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# CEO Incentives and Bank Risk over the Business Cycle

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**CEO Incentives and Bank Risk over the Business Cycle**


**Abstract**

We examine whether the relationship between managerial risk-taking incentives and bank risk is sensitive to the underlying macroeconomic conditions. We find that risk-taking incentives provided to bank executives are associated with higher bank riskiness during economic downturns. We attribute this finding to the increase in moral hazard during macroeconomic downturns when the perceived probability of future bailouts and government guarantees rises. This association is particularly strong for larger banks, banks that maintain lower capital ratios and banks that are managed by more powerful Chief Executive Officers (CEOs). Our findings highlight the importance of the interaction between managerial incentives and the macroeconomic environment. Boards and regulators may find it useful to consider the countercyclical nature of the relationship between risk-taking incentives and bank riskiness when designing managerial compensation.



JEL classification: G01, G2, G3, M52

Keywords: bank risk; executive compensation; equity-based compensation; macroeconomy

## 1 Introduction

In this paper, we investigate whether a given level of risk incentives to a manager might result in different levels of bank risk under different macroeconomic conditions. While previous studies established that bank executives who are compensated with stock and option grants make riskier decisions (Eufinger and Gill, 2016; Kolm et al., 2017), there is yet no study that looks into whether changes in managerial preferences along a business cycle have an impact on the risk-taking implications of their pay packages. This is an important question to answer for boards of directors and regulators who set executive compensation practices in the banking sector. If a given pay package induces different risk outcomes when macroeconomic conditions change, boards and regulators may need to alter the CEO compensation structures over the business cycle to meet their risk objectives.

The empirical banking literature is built on the assumption that the risk-taking consequences of managerial compensation is the same regardless of the state of the economy. Yet, recent research suggests that managerial risk preferences are sensitive to the underlying macroeconomic environment and therefore may influence firm outcomes differently depending on the state of the economy. Guiso et al. (2018) and Cohn et al. (2015) show that individual risk aversion increases during economic downturns. Relatedly, Savaser and Sisli-Ciamarra (2017) show that a given level of CEO performance incentives in the non-financial sector results in significantly lower firm risk when the economy is in a downturn. Hence, one possible outcome is that, bank managers take less risk for a given level of incentives during downturns because they become more risk averse as the economy contracts.

Existent research also illustrates that aligning managerial incentives with shareholders' incentives through stock and option-based pay, a practice that is normally considered as good governance behavior in non-financial firms, may in fact exacerbate risk-taking in the banking sector due to the moral hazard resulting from implicit and explicit government guarantees (Bolton et al., 2015; Eufinger and Gill, 2016; Thanassoulis and Tanaka, 2018; Kolm et al., 2017). Moral hazard incentives are sensitive to underlying conditions and intensify when the perceived probability of government support increases (Acharya and Yorulmazer, 2007; Black and Hazelwood, 2013; Li, 2013; Duchin and Sosyura, 2014). Hence, another possible outcome is that bank managers take more risk for a given level of risk incentives during downturns because of increased moral hazard and following gambling for resurrection behavior (Rochet, 1992; Hellmann et al., 2000).

Consequently, while the risk aversion mechanism would dampen managerial risk-taking, the moral hazard mechanism would amplify risk-taking for a given level of risk incentives during economic downturns. Since neither the managerial risk aversion nor the moral hazard incentives are observable, it is not possible to disentangle the magnitudes of the two mechanisms. However, risk aversion and moral hazard channels work in opposite directions in terms of how they affect the correlation between incentives and risk over the business cycle. Therefore, we suggest the following hypotheses: (i) If the risk aversion mechanism is more pronounced relative to the moral hazard mechanism, then a given level of risk incentives would result in less risk taking during downturns. (ii) If, on the other hand, the moral hazard mechanism is more pronounced relative to the risk aversion mechanism, then a given level of risk incentives would result in higher risk-taking during downturns.

To test these hypotheses, we use a quarterly panel dataset, covering the US public bank holding companies (BHC) between 1996 and 2013, a period that includes two business cycles. Our measure of managerial risk-taking incentives is the ratio of vega to cash compensation (vega/cash). We calculate vega as the change in the dollar value of a CEOs accumulated stock and stock options for a 0.01 change in the annualized standard deviation of stock returns (Core and Guay, 1999). We use realized stock return volatility as a measure of bank risk (Acharya et al., 2014). We also decompose total risk into its systematic and idio-syncratic components and consider them as additional measures of bank risk. To capture banks' downside risk, we calculate tail risk, which is equal to the BHC's average equity loss on days of extremely negative events experienced by the banks (Ellul and Yerramilli, 2013; Van Bekkum, 2016; Bushman et al., 2017). Our main measure for the underlying macroeconomic state is the seasonally-adjusted real GDP growth rates.

Using GDP growth rates, we show that there is in fact a state-dependent relationship between managerial risk-taking incentives and bank risk. In particular, when the GDP contracts (grows) by one percentage point, a one percent increase in vega/cash leads to a 0.024 percent increase (decrease) in bank risk. To state the impact in economic terms, consider that the GDP growth rate is at its minimum (-6.1 percent, 2009 Q2). In such a state, increasing bank manager's risk-taking incentives from its median value (vega/cash = 3.7 percent) to its 75th percentile (vega/cash = 9.6 percent) would be associated with a 23 percent increase in bank risk. On the other hand, when the GDP growth rate is at its maximum (7.2 percent, 2003 Q4), the same increase in risk incentives would result in a 27 percent decline in bank risk. This evidence supports the hypothesis that moral hazard mechanism is more pronounced relative to the risk aversion mechanism. Our results are robust to using alternative measures of macroeconomic state as well as alternative proxies for bank risk.

Next, we rule out several alternative explanations. Our results are not due to the changes in the investment opportunity sets of banks that result from economic expansions or contractions. “Reaching for yield” in low interest rate environments is also not sufficient to explain our findings. We illustrate that the design of compensation packages do not vary over the business cycles, therefore one cannot attribute the results solely to changes in pay structure. Research shows that better risk management practices within a bank can influence the level of bank riskiness (Ellul and Yerramilli, 2013), however the variations in the strength and quality of banks' risk management function is not enough to explain our findings. We also show that variations in bank leverage ratios over the business cycles do not confound our results. In addition, our results are also robust to using asset volatility instead of equity volatility as a measure of bank riskiness, yet again ruling out the concerns about varying leverage ratios under different macroeconomic states. Last, to ensure that our results are not solely driven by the severity of the 2008 recession or the related regulatory measures implemented by the US government (e.g., TARP, Dodd-Frank Reform), we conduct a sub-sample analysis by focusing on the periods before and after the financial crisis separately and show that our results are not just about the 2008 contraction.

The rest of the paper aims at uncovering whether cross-sectional differences in bank, governance and managerial characteristics affect the results we have documented so far. First, we show that our result holds only for those banks whose Tier-1 capital ratio is below 10 percent. This finding is in line with Berger et al. (2020), which shows that regulators are more likely to bail out banks as their capital ratios decline, providing further support for the moral hazard mechanism as the most likely explanation underlying our main result. This finding also suggests that holding sufficiently high amount of bank capital limits the risk-inducing effects of vega/cash during downturns, making the CEO compensation-bank risk relationship less sensitive to the underlying macroeconomic environment. Second, we check whether our results are sensitive to bank size. Larger banks that are considered to be too big to fail (TBTF) are more likely to receive government support due to the systemic risk they pose to the financial system. Therefore, shareholders of big banks are particularly susceptible to the moral hazard problem in times of economic contraction. Consistent with this conjecture, we find that the risk-amplifying effects of manager's vega/cash ratio are larger for TBTF banks. Third, we examine managerial power because an executive's ability to adjust the bank's risk profile over a short period of time depends critically on her managerial power over the bank's resources. If indeed the proposed effect of compensation on bank risk is due to the manager's actions, then we would expect our results to be more pronounced in banks that are run by more powerful CEOs. Using CEO tenure as a measure of managerial power over the bank's resources, we show that the counter-cyclical relationship between the executive's risk-taking incentives and bank risk is valid only for those banks that are managed by seasoned CEOs.

Our research contributes to prior empirical studies, which show that the strong alignment of shareholder and manager interests aggravates the moral hazard problem. Fahlenbrach and Stulz (2011) suggest that bank executives whose incentives were more aligned with shareholder interests performed worse during the US financial crisis. Similarly, banks that had higher CEO performance pay prior to the crisis were more likely to receive government support (Adams, 2012) and they had a higher probability of failure during the crisis, especially if they were highly levered (Boyallian and Ruiz-Verdu, 2018).

Our results are also in line with Duchin and Soysura (2014), which demonstrates that the increased bank risk during the 2008 recession was related to the actions that were taken during the contraction period and not solely predetermined by the actions that were taken prior to the crisis. In particular, the authors show that banks that were approved to receive government assistance went on to issue riskier loans and invest in volatile, higher-yield portfolios during the recession. The study also documents that the shift in risk occured within the same asset class, hence banks appeared safe according to the regulatory ratios, but exhibited an increase in volatility and default risk.

We also contribute to the empirical literature examining the effects of managerial compensation on bank risk. Chen et al. (2006) and DeYoung et al. (2013) show that higher pay-for-risk incentives are associated with higher bank risk. Similarly, Chesney et al. (2016) finds a positive link between bankers' asset-based risk-taking incentives and write-downs during the crisis; they also show that this relationship disappears when they use equity-based risk-taking incentives. Acharya et al. (2014) and Ellul and Yerramilli (2013) also find CEO vega to be an insignificant determinant of bank risk. Van Bekkum (2016) focuses on debt-based compensation and shows that, unlike stock-based managerial pay, it limits bank risk by encouraging more conservative decision making. Yet, none of these studies analyze the sensitivity of the link between CEO compensation and bank risk to the macroeconomic environment.[1] To our knowledge, this is the first empirical study that investigates the variability of the CEO compensation - bank risk relationship over the business cycle.

