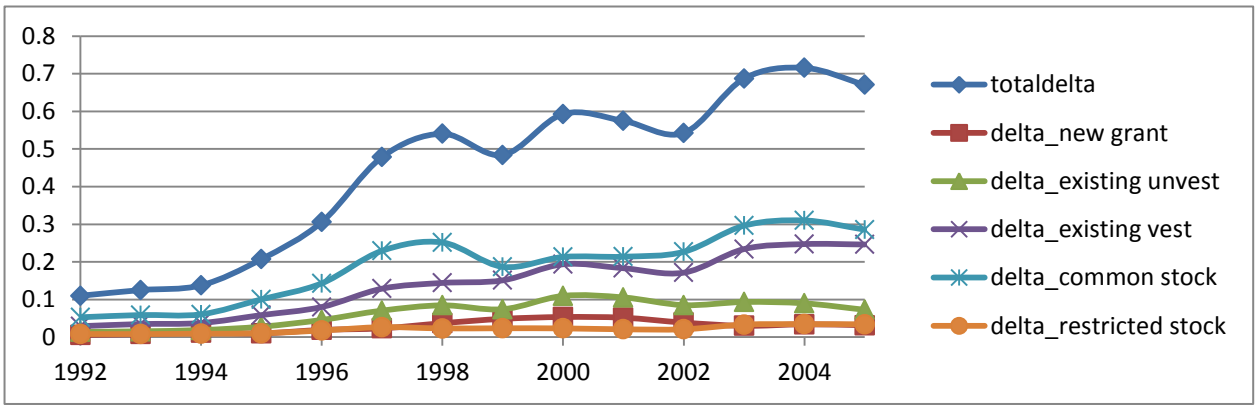
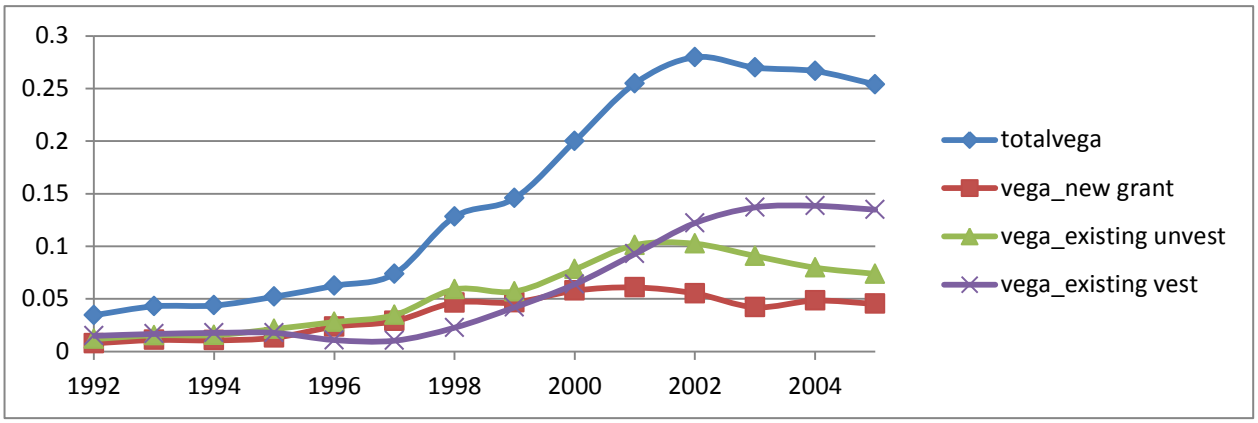


Figure 2. Time Trend of Vega and Its Components

(unit: millions)



We present the results of our subperiod regressions in Table 7 and indeed find results to support our reasoning. Vested vegas are negative and significant at conventional levels for the all three risk measure in the 1999-2006 subperiod. By a sharp contrast, in the 1993-1998 subperiod, vested vegas carry positive coefficients, and the positive coefficient is significant for systematic risk at 99% confidence level. Therefore, while bank CEO increased systematic risk aggressively in vega in the former period when the moneyness of their compensation portfolio was low, they reduced risk in vega for all three measures in the latter period. This result is more remarkable considering that the deregulation is generally reputed to increase risk taking due to product market competition (Cunat and Guadalupe, 2009).