Overall, our findings highlight the importance of the interaction between managerial incentives and the macroeconomic environment. Recent research suggests that compensation contracts tend to be sticky as CEOs are either granted a fixed dollar value or a fixed number of stock and option grants (Shue and Townsend, 2017). Our paper argues that compensation packages should vary with the underlying macroeconomic environment. In particular, boards and regulators may find it useful to consider the countercyclical nature of the relationship between risk-taking incentives and bank riskiness when designing compensation packages. For example, boards may reduce the option component in pay packages if they aim to reduce bank risk during downturns. Our results also indicate that holding a sufficiently high amount of bank capital limits the risk-

[1] A notable exception is Savaser and Sisli-Ciamarra (2016), which examines the non-financial sector rather than the banking industry and documents a procyclical relationship between manager's performance incentives (delta) and firm risk.

inducing effects of vega during downturns, highlighting the important interaction between capital requirement and compensation regulations that simultaneously aim at reducing bank risk.

## 2 Hypothesis Development

Behavioral economics literature suggests that individuals' decision-making processes and their reactions to incentives are context-specific (Kahneman and Frederick 2004, 2005) and executives' reaction to incentives is significantly influenced by their operating environment (Farrell et al., 2014). Since business cycle fluctuations trigger substantial changes in managers' environment, one would expect that they would respond to risk-taking incentives provided to them through compensation packages differently as the underlying macroeconomic conditions change. What is not clear is whether they would respond to deteriorating market conditions by increasing or decreasing risk for a given level of incentives.

We consider two possible mechanisms that provide predictions about the directionality of this relationship in the banking sector: (i) individual risk aversion, and (ii) moral hazard incentives. First, because individual risk aversion increases during economic downturns (Guiso et al., 2018), a given level of risk incentives would lead to lower bank riskiness during economic contractions. Two expected changes in the characterization of a CEO's utility function lead to this prediction: First, the CEO's risk aversion coefficient is expected to rise during contractions. This increase can be interpreted as a shift in the expected utility function of the manager for a given level of wealth. Second, the general decline in stock prices during downturns may lead to a decline in managerial wealth, increasing CEO's marginal utility of consumption. This wealth effect can be viewed as moving to a more concave region of the utility function, making the CEO more sensitive to risk. As a manager's risk appetite decreases during contractions, s/he is expected to react less strongly to a given level of risk-taking incentives. Thus, the same manager with exactly the same level of risk incentives facing the same bank characteristics would target a *lower* risk level during economic recessions.

The second mechanism is built on the theoretical and empirical finding that moral hazard incentives intensify when the perceived probability of government support increases (Acharya and Yorulmazer, 2007; Black and Hazelwood, 2013; Li, 2013; Duchin and Sosyura, 2014; Hett and Schmidt, 2017). The perceived probability of government support is related to the underlying economic conditions. Bailouts usually take place in crisis periods because they are most effective when systemic problems are at their worst (Berger et al., 2016). State-dependent contingent claims estimates of bailout costs also assume higher bailout probabilities under weakening market conditions (Lucas, 2019). Bailouts are also harder to justify politically and economically in the absence of a wide-spread weakening in the economy. Thus, these studies offer substantial evidence that moral hazard incentives are amplified during downturns due to higher perceived bailout probability. The increase in moral hazard incentives will lead to an increase in risky behavior and consequently, managers will react more strongly to a given level of risk-taking incentives. In this case, the same manager with exactly the same level of risk incentives facing the same bank characteristics would target a *higher* risk level during economic recessions.

Since we are not able to observe and measure risk aversion and moral hazard incentives of individual managers, we are unable to test these mechanisms directly. Instead, we propose the following joint hypotheses:

Hypothesis 1: If the influence of the risk aversion mechanism is greater relative to the moral hazard mechanism, then a given level of risk-taking incentives to a manager would be associated with *less* risk taking in a contracting economy as compared to an expanding economy.

Hypothesis 2: If the influence of the moral hazard mechanism is greater relative to the risk aversion mechanism, then a given level of risk-taking incentives to a manager would be associated with *higher* risk taking in a contracting economy as compared to an expanding economy.

To clarify our hypotheses further, let's suppose that there are two identical banks, Bank A and Bank B. The manager of Bank A is compensated by stock, but no options. The manager of Bank B, on the other hand, is compensated by stock options, thus her compensation package has a higher vega. Otherwise both managers are identical. Now, ceteris paribus, the economy faces a recessionary period. Existing literature (Guido, 2008) suggests that the risk aversion of both CEOs will increase relative to their pre-recession levels. Existing literature (Acharya and Yorulmazer, 2007; Black and Hazelwood, 2013; Li, 2013; Duchin and Sosyura, 2014; Hett and Schmidt, 2017) also suggests that the moral hazard incentives of both managers will increase relative to their baseline preferences during non-crisis periods. As a result, regardless of whether the CEO has low or high vega, the net effect of these opposing forces on how the CEO would react to a given level of risk-taking incentives is unknown ex-ante and is an empirical matter. A stronger (weaker) relationship between vega and risk during recessions would be interpreted as follows: On average, the impact of the increase in moral hazard incentives is more (less) pronounced than the impact of the increase in risk aversion for both managers during recessions.

# 3 Data and Variables

## 3.1 Sample Construction

We construct our sample of publicly traded banks by gathering data from several sources. Quarterly balance sheet and income statement information are from the Bank Regulatory database of the Federal Reserve Bank of Chicago, which collects data from the FR Y-9C reports that banks file with the Federal Reserve between 1996 and 2013. We merge this dataset with financial data from

Compustat and stock price data from Center for Research in Security Prices (CRSP). Compensation data including salary, bonus, stock option grants, restricted stock grants and total pay are from ExecuComp. Hence, we match quarterly bank information with annual compensation data and assume that CEOs base their financial decisions on the value of their annual compensation. Our final sample size to 207 BHCs (Appendix Table 1).

## 3.2 Variable Definitions

### 3.2.1 Compensation Variables

ExecuComp database contains data on managerial pay components including cash compensation (i.e., salary and bonus) and stock compensation (i.e., stock and options).[2] The reporting of compensation variables changed due to the FAS 123(R) regulatory standard after 2006. We follow Hayes et al. (2012) to make the necessary adjustments to these variables in the post-2006 period.

We measure CEO risk-taking incentives by vega, the change in the dollar value of a CEO`s accumulated stock and stock options for a 0.01 change in the annualized standard deviation of stock returns (Core and Guay, 1999; Coles et al., 2006). We then divide vega by CEO's cash compensation (salary plus bonus). Cash compensation encourages entrenchment and limits managerial risk-taking (Armstrong and Vashishtha, 2012; Berger et al. 1997; Coles et al. 2006). Thus,

[2] If option or stock holdings are missing in ExecuComp database, we set their values equal to zero. In addition, we replace observations with negative bonus values with zero. Also, if for a given year CEO tenure data is missing, we hand-collect and fill in the missing information by searching bank 10-K reports and online resources.

vega/cash captures the magnitude of option-based risk-taking incentives relative to the CEO’s risk dampening cash earnings. This measure also aligns our empirical specification with the theoretical literature (e.g., Eufinger and Gill, 2016).

We control for performance incentives provided to managers since they, too, can affect the manager's risk taking-behavior. We measure performance incentives by delta, the change in the dollar value of a CEO`s wealth for a one percent change in the stock price (Coles et al., 2006). We divide delta by cash compensation to capture the magnitude of CEO's stock and option-based performance incentives relative to her cash earnings. We winsorize delta, vega, bonus and salary variables at the 1st and 99th percentiles (Core and Guay, 2002). We use the GDP deflator to convert the compensation and bank financial variables to 1992 dollars.

**3.2.2 Other Variables**

Our first measure is total risk, which is the annualized variance of daily stock returns in a given quarter (DeYoung et al., 2013; Ellul and Yerramilli, 2013; Acharya et al., 2014). Stock return volatility is an informative measure of bank riskiness as shocks to a bank's stock returns are reactions to the news about the bank's future expected cash flows resulting from its investment and financing activities. To analyze the systematic and unsystematic components of bank risk, we estimate the market model using CRSP value-weighted returns as our proxy for the returns on the market portfolio (Bhattacharyya and Purnanandam, 2011;

DeYoung et al., 2013). To obtain market betas, we regress bank excess returns on market excess returns. We compute unsystematic risk as the annualized variance of the residuals from the market model and the systematic risk as the variance of the product of the bank beta and the market daily returns.

We also consider tail risk as an additional measure of bank riskiness, which captures the average equity loss on days of extremely negative events specific to the individual bank. We define tail risk as the average return on the bank's equity over the 10% worst return days for the bank's stock in a given quarter (Ellul and Yerramilli, 2013; Van Bekkum, 2016; Bushman et al., 2017). We use the negative of this measure, so higher values indicate higher downside risk.

We include cash compensation (salary plus bonus), CEO age and tenure to proxy for the CEO's level of risk aversion (Coles et al., 2006; Hayes et al., 2012). To control for managerial power, we also add an indicator variable that takes the value one if the manager is also a board member. We use the standard set of control variables, which may influence BHC risk independently from executive incentives (Ellul and Yerramilli, 2013; Acharya et al., 2014). List and descriptions of the control variables are in Appendix 2.[3]

Table 1 presents summary statistics on the compensation variables and bank financial characteristics. Median total assets is $11.6 bn. in 1992 dollars.

[3] We refer the reader to Ellul and Yerramilli, 2013 and Acharya et al., 2014 for a detailed explanation of the rationale behind including these control variables in the specification.

Median vega is $30,750, median delta is $163,290, and median cash compensation is $833,256. This translates into a median vega/cash ratio of 3.71 and a median delta/cash ratio of 16.33. As Figure 1 shows there is considerable variation in the vega/cash ratio over our sample period.

Throughout our analysis, instead of a binary recession indicator, we use continuous variables to measure the state of the economy since they identify not only the recessions, but also the degree of the variations in macroeconomic conditions as perceived by the manager. To capture the degree of macroeconomic contractions and expansions, we conduct our analysis using the quarterly advanced release of the seasonally-adjusted real GDP growth rates (Figure 2). We consider the unrevised announcement values of the variable to capture the macroeconomic climate as perceived by the bank managers in a given quarter.[4] Hence, the CEO's information set includes the latest GDP release observed by the manager in each period. The minimum value for the GDP growth measure is -6 percent (2009 Q2) and the maximum value is 7 percent (2003 Q4).

## 4 Results

### 4.1 Baseline Specification

We use the following empirical specification to test the relationship between stock and option-based managerial incentives and bank risk:

[4] Revised values are released with a substantial lag, hence are unlikely to be within the information set of the bank executive in a given quarter. Using unrevised data has a number of advantages over fully revised data for the purposes of real-time forecasting. For a detailed discussion, see Swanson (1996). We obtain the unrevised values from Action Economics.

$$Bank\ Risk_{i,t} = \alpha + \beta_1 \left(\frac{Vega}{Cash\ Compensation}\right)_{i,t-1} + \gamma X_{i,t} + \varepsilon_{i,t} \qquad (1)$$

Our main variable of interest is vega/cash compensation. To mitigate endogeneity concerns, as in Coles et al. (2006), we use the lagged values of vega/cash, delta/cash and cash compensation in our specifications. All regressions are estimated with bank-manager and year fixed effects. Bank-manager fixed effects are used to account for the possibility that a CEO might be compensated differently in similar banks due to the heterogeneity in unobservable bank characteristics such as corporate culture (Graham et al., 2013). These fixed effects also mitigate the concern that career concerns and fear of large losses which affect risk aversion might vary for different managers due to the heterogeneity in their unobserved characteristics such as outside employment options. Year fixed effects help capture systemic variations in bank risk over time. We cluster the robust standard errors at the bank-manager level.

Baseline results indicate that vega/cash does not have a statistically significant effect on bank risk (Table 2), which is in line with the estimates reported in the literature. Our results also support the previously documented depressive effects of managerial performance incentives on bank risk.[5] A one percent increase in delta/cash compensation ratio translates into a 0.12 percent decrease

[5] Delta may reduce risk-taking due to a desire to limit portfolio risk. CEOs are more risk averse than diversified shareholders due to their firm-specific human capital and undiversified portfolios (Amihud and Lev, 1981; Smith and Stulz, 1985; Tufano, 1996). Acharya et al. (2014), Van Bekkum (2016) and Chesney et al. (2016) also empirically show delta to have a depressive effect on bank risk.

in bank risk (column 2). We find similar depressive effects for downside, systematic and unsystematic risk.

### 4.2 Bank Risk and CEO Compensation over the Business Cycle

Next, we augment our baseline model (Equation 1) with measures of macroeconomic state and interactions of these measures with managerial incentives:

$$Bank\ Risk_{i,t} = \alpha + \beta_1 \left(\frac{Vega}{Cash\ Compensation}\right)_{i,t-1} +$$

$$\beta_2 \left(\frac{Delta}{Cash\ Compensation}\right)_{i,t-1} + \delta_1 Macroeconomic\ State_{i,t-1} +$$

$$\delta_2 Macroeconomic\ State_{i,t-1} * \left(\frac{Vega}{Ca\quad Compensation}\right)_{i,t-1} +$$

$$\delta_3 Macroeconomic\ State_{i,t-1} * \left(\frac{Delta}{Cash\ Compensation}\right)_{i,t-1} + \gamma X_{i,t} + \varepsilon_{i,t}$$

(2)

Interaction of the macroeconomic state variable with vega/cash ratio is our main coefficient of interest ($\delta_2$). The risk aversion mechanism suggests that managers may become more risk averse during recessions. If, as stated in Hypothesis 1, the risk aversion mechanism is more pronounced relative to the moral hazard mechanism, then we would expect a weaker relationship between option-based CEO pay and bank risk in a contracting economy. Since negative

GDP growth rates indicate a contracting economy, Hypothesis 1 predicts a positive coefficient on the interaction term (vega/cash x GDP), producing a negative (i.e. weaker) effect on bank risk during contractions.

If, on the other hand, the moral hazard mechanism is more pronounced relative to the risk aversion mechanism, as stated in Hypothesis 2, then the increase in moral hazard incentives leads to a stronger relationship between option-based CEO pay and bank risk in a contracting economy. Since negative GDP growth rates indicate a contracting economy, Hypothesis 2 predicts a negative coefficient on the interaction term (vega/cash x GDP), producing a positive (i.e. stronger) effect on bank risk during contractions.

In terms of timing, we set up the empirical design such that the CEO's information set includes the most recent GDP release observed in a given quarter. Since not all banks' fiscal years end in the same month, there is some cross sectional variation in our macroeconomic variables in a calendar year. Hence, the macroeconomic variables carry a bank subscript as well. This allows us to include year fixed effects and control for other possible time-varying factors that may drive the compensation-bank risk relationship. Thus, macroeconomic variables and time fixed effects are not collinear in our specifications. All regressions also control for bank-manager fixed effects.

When total risk is used as the outcome variable, the coefficient on the interaction term is -0.022 and statistically significant at the one percent level (Table 3, column 2). Thus, in quarters when GDP contracts by one percentage point, a one percent increase (decrease) in vega/cash ratio leads to a 0.022 percent increase (decrease) in bank risk. To state the impact in economic terms, consider that the GDP growth rate is at its minimum (-6.1 percent). In such a state, increasing bank manager's risk-taking incentives from its median value (vega/cash = 3.7 percent) to its 75th percentile (vega/cash = 9.6 percent) would be associated with a 21 percent increase in bank risk. In contrast, when the GDP growth rate is at its maximum (7.2 percent), the same increase in risk incentives would result in a 25 percent decline in bank risk. Results are similar when we use tail risk, systematic and unsystematic risk as a measure of bank riskiness.

In Table 4, we replicate these findings using alternative measures of economic activity. Chicago Fed National Activity Index (CFNAI) captures the managers' real time assessment of the aggregate economy. Yale/Shiller crash confidence index is a forward-looking indicator of economic outlook. Finally, the Baker, Bloom and Davis (2016) index measures the aggregate economic policy uncertainty in the US.

In sum, consistent with Hypothesis 2, the results from Tables 3 and 4 indicate that a higher vega/cash ratio is associated with higher risk taking during contractions, and suggest that the effect of moral hazard mechanism is more pronounced relative to the risk aversion mechanism.

While our analysis clearly shows a stronger association between vega and bank risk during contractions, we cannot claim strict causality due to the endogenous nature of the relationship between bank risk and compensation contracts (Murphy, 2013; Edmans et al., 2017). Due to this reason, we rule out possible alternative explanations, address omitted variable biases, and also perform cross-sectional analyses that help interpret our findings in the rest of the paper.

## 5 Ruling Out Alternative Explanations

### 5.1 Investment Opportunities

During economic downturns, banks' investment opportunities may decrease while the riskiness of available investment opportunities increase. If so, the amplified effect of vega/cash on bank risk that we document during contractions may simply be an artefact of the decline in the available investment opportunities. To explore this possibility, we augment our main regression specification with a measure of bank's investment opportunities and its interactions with our compensation and macroeconomic variables. Since investment opportunities are not directly observable, we employ several proxies proposed in the literature, which include total asset growth, total income growth and non-interest income growth as well as the market-to-book ratio (Lambert and Larcker, 1987; Lehn and Paulson, 1989) or the market-to-book ratio (Smith and Watts, 1992; Gaver and Gaver, 1993). The variable definitions are available in the Data Appendix.

We estimate the augmented regression model with alternative measures of investment opportunities and present the results in Table 5, Panel A. The interaction of vega/cash with GDP remains negative and statistically significant. Hence, we conclude that cyclical variation in investment opportunities cannot be the mechanism underlying our main finding.

### 5.2 Search for Yield in a Low-interest Rate Environment

Another factor that can change over the business cycle that may affect risk-taking is banks' incentive to search for yield. When short-term nominal interest rates are near zero, banks cannot easily reduce the rates paid to depositors due to depositors' option of holding cash. Thus, in a low interest rate environment, financial institutions may try to earn higher yields on their assets by taking on more credit or portfolio risk.[6] Since expansionary monetary policies that are associated with low interest rates also depend on the state of the economy, our results may simply be driven by the low risk-free rates that increase the incentives to search for yield, and not necessarily due to the strengthening of moral hazard incentives during contractions. Therefore, it is important to consider the effect of the near-zero nominal interest rates on our

[6] For a review of the literature investigating the search for yield incentives in a low interest rate environment, see Borio and Zhu (2012), Dell'Ariccia et al (2013), Jimenez et al (2014) among others.

findings. To explore this possibility, we augment our main regression specification by including an indicator variable that takes the value one if the end-of quarter 3-month Treasury bill rate is below its 20$^{th}$ percentile value (0.13 percent) and zero otherwise. In this triple interaction model, we also include the interactions of this indicator with our compensation and macroeconomic variables. As a robustness check, we re-estimate this specification using alternative cutoffs such as the 15$^{th}$ (0.09 percent) and 10$^{th}$ percentile (0.07 percent) values to define the low-interest rate dummy and report these findings as well.

We present the results in Table 5, Panel B. The positive and significant coefficient on the low-interest rate dummy variable suggests that risk taking tend to be higher in low interest-rate environments. This may suggest that moral hazard may become more severe in times of low interest rates as banks would earn less return on their asset side, but cannot reduce deposit rates further. However, the coefficients on the interactions between the low-interest rate dummy variable and vega/cash, and the triple interaction term are insignificant. These results as a whole imply that while risk increases in times of low interest rates, it is not linked to the CEOs' behavior resulting from their pay packages.

Further, while the triple interaction term of the low-interest rate dummy variable with vega and GDP growth rate is insignificant, our main coefficient of interest (vega x GDP) remains negative and statistically significant. This suggests that even after controlling for the effects of the low interest rates on banks' risk-taking, our previous results remain unchanged.

In sum, even when interest rates are not low and hence the reach for yield incentives are not as pronounced, bank managers still react to risk-taking incentives more strongly during downturns. Since the risk-taking consequences of a given level of vega/cash is stronger during recessions even when the risk-free rates are not low, banks' search for yield cannot be the primary explanation of our results.