Table 7: Risk-Vega Relation by Subperiods

We divide the full sample into two subperiods: 1993 to 1998 and 1999 to 2006. In each sub-period, we regress risk measures on lagged newly granted option vega, existing unvested and vested vega. Other control variables are as defined in Table 1. The lagged value of the dependent variable, firm fixed effects, year dummies are also included. Standard errors are clustered by firms. T-statistics are reported below coefficient estimates. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

VARIABLES	Total Risk		Systematic Risk		Idiosyncratic Risk	
	1993-1998	1999-2006	1993-1998	1999-2006	1993-1998	1999-2006
	(1)	(2)	(3)	(4)	(5)	(6)
Vega, newly granted	-0.586	-0.380	-1.205	-0.564*	-0.680	-0.369
	(-0.61)	(-1.63)	(-0.62)	(-1.68)	(-0.65)	(-1.53)
Vega, existing unvested	0.056	0.025	1.544	-0.118	-0.388	-0.079
	(0.05)	(0.12)	(0.75)	(-0.38)	(-0.31)	(-0.31)
Vega, existing vested	1.323	-0.518***	5.537**	-0.796***	0.736	-0.416**
	(0.87)	(-3.71)	(2.43)	(-3.09)	(0.37)	(-2.55)
Delta	0.343**	0.155**	0.095	0.134*	0.365**	0.170**
	(2.50)	(2.26)	(0.51)	(1.87)	(2.51)	(2.40)
Cash Compensation	-0.032	-0.009	-0.003	0.003	-0.067***	-0.023
	(-1.61)	(-0.44)	(-0.09)	(0.11)	(-4.51)	(-1.15)
CEO Ownership	0.015**	-0.004	0.001	-0.003	0.017**	-0.006
	(2.25)	(-1.24)	(0.06)	(-0.74)	(2.54)	(-1.39)
Assets/1,000,000	0.726	-0.716***	-1.941	-1.001**	1.165	-0.567***
	(0.76)	(-4.11)	(-1.17)	(-2.09)	(1.32)	(-2.95)
Market to Book Ratio	0.008	-0.044	-0.019	0.003	-0.001	-0.054*
	(0.15)	(-1.55)	(-0.24)	(0.08)	(-0.03)	(-1.94)
Leverage	5.314*	2.158	4.087	2.221	4.606	1.632
	(1.66)	(1.59)	(1.00)	(1.22)	(1.48)	(1.12)
CEO tenure	-0.005	0.004	-0.013	0.000	-0.002	0.009
	(-0.71)	(0.80)	(-1.21)	(0.00)	(-0.31)	(1.51)
ROA	-0.027	-0.067	-0.042	0.023	-0.038	-0.089
	(-0.36)	(-0.68)	(-0.35)	(0.17)	(-0.51)	(-0.94)
Dependent variable at lag 1	0.092	0.228***	-0.072	0.238***	0.057	0.211***
	(1.52)	(3.59)	(-1.26)	(4.88)	(0.94)	(4.07)
Constant	1.339	3.443***	1.529	2.630*	2.155	3.460***
	(0.46)	(3.04)	(0.41)	(1.82)	(0.76)	(2.95)
Year and firm dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	463	634	463	634	463	634
R-squared	0.812	0.888	0.880	0.756	0.775	0.896

4.5. Risk-vega relationship and the bank size

Finally, we address the perception that larger banks engaged in aggressive risk-taking under a belief that the government would be obliged to rescue them if the risk materialized in a bad outcome. This externality is commonly known as "too-big-to-fail." We produce some preliminary evidence on this issue by splitting our sample each year into two halves by market capitalization. Next, regressions are run for large and small banks separately and the results are presented in Table 8. The vega coefficient for large and small banks always carries a negative sign. However, none of the coefficient values are significant at conventional levels for small banks, while the large-bank coefficients are significant for total risk at 90% significance level and at 95% for the systematic risk. Though not present here, we revised the definition of large banks from median to top 25 percentile and then to top 10 percentile and the results remained largely unchanged. Thus, the risk-vega relation is reliably negative for total and systematic risk for large banks, suggesting that large bank CEOs reduced risk more in vega compared to small bank CEOs, well in advance of the financial crisis. This evidence appears to argue against the "too-big-to-fail" perception.