### 5.3 Pro-cyclical Compensation

An alternative factor that can vary over the business cycle is the design of the managerial compensation packages themselves. For example, Eisfeldt and Rampini (2008) argue that executive compensation is pro-cyclical and report a high degree of correlation between output and CEOs' *total* compensation during the decade prior to 2003. Since executive pay packages include performance-based components such as stocks and bonuses, it is natural to expect compensation values to be tightly linked to the underlying economic conditions. Consistent with this conjecture, over our sample period, CEO *total* compensation and cash compensation (salary plus bonus) are positively related to output growth, with correlation coefficients of 53 and 54 percent, respectively (Table 5, Panel C). However, rather than the effect of *total* compensation, our analysis focuses on the *composition* of pay packages in influencing bank risk as suggested by prior literature (Murphy, 2013) and in particular, on the effect of option-based convex components that encourage risk-taking. When we look at the correlation between output growth rate and vega, we see that the correlation is only 18 percent. The correlation coefficient is even lower (at one percent) for our main variable of interest, vega/cash. The absence of a strong pro-cyclical pattern in option-based compensation is also evident from the single-peaked distribution plot of this variable over time (Figure 1). The declining trend in option compensation in the second half of our sample continues even during expansions. Hence, rather than business cycle dynamics, the use of option-based compensation during this period is primarily influenced by the changes in its accounting treatment as discussed in detail in Murphy (2013).

Overall, our analysis suggests that alternative factors such as the pro-cyclicality of banks' investment opportunities, compensation packages or banks' reach for yield in a low interest rate environment are limited in their ability to explain our main finding. Thus, moral hazard mechanism remains as the most likely explanation underlying our results.

## 6 Robustness Tests

Next, we conduct additional robustness checks to address the possibility that omitted variables might be driving our results. One potentially important variable that can affect bank risk is the strength of the risk management function within the BHC. To measure the quality of risk management function at the bank level, Ellul and Yerramilli (2013) develop the risk management index (RMI), which captures the importance of the risk management function within a bank and the quality of risk oversight provided by the board of directors.[7] RMI is a hand-collected dataset and covers only a subset of our banks, reducing the sample size by about a third. We find that the coefficients on the macroeconomic interaction terms remain unchanged (Table 6, column 2). As an additional robustness check, we also confirm that our results hold when we use bank fixed effects instead of bank-manager fixed effects to capture other possible unobserved bank characteristics (Table 6, column 3).

One may also argue that the financial crisis that started in 2007 and the ensuing regulatory reforms have changed the relationship between bank risk and managerial compensation schemes. In particular, banks that received financial assistance from the TARP were subject to restrictions on executive pay and a closer oversight of bank activities. Thus, government influence may pose an omitted variable bias in our empirical design since it could jointly affect the structure of executive compensation and bank risk. Another concern is that the identification over our sample period could be limited because it is based only on two economic downturns, one of which was mild. To ensure that our results are not solely driven by the 2008 recession or the related changes in the regulatory and institutional environment following the financial crisis (such as TARP, Dodd-Frank Reform), we conduct a sub-sample analysis for the period

[7] We thank Andrew Ellul for sharing the RMI data with us.

before and after 2007 separately (Table 6, columns 4 and 5). When we rerun our regressions, our results remain robust.

Next, we repeat our analyses using asset risk instead of equity risk (i.e. volatility of stock returns) as a measure of bank riskiness. In standard models, moral hazard is induced by proximity to the bankruptcy threshold, hence these models are about choices of asset risk. Accordingly, we compute asset risk as $\text{Asset Risk} = \text{Equity Risk} * \frac{\text{Equity Value}}{\text{Equity Value} + \text{Deb Value}}$ where we use book values of debt and equity. Our main conclusion remains unchanged when we use asset risk as a measure of bank riskiness (Table 6, column 6).

As an additional check for the possible impact of changes in bank leverage along the business cycle, we control for the interaction of bank leverage and GDP growth. The effects of the economic state on the risk of equity are likely to be greater for a high-leverage bank than for a low-leverage bank for purely mechanical reasons. If leverage is correlated with vega, then omitting this interaction as a control may result in a mis-specified regression. Our results are robust to controlling for the leverage effects and its interactions with the macroeconomic state (Table 6, column 7).

Compensation, our main variable of interest, is measured annually. Yet, the rest of our variables are defined at the quarterly level. Last, we rerun our specification using annual rather than quarterly data. We employ the minimum

GDP growth rate over a fiscal year to measure the state of the economy as in Savaser and Sisli Ciamarra (2017). Consistent with our earlier results, the coefficient on (vega/cash x GDP) is negative and significant (Table 6, column 8), which suggests that the effect of CEO risk-taking incentives on bank risk intensifies during contractions. Thus, our results hold both at the quarterly as well as the annual level.

## 7 Cross-Sectional Differences

### 7.1 Bank Capital

Recent studies argue that it is optimal to combine compensation regulation with capital regulation to reduce shareholders' moral hazard incentives (Eufinger and Gill 2016; Kolm et al., 2017). Due to government guarantees, banks whose CEO incentives are more aligned with shareholders tend to take more risk since shareholders gain if the risks pay off and taxpayers pay the bill if they fail. By requiring these banks to hold more capital (compared to banks that do not exhibit such alignment), regulators can counteract the moral hazard incentives that are passed on to the managers via stock and option-based compensation. The implication of these models' predictions for our analysis is that, during contractions, the risk-increasing effect of CEO's vega/cash ratio should be muted for well-capitalized banks. To test whether bank capital mitigates the risk-inducing effects of the executive`s risk-taking incentives, we conduct a sub-sample analysis and estimate Equation 2 for banks whose Tier-1 capital ratio is (i) less than or equal to 10 percent, and (ii) above 10 percent, separately.

In line with the predictions of the Eufinger and Gill (2016) model, we find that during contractions the sensitivity of bank risk to option-based risk incentives is more pronounced among banks that have less than 10 percent Tier-1 capital ratio. The coefficient on the interaction term (vega/cash x GDP) is insignificant for well-capitalized banks whereas the same coefficient is negative and significant for banks that maintain low capital ratios, with the difference being statistically significant at the one percent level (Table 7, columns 2 and 3)[8]. This finding is also in line with Berger et al (2020), which shows that regulators are more likely to bail out banks as their capital ratios decline, providing further support for the moral hazard mechanism as the most likely explanation underlying our main result.

In sum, holding sufficiently high amount of bank capital limits the risk-inducing effects of vega during downturns, making the CEO compensation-bank risk relationship less sensitive to the underlying macroeconomic environment. In terms of policy implications, our findings lend support to the necessity of strong capital requirements as they help mitigate the risk-inducing effects of option-based managerial incentives during economic downturns.

### 7.2 Too-Big-To-Fail Banks

[8] To test the significance of the differences between the coefficients of the subsamples, we stacked the data and re-ran the regressions with triple interactions (e.g., vega/cash x large bank x GDP). The coefficients on the triple interactions are statistically significant. We report the p-values for the triple interaction terms at the bottom of the cross-sectional test tables.

In this section, we investigate whether there are any significant differences between the large and small banks. Large banks have a systematically important and too-big-to-fail status, hence are more likely to receive government support due to the risk they may pose to the financial system (Afonso et al., 2015). As shareholders of TBTF banks are more certain that the government will step in to save these banks in the event of financial distress, they are particularly susceptible to moral hazard that may lead to increased risk-taking during contractions. Consequently, we expect the counter-cyclical relationship between managerial risk incentives and bank risk to be more pronounced for TBTF banks.

To test our prediction, we divide the banks into two groups, banks whose assets are (i) below and (ii) above the 90$^{th}$ percentile value. We then estimate Equation 2 separately for the two subsamples and test whether the vega/cash - bank risk relationship is stronger during contractions for large banks. Although the coefficient on the interaction term is negative and significant for both groups, the absolute value of the coefficient is larger in magnitude for TBTF banks compared to smaller banks, with the difference in coefficients being statistically significant at the five percent level (Table 7, columns 4 and 5). These findings confirm our prediction that managers of TBTF banks have a higher tendency to make risky business decisions during contractions in response to a given level of vega/cash ratio compared to managers of smaller banks.

A related research question is whether the net effect of moral hazard and risk aversion incentives on the systemic risk of the banking sector as a whole. A plausible hypothesis would be that smaller, non-TBTF banks might alter their risk profile in such a way that their risk becomes more correlated with the overall state of the economy and/or the performance of other, larger banks. This can create a too-many-to-fail problem (Acharya and Yorulmazer, 2007). By achieving correlated failure states, smaller banks can ensure that their probability of a bailout increases in bad times. We leave this question for future research.

### 7.3 CEO Control

Our analysis suggests a counter-cyclical relationship between the executive's risk incentives and bank risk. We attribute this relationship to the presence of state-dependent moral hazard incentives that result from government guarantees. Moral hazard becomes more pronounced as economic conditions deteriorate since the perceived likelihood of receiving government support rises during contractions. More importantly, shareholders can pass their increased risk-taking preferences onto the bank manager via a compensation package that includes stock and option-based components. Thus, reflecting the shareholders' increased risk appetite, the same manager with exactly the same level of option-based risk incentives, facing the same bank characteristics may target a higher risk level as the economy contracts.

If indeed the proposed effect of compensation on bank risk is due to the manager's actions (and not due to some omitted bank-specific or macroeconomic factor), then we would expect our results to be more pronounced in banks that are run by powerful CEOs. The executive's ability to adjust risk depends critically on her managerial power. This is because if the manager has more control, she can influence business decisions to a greater extent and adjust bank risk according to her preferences. Hence, in this section, we examine whether the documented counter-cyclical link between the vega/cash ratio and bank risk is sensitive to managerial power.

To measure managerial control, we use CEO tenure (Abernethy et al., 2015; Onali et al., 2016; Pan et al., 2016; van Essen et al., 2015). This is a suitable proxy for managerial power since boards' control over the CEOs' actions tends to weaken as they become more seasoned. For example, number of independent outsiders on the board decreases with the tenure of the CEO (Baker and Gompers, 2003). Also seasoned CEOs are more likely to capture the board because directors that are appointed by a CEO exert less control over that manager (Shivdasani and Yermack, 1999; Baker and Gompers, 2003; Morse et.al., 2011; Coles et al., 2014). Such a weakening in the board's monitoring effectiveness allows the CEO to have a greater impact on policies and more control over risk.

To examine whether the link between vega/cash ratio and bank risk is sensitive to managerial power, we divide the banks into two groups, banks whose CEOs have a tenure of (i) at least 3years and (ii) less than 3 years. We test whether the vega/cash - bank risk relationship is stronger during contractions for banks with seasoned CEOs. In line with our prediction, the coefficient on the interaction term (vega/cash x GDP) is negative and significant for banks with seasoned CEOs while the same coefficient is statistically insignificant for banks with short-tenured CEOs (Table 7, columns 6 and 7). These findings indicate that the risk-increasing effects of vega in downturns is valid only for banks that are run by seasoned CEOs. Thus, powerful CEOs are more able to increase risk during downturns in response to a given level of vega/cash ratio compared to banks that are managed by less powerful CEOs.

A caveat in our analysis is that CEO tenure may be capturing shareholder-manager conflicts instead of managerial control.[9] To alleviate this concern, we note that according to the risk-shifting theory, shareholders are expected to benefit from an increase in bank risk when the probability of financial distress increases. Thus, a CEO whose interests are aligned with the interests of shareholders would increase risk more during downturns when compared to a manager whose interests are not as aligned with the interests of the shareholders. Hence, if CEO tenure were actually capturing conflicts of interest between managers and shareholders (rather than CEO power), we would expect vega to be associated with higher risk during downturns in banks that are

[9] The literature on managerial power uses CEO-chairman duality, board size, board independence, concentrated ownership and institutional ownership as alternative measures for managerial power (van Essen et al., 2015). All of these measures are subject to the same caveat.

managed by CEOs with shorter tenures. Yet, our results indicate the opposite. It is possible that in our setting, tenure isolates the notion of CEO control, as performance incentives (delta) likely control for shareholder-manager alignment.

## 8 High-Bailout Probability Periods

Our cross-sectional analyses so far provides further evidence that the moral hazard mechanism is more pronounced than risk aversion mechanism, because existing research shows that bailout probabilities are likely to be higher for larger and less-capitalized banks. However, this evidence is indirect. In order to provide a more direct evidence that links the relationship between bank risk taking and vega to the changes in the bailout probability, we incorporate the bank bailout probabilities estimated by Hett and Schmidt (2017) directly into our analysis. According to these estimates, bailout likelihood was substantially higher between March 2008 and July 2010, declining to the pre-crisis levels only after the signing of the Dodd-Frank Reform Bill in July 2010. Using the bailout probabilities Hett and Schmidt (2017) calculated over the 2004-2014 interval, we conduct a sub-sample analysis that divides the decade into high-bailout versus low-bailout periods[10]. If a quarter includes a month during which the bailout probability was substantially higher than the pre-crisis level, the high-bailout indicator is equal to one, and zero otherwise. We find that while the coefficient on the interaction term between vega and GDP is negative and significant during

[10] For this analysis, our sample period is limited to 2004-2014, for which Hett and Schmidt (2017) provides the estimates for bailout probabilities.

the high-bailout period, it is insignificant during the low-bailout period, with the difference between coefficients being statistically significant across two sub-periods (Table 8). Since the risk-increasing effect of vega is valid only during the high-bailout period, this evidence is consistent with moral hazard incentives being more pronounced relative to the risk aversion during downturns.

## 9 Performance Incentives

In our analyses so far, the coefficient on delta/cash is negative. Hence, performance incentives have a risk-dampening effect, consistent with prior literature (Acharya et al., 2014). Further, the coefficient on the interaction term (delta/cash x GDP) is also significant. Thus, the relationship between managerial performance incentives and bank risk also varies over the business cycle. In contrast to risk incentives however, we find the relationship between performance incentives and bank risk to be pro-cyclical. In line with earlier studies, we show that performance incentives have a depressive effect on bank risk: A one percent increase in delta/cash ratio leads to about 0.15 percent decline in total risk (Table 3). However, in quarters when GDP contracts (grows) by one percentage point, this depressive effect is amplified (dampened) by a 0.013 percent decrease (increase) in bank risk.

These results suggest that while the risk aversion mechanism works primarily through CEO’s performance incentives (delta/cash), the moral hazard mechanism is operative through the risk-taking incentives (vega/cash). The pro-cyclical relationship between performance incentives and bank risk is also consistent with the evidence from the non-financial sector. Focusing on the US non-financial firms, Savaser and Sisli-Ciamarra (2017) document that the same level of delta is associated with a lower (higher) firm risk in a contracting (expanding) economy. They attribute this finding to the increase (decrease) in CEO risk aversion coefficient during recessions (expansions). Yet, they do not find a state-dependent link between firm risk and vega in the non-financial sector, which is consistent with the fact that government guarantees are not as common in the non-financial sector as they are in the banking sector. This earlier evidence together with the results here suggest that banks are indeed different: In the absence of government guarantees that encourage moral hazard, the amplified effect of vega on firm risk during downturns disappears.

## 10 Conclusion

In this paper, we investigate whether a given level of risk incentives to a manager might result in different levels of bank risk under different macroeconomic conditions. Our main result is that compared to the periods of economic expansion, the same level of risk-taking incentives given to a bank manager is associated with higher bank risk during economic downturns. This finding suggests that the increase in moral hazard incentives is more pronounced relative to the increase in managerial risk aversion during economic downturns. The extant banking literature is built on the assumption that the risk-taking consequences of managerial pay packages are the same regardless of the state of the economy. To our knowledge, we provide the first evidence of the counter-cyclical relationship between CEO risk-taking incentives and bank risk.

Our findings may help policymakers and board of directors better assess the risk-taking implications of CEO pay packages by incorporating the state of the economy when they make compensation decisions to meet their objectives. Compensation contracts tend to be sticky since managers are either granted a fixed dollar value or a fixed number of stock and option grants (Shue and Townsend, 2017), but our results suggest that the structure of pay packages should vary with the underlying macroeconomic environment.

Our findings also highlight the interaction between capital requirements and compensation practices in the banking sector. We document that holding sufficiently high amount of bank capital limits the risk-inducing effects of vega during downturns, making the CEO compensation-bank risk relationship less sensitive to the underlying macroeconomic environment. By highlighting the interaction between capital requirements and compensation design over the business cycle, this finding underscores the necessity of strong capital requirements as they help mitigate the risk-increasing incentives generated by option-based managerial incentives.

**References**

Abernethy, M. A., Kuang, Y. F. and Qin, B. (2015). The influence of CEO power on compensation contract design, Accounting Review, 90(4), 1265-1306.

Acharya, V., Litov, L. P. and Sepe, S. M. (2014). Seeking alpha, taking risk: Evidence from non-executive pay in US bank holding companies, University of Pennsylvania, Wharton School, Weiss Center Working Paper, 13-18.

Acharya V. and Yorulmazer, T. (2007). Too many to fail an analysis of time-inconsistency in bank closure policies, Journal of Financial Intermediation, 16, 1–31.

Adams, R.B. (2012). Governance and the financial crisis, International Review of Finance, 12(1), 7-38.

Afonso, G., Santos, J. A. C. and Traina, J. (2015). Do 'too-big-to-fail' banks take on more risk? Journal of Financial Perspectives, 3(2): 129-143.

Amihud, Y. and Lev, B. (1981). Risk reduction as a managerial motive for conglomerate mergers, Bell Journal of Economics, 12, 605-617.

Armstrong, C. and Vashishtha R. (2012). Executive stock options, differential risk-taking incentives, and firm value, Journal of Financial Economics, 104, 70-88.

Baker, S. R., Bloom, N. and Davis, S. J. (2016). Measuring economic policy uncertainty, Quarterly Journal of Economics, 131(4), 1593-1636.

Baker, M. and Gompers, P. A. (2003). The determinants of board structure at the initial public offering, Journal of Law and Economics, 46(2), 569-598.

Berger, P., Ofek, E. and Yermack, D. (1997). Managerial entrenchment and capital structure decisions, Journal of Finance 52, 1411–1438.

Berger, A.N., Roman, R. and Sedunov, J. (2016). Do bank bailouts reduce or increase systemic risk? The effects of TARP on financial system stability, Federal Research Bank of Kansas City Working Paper.

Bhattacharyya, S. and Purnanandam, A. K. (2011). Risk-taking by banks: What did we know and when did we know it? AFA 2012 Chicago Meetings Paper.

Black, L. and Hazelwood, L. (2013). The effect of TARP on bank risk-taking, Journal of Financial Stability, 9, 790-803.

Bolton P., Mehran H. and Shapiro J. (2015). Executive compensation and risk taking. Review of Finance, 19(6), 2139-2181.

Borio, C. and Zhu. H. (2012). Capital regulation, risk-taking and monetary policy: A missing link in the transmission mechanism?, Journal of Financial Stability, 8(4): 236–251.

Boyallian, P. and Ruiz-Verdu, P. (2018). Leverage, CEO risk-taking incentives, and bank failure during the 2007 financial crisis, Review of Finance 22(5), 1763-1805.

Bushman, R. M. and Davidson, R. H., Dey, A. and Smith, A. J. (2017). Bank CEO materialism: Risk controls, culture and tail risk, Journal of Accounting and Economics, 65(1), 191-220.

Chen, C. R., Steiner, T. L. and Whyte, A. M. (2006). Does stock option-based executive compensation induce risk-taking? An analysis of the banking industry, Journal of Banking and Finance, 30(3), 915-945.

Chesney, M., Stromberg, J. and Wagner, A. F. (2016). Managerial incentives to take asset risk, Swiss Finance Institute Research Paper, 10-18.

Cohn, A., Engelmann, J., Fehr, E. and Maréchal, M. A. (2015). Evidence for countercyclical risk aversion: An experiment with financial professionals, American Economic Review, 105(2), 860-85.

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

Coles, J. L., Daniel, N. and Naveen, L. (2014). Co-opted boards, Review of Financial Studies, 27(6), 1751-1796.

Core, J. and Guay, W. (1999). The use of equity grants to manage optimal equity incentive levels, Journal of Accounting and Economics, 28, 151-184.

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

Dell'Ariccia, G. and Marquez, R. (2013). Interest rates and the bank risk-taking channel. Annual Review of Financial Economics (5), 123–141.

DeYoung, R., Peng, E. and Yan, M. (2013). Executive compensation and business policy choices at U.S. commercial banks, Journal of Financial and Quantitative Analysis, 48(1), 165-196.

Duchin R. and Sosyura, D. (2014). Safer ratios, riskier portfolios: Banks' response to government aid, Journal of Financial Economics, 113, 1-28.