Table 8: Firm Size and the Risk-Vega Relationship

The full sample is divided into two subgroups according to the annual median value of firm size: firm size is lower (higher) than annual median for Small (Large) Bank Group. We conduct the same tests as in Table 2 for each of these two subsamples. The results for Small Bank Group are reported in Columns (1), (3), and (5) and those for Large Bank Group are reported in Columns (2), (4), and (6). Standard errors are clustered by firms. T-statistics are reported below coefficient estimates. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Type of Risk Measure					
VARIABLES	Total Risk		Market Risk		Unique Risk	
	Small Banks Group	Large Banks	Small Banks Group	Large Banks	Small Banks Group	Large Banks
	(1)	(2)	(3)	(4)	(5)	(6)
Vega	-0.444	-0.216*	-0.611	-0.268**	-0.504	-0.170
	(-1.41)	(-1.91)	(-1.02)	(-2.30)	(-1.32)	(-1.25)
Delta	0.363***	0.135**	0.237	0.096*	0.453***	0.114*
	(3.20)	(2.33)	(1.32)	(1.72)	(3.36)	(1.94)
Cash Compensation	-0.056	-0.015	-0.097	0.002	-0.047	-0.029
	(-0.62)	(-0.87)	(-0.72)	(0.14)	(-0.53)	(-1.46)
CEO ownership	0.000	-0.002	-0.003	0.002	0.001	-0.004
	(0.17)	(-0.35)	(-0.89)	(0.31)	(0.35)	(-0.53)
Assets/1,000,000	4.522	-0.422**	31.486	-0.520**	-1.387	-0.449**
	(0.27)	(-2.41)	(1.36)	(-2.55)	(-0.07)	(-2.02)
Market to Book Ratio	-0.021	-0.046	-0.020	-0.014	-0.023	-0.052
	(-0.69)	(-1.57)	(-0.34)	(-0.45)	(-0.83)	(-1.44)
Leverage	1.238	2.625*	0.882	2.435	1.086	2.172
	(0.81)	(1.69)	(0.37)	(1.55)	(0.71)	(1.11)
CEO tenure	0.004	-0.000	0.002	-0.001	0.007	0.001
	(0.50)	(-0.05)	(0.16)	(-0.11)	(0.95)	(0.23)
ROA	0.022	-0.150*	0.199	-0.159*	-0.034	-0.165*
	(0.29)	(-1.98)	(1.50)	(-1.98)	(-0.50)	(-1.77)
Dependent variable at lag 1	0.162***	0.165***	0.085	0.144**	0.164***	0.125**
	(2.64)	(3.31)	(1.52)	(2.60)	(2.85)	(2.38)
Intercept	4.593***	3.948***	3.502	2.138	4.625***	4.765**
	(2.85)	(2.70)	(1.61)	(1.44)	(2.86)	(2.47)
Year and firm dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	550	547	550	547	550	547
R-squared	0.838	0.901	0.845	0.888	0.852	0.881

5. Conclusion

We focus on the issue of increased incentive to bank CEOs for risk taking based on the convexity of the compensation scheme, which we measure as the vega of the compensation grant – while correcting for endogeneity through the use of lagged risk measures. Unlike the previous studies that postulate an unconditional risk-vega relation, we posit an asymmetric risk-vega relation conditional on moneyness. This view is supported by a stream of literature that asserts, assuming a risk-averse manager, that in-the-money options curb risk-taking while out-of-the-money options encourage it.

Our results present an interesting CEO risk attitude, unlike a majority of prior studies. Unconditionally, bank risk decreases in vega. Further analyses demonstrate that risk-vega relationship is negative when moneyness is high, while there is no clear risk-vega relationship when moneyness is low. This result is clearly supportive of the models of Carpenter (2000), Ross (2004), and Lewellen (2006) that incorporate risk aversion to show that CEOs may avoid risk when the potential downside loss is high. We also find the risk-vega relation to change over time. Prior to 1999 (a period characterized by lower average deltas and vegas), the relationship between bank risk and vested vega is positive, though not always significant. However, for the 1999-2006 period, the relationship between bank risk and vested vega is reliably negative at the conventional levels (also a period marked by high average annual deltas and vegas). As our above results demonstrate, CEOs appear to be more risk-averse when their downside risk is too large. Thus, the traditional interpretations of risk taking incentives based on the comparative statistics of the Black-Scholes option pricing model may be less than appropriate in the real world of undiversified, trading and hedging constrained and risk-averse CEO. As indicated in Fung et al. (2011), Black-Scholes-type option pricing models (OPM) assume no information

flows in a steady state setting and volatility is supposed to be constant across different strike prices. However empirical evidence does not fully support the above assumptions. Probably in the future, study of executive compensation should consider using different compensation measures which better capture the risk-taking incentives.

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Appendix on Data Sources:

Copies of the SAS and STATA computer programs employed to estimate the presented results are available from the second author upon request (jjia@siue.edu). Similarly we can also provide a listing of the banks names for authors wishing to replicate or extend results. However, all bank-specific data used here is proprietary and is only available through subscription. The CRSP database, containing stock price and return information, is available from University of Chicago (http://www.crsp.com/). COMPUSTAT was used to acquire financial statement based information and is available from S&P Capital IQ (https://www.capitaliq.com/home/what-we-offer/information-you-need/financials-valuation/compustat-financials.aspx). Finally, ExecuComp was used to acquire CEO compensation data and it is also available from Standard and Poor's (https://www.capitaliq.com/home/what-we-offer/information-you-need/qualitative-data/execucomp.aspx).