Edmans, A., Gabaix, X. and Jenter, D. (2017). Executive compensation: A survey of theory and evidence, Handbook of the Economics of Corporate Governance, 1, 383-539, North-Holland.

Eisfeldt, A. L. and Rampini, A. A. (2008). Managerial incentives, capital reallocation, and the business cycle. Journal of Financial Economics, 87(1), 177-199.

Ellul, A. and Yerramilli, V. (2013). Stronger risk controls, lower risk: Evidence from U.S. bank holding companies, Journal of Finance, 68, 1757-1803.

Eufinger, C. and Gill, A. (2016). Incentive-based capital requirements, Management Science, 63(12), 4101-4113.

Fahlenbrach, R. and Stulz, R. M. (2011). Bank CEO incentives and the credit crisis, Journal of Financial Economics, 99(1), 11-26.

Farrell, A.M., Goh, J.O. and White, B.J. (2014). The effect of performance-based incentive contracts on system 1 and system 2 processing in affective decision contexts: fMRI and behavioral evidence, Accounting Review, 89(6), 1979-2010.

Gaver, J.J. and Gaver, K.M. (1993). Additional evidence on the association between the investment opportunity set and corporate financing, dividend, and compensation policies, Journal of Accounting and Economics (January/April/June), 125-160.

Gaver, J.J. and Gaver, K.M. (1995). Compensation policy and the investment opportunity set, Financial Management (Spring) 9-32.

Graham, J., Harvey, C. and Puri, M. (2013). Managerial attitudes and corporate actions, Journal of Financial Economics, 109, 103-121.

Guiso, L., Sapienza, P. and Zingales, L. (2018). Time varying risk aversion, Journal of Financial Economics, 128(3), 403-421.

Hayes, R., Lemmon, M. and Qiu, M. (2012). Stock options and managerial incentives for risk-taking: Evidence from FAS 123R, Journal of Financial Economics, 105, 174 -190.

Hellmann, T. F., Murdock, K. C. and Stiglitz, J. E. (2000). Liberalization, moral hazard in banking, and prudential regulation: Are capital requirements enough? American Economic Review, 90(1) 147–165.

Hett, F. and Schmidt, A. (2017). Bank rescues and bailout expectations: The erosion of market discipline during the financial crisis, Journal of Financial Economics, 126(3), 635-651.

Houston, J.F. and James, C. (1995). CEO compensation and bank risk: Is compensation in banking structured to promote risk taking? Journal of Monetary Economics, 36(2), 405-431.

Jiménez, G., Ongena, S., Peydró, J.L. and Saurina, J. (2014). Hazardous times for monetary policy: What do twenty-three million bank loans say about the effects of monetary policy on credit risk-taking? Econometrica, 82(2), 463-505.

Kahneman, D., and Frederick S. (2004). Attribute substitution in intuitive judgment. In Models of a Man: Essays in Memory of Herbert A. Simon, edited by Augier, M., and J. March, 411-432. Cambridge, MA: MIT Press.

Kahneman, D., and Frederick S. (2005). A model of heuristic judgment. In The Cambridge Handbook of Thinking and Reasoning, edited by Holyoak, K., and R. Morrison, 267-294. New York, NY: Cambridge University Press.

Kolm, J., Laux, C. and Loranth, G. (2017). Bank regulation, CEO compensation, and boards, Review of Finance, 21(5), 1901-1932.

Lambert, R.A. and Larcker, D.F. (1987). An analysis of the use of accounting and market measures of performance in executive compensation contracts, Journal of Accounting Research (Supplement), 85-125.

Lehn, K. and Poulsen, A. (1989). Free cash flow and stockholder gains in going private transactions, Journal of Finance (July), 771-787.

Li, L. (2013). TARP funds distribution and bank loan supply, Journal of Banking and Finance, 37, 4777-4792.

Lucas, D., (2019). Measuring the cost of bailouts, Annual Review of Financial Economics, 11, 85-108.

Morse, A., Nanda, V. and Seru, A. (2011). Are incentive contracts rigged by powerful CEOs? Journal of Finance, 66, 1779-1821.

Murphy, K. (2013). Executive Compensation: Where we are, and how we got there, Handbook of the Economics of Finance, 2, 211-356.

Onali, E., Galiakhmetova, R., Molyneux, P., and Torluccio, G. (2016). CEO power, government monitoring, and bank dividends, Journal of Financial Intermediation, 27, 89-117.

Pan, Y. Wang, T. Y. And Weisbach, M.S. (2016). CEO Investment Cycles, Review of Financial Studies, 29 (11), 2955–2999.

Rochet, J. C. (1992). Capital requirements and the behaviour of commercial banks, European Economic Review, 36, 1137–1170.

Savaser, T. and Sisli-Ciamarra, E. (2017). Managerial performance incentives and firm risk during economic expansions and recessions, Review of Finance, 21(2), 911-944.

Shivdasani, A. and Yermack, D. (1999). CEO involvement in the selection of new board members: An empirical analysis, Journal of Finance, 54, 1829-1853.

Shue, K. and Townsend, R. R. (2017). Growth through rigidity: An explanation for the rise in CEO pay, Journal of Financial Economics, 123(1), 1-21.

Smith, C. and Watts, R. (1992). The investment opportunity set and corporate financing, dividend and compensation policies, Journal of Financial Economics, 32, 263-292.

Swanson, N. (1996). Forecasting using first-available versus fully revised economic time-series data, Studies in Nonlinear Dynamics and Econometrics, 1(1).

Thanassoulis, J. and Tanaka, M. (2018). Optimal pay regulation for too-big-to-fail banks, Journal of Financial Intermediation, 33, 83-97.

Berger, A. N., Nistor, S., Ongena S. and Tsyplakov, S. (2020). Catch, restrict, and release: The real story of bank bailouts, August, Mimeo.

Tufano, P. (1996). Who manages risk? An empirical examination of risk management practices in the gold mining industry, Journal of Finance, 51, 1097-137.

Van Bekkum, S. (2016). Inside debt and bank risk, Journal of Financial and Quantitative Analysis, 51(2), 359-385.

Van Essen, M., Otten, J. and Carberry, E. J. (2015). Assessing managerial power theory: A meta-analytic approach to understanding the determinants of CEO compensation, Journal of Management 41 (1), 164–202.

**Appendix 1: List of Banks in the Sample**

AMEGY BANCORPORATION INC
AMERICAN EXPRESS CO
AMERIS BANCORP
AMSOUTH BANCORPORATION
ASSOCIATED BANC-CORP
ASTORIA FINANCIAL CORP
BANCORPSOUTH INC
BANCWEST CORP
BANK MUTUAL CORP
BANK OF AMERICA CORP
BANK OF HAWAII CORP
BANK OF NEW YORK MELLON CORP
BANK OF THE OZARKS INC
BANK ONE CORP
BANKAMERICA CORP-OLD
BANKBOSTON CORP
BANKERS TRUST CORP
BANKNORTH GROUP INC-OLD
BANNER CORP
BARNETT BANKS INC
BB&T CORP
BOATMENS BANCSHARES INC
BOFI HOLDING INC
BOSTON PRIVATE FINL HOLDINGS
BROOKLINE BANCORP INC
CAPITAL ONE FINANCIAL CORP
CARDINAL FINANCIAL CORP
CASCADE BANCORP
CATHAY GENERAL BANCORP
CCB FINANCIAL CORP
CENTRAL FIDELITY BANKS INC
CENTRAL PACIFIC FINANCIAL CP
CENTURA BANKS INC
CHARTER ONE FINANCIAL INC
CHASE MANHATTAN CORP -OLD
CHITTENDEN CORP
CIT GROUP INC
CITIGROUP INC
CITY HOLDING CO
CITY NATIONAL CORP
COLONIAL BANCGROUP
COLUMBIA BANKING SYSTEM INC
COMERICA INC
COMMERCE BANCORP INC/NJ
COMMERCE BANCSHARES INC
COMMUNITY BANK SYSTEM INC
COMMUNITY FIRST BANKSHARES
CONCORD EFS INC
CONTINENTAL BANK CORP
CORESTATES FINANCIAL CORP
CORUS BANKSHARES INC
COUNTRYWIDE FINANCIAL CORP
CRESTAR FINANCIAL CORP
CULLEN/FROST BANKERS INC
CVB FINANCIAL CORP
DAUPHIN DEPOSIT CORP
DEPOSIT GUARANTY CORP
DIME COMMUNITY BANCSHARES
DISCOVER FINANCIAL SVCS INC
E TRADE FINANCIAL CORP
EAST WEST BANCORP INC
F N B CORP/FL
FIFTH THIRD BANCORP
FIRST AMERICAN CORP/TN
FIRST AMERICAN FINANCIAL CP
FIRST BANCORP P R
FIRST CHICAGO CORP
FIRST CHICAGO NBD CORP
FIRST COMMERCIAL CORP
FIRST COMMONWLTH FINL CP/PA
FIRST FIDELITY BANCORP
FIRST FINL BANCORP INC/OH
FIRST FINL BANKSHARES INC
FIRST HORIZON NATIONAL CORP
FIRST INTERSTATE BNCP
FIRST MICHIGAN BANK CORP
FIRST MIDWEST BANCORP INC
FIRST NIAGARA FINANCIAL GRP
FIRST OF AMERICA BANK CORP
FIRST SECURITY CORP/DE
FIRST VIRGINIA BANKS INC
FIRSTAR CORP-OLD
FIRSTMERIT CORP
FLAGSTAR BANCORP INC
FLEETBOSTON FINANCIAL CORP
FRANKLIN RESOURCES INC
FRONTIER FINANCIAL CORP/WA
FULTON FINANCIAL CORP
GBC BANCORP/CA
GLACIER BANCORP INC
GOLD BANC CORP INC
GOLDMAN SACHS GROUP INC
GREATER BAY BANCORP
GREENPOINT FINANCIAL CORP
HANCOCK HOLDING CO
HANMI FINANCIAL CORP
HIBERNIA CORP -CL A
HOME BANCSHARES INC
HUDSON CITY BANCORP INC
HUDSON UNITED BANCORP
HUNTINGTON BANCSHARES
IMPERIAL BANCORP
INDEPENDENT BANK CORP/MA
INDEPENDENT BANK CORP/MI
INTL BANCSHARES CORP
INVESTORS FINANCIAL SVCS CP
IRWIN FINANCIAL CORP
JPMORGAN CHASE & CO
KEYCORP
KEYSTONE FINANCIAL INC
LEGACY TEX FINANCIAL GRP INC
LIBERTY BANCORP INC/OK
LIBERTY NATIONAL BANCORP/KY
M & T BANK CORP
MAGNA GROUP INC
MARK TWAIN BANCSHARES
MARSHALL & ILSLEY CORP
MB FINANCIAL INC/MD
MBNA CORP
MELLON FINANCIAL CORP
MERCANTILE BANCORPORATION
MERCANTILE BANKSHARES CORP
MERIDIAN BANCORP INC
METLIFE INC
MORGAN (J P) & CO
MORGAN STANLEY
N B T BANCORP INC
NATIONAL CITY CORP
NATIONAL COMMERCE FINANCIAL
NATIONAL PENN BANCSHARES INC
NBB BANCORP INC
NEW YORK CMNTY BANCORP INC
NEWALLIANCE BANCSHARES INC
NORTH FORK BANCORPORATION
NORTHERN TRUST CORP
NORTHWEST BANCSHARES INC
OFG BANCORP
OLD KENT FINANCIAL CORP
OLD NATIONAL BANCORP
ONBANCORP INC
ORITANI FINANCIAL CORP
PACWEST BANCORP
PEOPLE'S UNITED FINL INC
PINNACLE FINL PARTNERS INC
PNC FINANCIAL SVCS GROUP INC
POPULAR INC
PREMIER BANCORP
PREMIER BANCSHARES INC
PRIVATEBANCORP INC
PROSPERITY BANCSHARES INC
PROVIDENT BANKSHARES CORP
PROVIDENT FINANCIAL GRP INC
PROVIDENT FINANCIAL SVCS INC
RAYMOND JAMES FINANCIAL CORP
REGIONS FINANCIAL CORP
REPUBLIC BANCORP INC
RIGGS NATIONAL CORP
S & T BANCORP INC
SCHWAB (CHARLES) CORP
SEACOAST FINANCIAL SERVICES
SHAWMUT NATIONAL CORP
SIMMONS FIRST NATL CP -CL A
SOUTH FINANCIAL GROUP INC
SOUTHSIDE BANCSHARES INC
SOUTHTRUST CORP
STATE STREET CORP
STERLING BANCORP
STERLING BANCORP/NY -OLD
STERLING BANCSHARES INC/TX
STERLING FINANCIAL CORP/WA
STIFEL FINANCIAL CORP
SUMMIT BANCORP
SUNTRUST BANKS INC
SUSQUEHANNA BANCSHARES INC
SVB FINANCIAL GROUP
SYNOVUS FINANCIAL CORP
TAYLOR CAPITAL GROUP INC
TCF FINANCIAL CORP
TEXAS CAPITAL BANCSHARES INC
TEXAS REGL BCSHS INC -CL A
TOMPKINS FINANCIAL CORP
TRUSTCO BANK CORP/NY
TRUSTMARK CORP
U S BANCORP
U S BANCORP-OLD
U S TRUST CORP
UCBH HOLDINGS INC
UMB FINANCIAL CORP
UMPQUA HOLDINGS CORP
UNION PLANTERS CORP
UNITED BANKSHARES INC/WV
UNITED COMMUNITY BANKS INC
UST CORP
VALLEY NATIONAL BANCORP
WACHOVIA CORP
WACHOVIA CORP-OLD
WASHINGTON FEDERAL INC
WEBSTER FINANCIAL CORP
WELLS FARGO & CO
WELLS FARGO & CO -OLD
WEST ONE BANCORP
WESTAMERICA BANCORPORATION
WHITNEY HOLDING CORP
WILMINGTON TRUST CORP
WILSHIRE BANCORP INC
WINTRUST FINANCIAL CORP
ZIONS BANCORPORATION

**Appendix 2. Variable Descriptions**

| Variable | Description |
|---|---|
| **A. CEO Incentive Measures** | |
| Salary ($000s) | Base salary of the CEO. |
| Bonus ($000s) | Bonus payments to the CEO. Calculated as "Bonus + Nonequity Incentives" after the fiscal year 2006. |
| Cash Compensation ($000s) | Salary plus bonus. We use the log form of this variable in regressions. |
| Delta ($000s) | Dollar change in the CEO stock and option portfolio for a 1% change in stock price. |
| Vega ($000s) | Dollar change in the CEO stock and option portfolio for a 1% change in stock return volatility. |
| Delta/Cash Compensation | CEO performance incentives scaled by cash compensation. We use the log form of this variable in regressions. |
| Vega/Cash Compensation | CEO risk taking incentives scaled by cash compensation. We use the log form of this variable in regressions. |
| Tenure as CEO | Number of years as CEO. We use the log form of this variable in regressions. |
| CEO Age | Age of the CEO. We use the log form of this variable in regressions. |
| CEO Transition | Indicator variable which takes the value one for fiscal years when a CEO change occurred, zero otherwise. |
| CEO Board Member | Indicator variable which takes the value one if CEO is a board member, zero otherwise. |
| High CEO Control | CEO tenure more than 3 years. |
| **B. Risk Measures** | |
| Total risk | Annualized variance of daily stock returns during a firm's fiscal quarter. We use the log form of this variable in regressions. |
| Tail risk | Average return on a bank's equity over the 10% worst return days for the bank's stock in a given quarter. We use the log form of this variable in regressions. |
| Systematic Risk | Annualized variance of the product of the bank beta and the market daily returns. We use the log form of this variable in regressions. |
| Unsystematic Risk | Annualized variance of residuals from the market model. We use the log form of this variable in regressions. |
| **C. Bank Financial Characteristics** | |
| Total Assets ($000s) | Total assets of the bank. We use the log form of this variable in regressions. |
| ROA | Income before extraordinary items scaled by total assets. |
| Deposits/Assets | Total deposits scaled by total assets. |
| Tier 1 Capital / Assets | Tier 1 capital (reported) scaled by total assets. |
| Loans / Assets | Total loans scaled by total assets. |
| Bad Loans / Assets | Ratio of the sum of loans past due 90 days or more and non-accrual loans to assets. |
| Non-interest Income / Income | Ratio of non-interest income to the sum of interest income and non-interest income. |
| Insurance Assets / Assets | The ratio of the assets of subsidiaries engaged in insurance and reinsurance to assets. |
| Derivative Trading Assets / Assets | The ratio od total gross notional amount of derivative contracts held for trading (interest rate contracts, foreign exchange contracts, equity derivative contracts, and commodity and other contracts) to assets. |
| Derivative Hedging Assets / Assets | Derivative Trading assets scaled by total assets. |
| Underwriting Assets / Assets | The ratio of the assets of subsidiaries engaged in underwriting or dealing securities to assets. |
| RMI | Risk Management Index (Ellul and Yerramilli, 2013). |
| Asset Growth | Growth rate of total assets over a quarter |
| Income Growth | Growth rate of total revenues over a quarter |
| Non-interest Income Growth | Growth rate of non-interest income over a quarter |
| Market-to-Book Ratio | Ratio of market value of equity to book value of equity. |
| **D. Macroeconomic State Measures** | |
| Gross Domestic Product (GDP) Growth Rate | Advance release values for real GDP growth rate (percentage changes from a year ago), seasonally adjusted. |
| Chicago FED Index | Chicago Fed National Activity Index (CFNAI). |
| Confidence Index | Standardized Yale/Shiller crash confidence index. |
| Economic Policy Uncertainty (EPU) Index | Standardized Baker, Bloom and Davis index. |
| NBER Recession Indicator | Indicator variable which takes the value one for each quarter that overlaps with the NBER recession periods (i.e. Q2-Q4 of 2001; Q1-Q4 of 2008 and Q1-Q2 of 2009). |
| Low Interest Rate Environment Indicator | Indicator variable which takes the value one for quarters when the yield on 3-month treasury bills is below a threshold (p25, p20 or p15). |

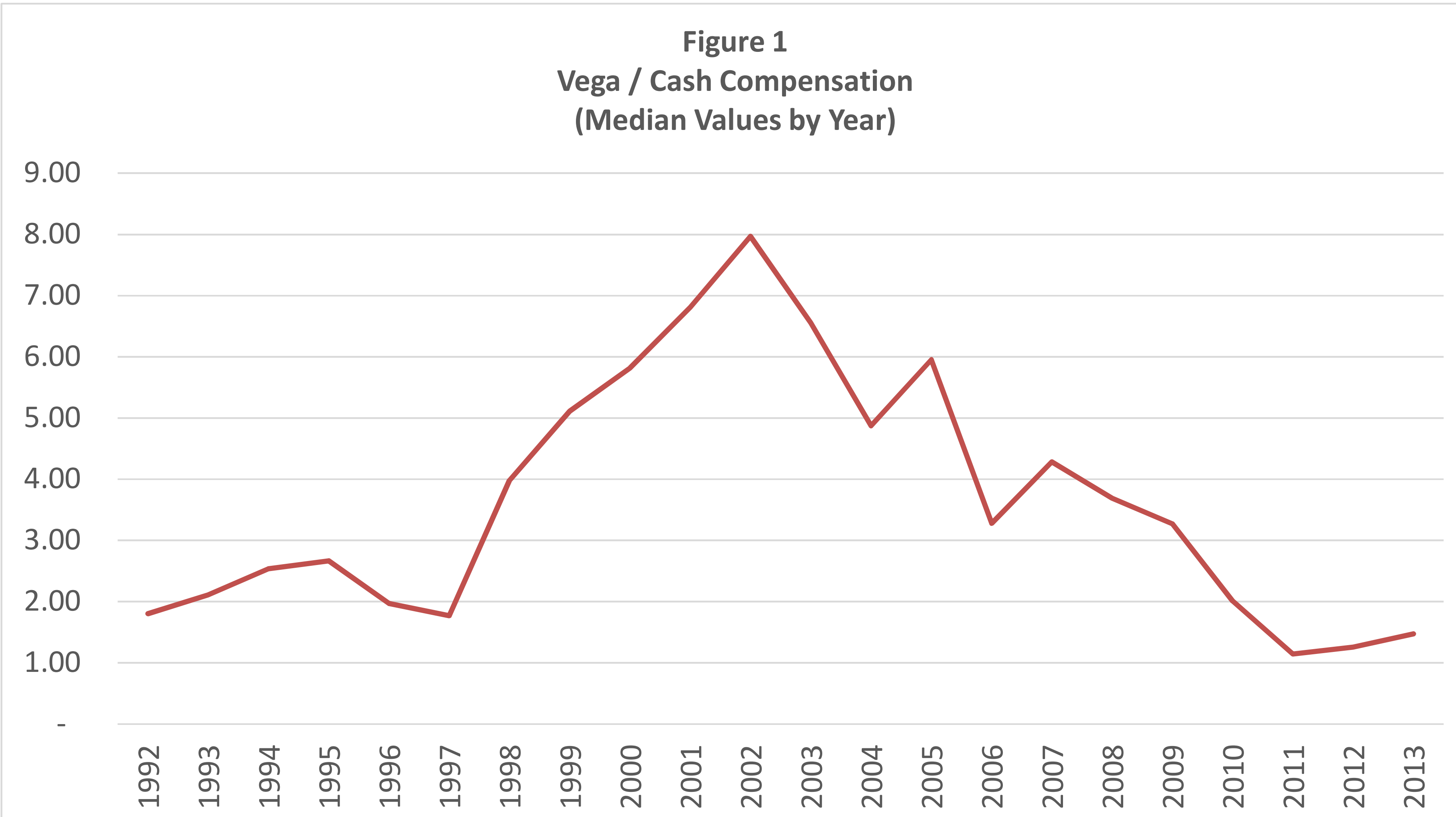
Figure 1
Vega / Cash Compensation
(Median Values by Year)
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
-
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013

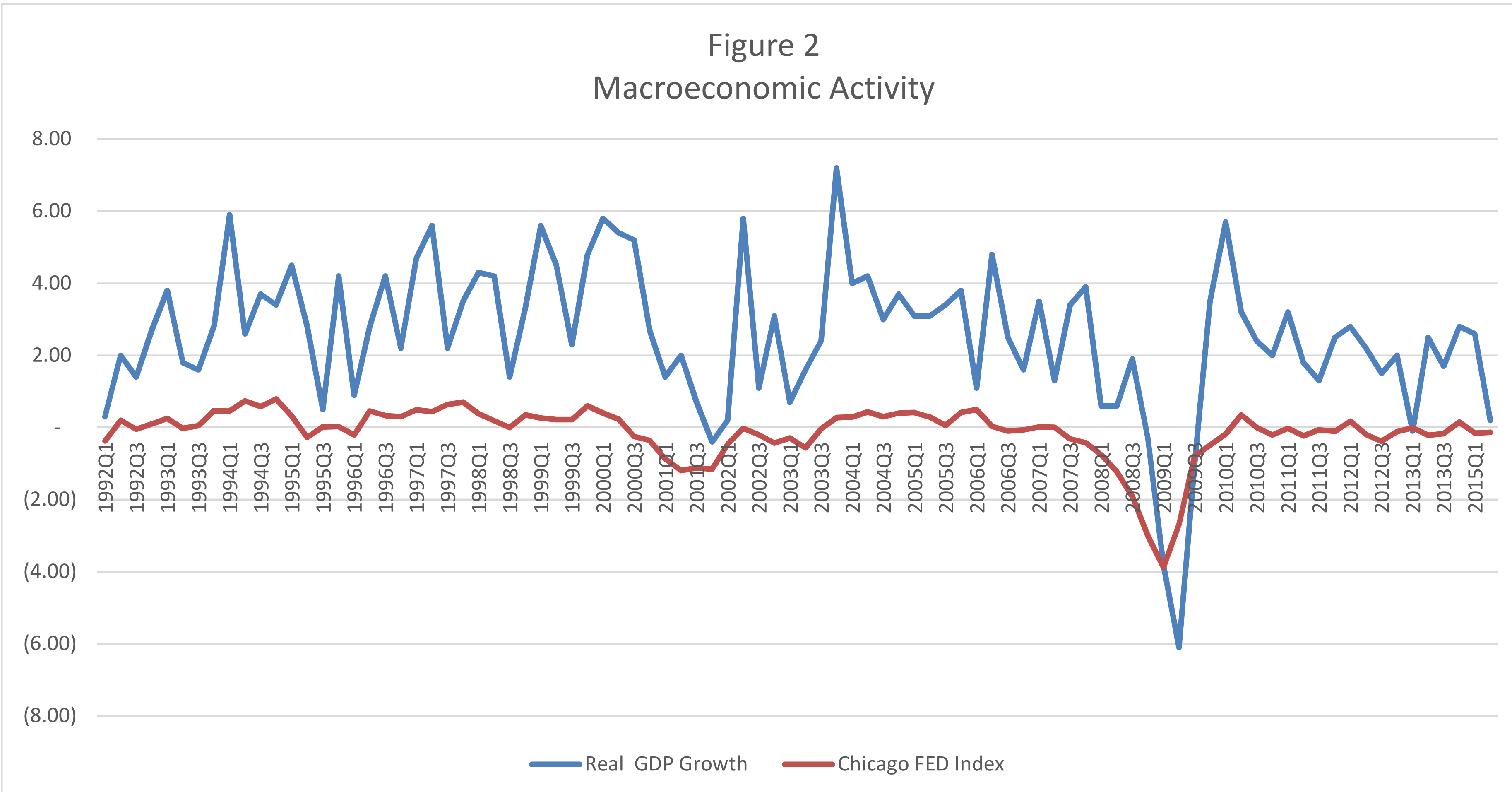
Figure 2
Macroeconomic Activity
8.00
6.00
4.00
2.00
-
(2.00)
(4.00)
(6.00)
(8.00)
1992Q1
1992Q3
1993Q1
1993Q3
1994Q1
1994Q3
1995Q1
1995Q3
1996Q1
1996Q3
1997Q1
1997Q3
1998Q1
1998Q3
1999Q1
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2004Q1
2004Q3
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2005Q3
2006Q1
2006Q3
2007Q1
2007Q3
2008Q1
2008Q3
2009Q1
2009Q3
2010Q1
2010Q3
2011Q1
2011Q3
2012Q1
2012Q3
2013Q1
2013Q3
2015Q1
Real GDP Growth
Chicago FED Index

**Table1. Summary Statistics**

This table presents the summary statistics for the variables used in the analyses. The definition of the variables and the data sources are provided in Appendix.

| | N | Mean | Standard Deviation | p25 | p50 | p75 |
|---|---|---|---|---|---|---|
| **A. CEO Compensation Measures** | | | | | | |
| Salary ($000s) | 5890 | 542.69 | 244.10 | 369.15 | 517.05 | 673.08 |
| Bonus ($000s) | 5890 | 737.22 | 1,131.37 | 53.03 | 326.00 | 846.42 |
| Cash Compensation ($000s) | 5890 | 1,291.01 | 1,285.26 | 520.28 | 833.26 | 1,503.66 |
| Delta ($000s) | 5890 | 485.92 | 1,053.77 | 45.67 | 153.74 | 472.79 |
| Vega ($000s) | 5890 | 114.54 | 191.89 | 8.01 | 30.75 | 119.40 |
| Delta/Cash Compensation | 5890 | 65.25 | 480.32 | 6.86 | 16.33 | 35.62 |
| Vega/Cash Compensation | 5890 | 15.31 | 106.71 | 1.16 | 3.71 | 9.57 |
| Tenure as CEO (years) | 5890 | 9.38 | 7.11 | 4.00 | 7.00 | 13.00 |
| High CEO Control | 5890 | 0.85 | 0.36 | 1.00 | 1.00 | 1.00 |
| CEO Age | 5890 | 56.45 | 6.71 | 52.00 | 56.00 | 61.00 |
| CEO Turnover | 5890 | 0.14 | 0.35 | 0.00 | 0.00 | 0.00 |
| CEO is a Board Member | 5890 | 0.94 | 0.24 | 1.00 | 1.00 | 1.00 |
| **B. Risk Measures** | | | | | | |
| Total Risk | 5890 | 19.74 | 41.10 | 4.52 | 8.23 | 17.53 |
| Tail Risk | 5890 | 3.82 | 2.57 | 2.26 | 3.06 | 4.45 |
| Systematic Risk | 5890 | 6.54 | 13.03 | 1.40 | 2.76 | 5.84 |
| Unsystematic Risk | 5890 | 12.58 | 26.68 | 2.80 | 5.27 | 11.31 |
| **C. Bank Financial Characteristics** | | | | | | |
| Total Assets ($mns) | 5890 | 92,700 | 291,000 | 5,348 | 11,600 | 44,400 |
| ROA | 5890 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Deposits/Assets | 5890 | 0.68 | 0.16 | 0.64 | 0.71 | 0.79 |
| Tier 1 Capital / Assets | 5890 | 0.09 | 0.04 | 0.07 | 0.08 | 0.09 |
| Loans / Assets | 5890 | 0.61 | 0.17 | 0.55 | 0.66 | 0.72 |
| Bad Loans / Assets | 5890 | 0.01 | 0.01 | 0.00 | 0.00 | 0.01 |
| Non-interest Income / Assets | 5890 | 0.27 | 0.18 | 0.15 | 0.23 | 0.33 |
| Insurance Assets / Assets | 5890 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Derivative Trading Assets / Assets | 5890 | 1.31 | 5.23 | 0.00 | 0.00 | 0.10 |

**Table1. Summary Statistics (cont'd)**

| | N | Mean | Standard Deviation | p25 | p50 | p75 |
|---|---|---|---|---|---|---|
| Derivative Hedging Assets / Assets | 5890 | 0.09 | 0.18 | 0.00 | 0.03 | 0.10 |
| Underwriting Assets / Assets | 5890 | 0.01 | 0.04 | 0.00 | 0.00 | 0.00 |
| Asset Growth | 5890 | 0.03 | 0.09 | 0.00 | 0.01 | 0.04 |
| Income Growth | 5890 | 0.06 | 10.03 | -0.09 | 0.02 | 0.10 |
| Non-interest Income Growth | 5890 | -0.04 | 9.77 | -0.06 | 0.02 | 0.10 |
| Market-to-Book Ratio | 5890 | 2.03 | 1.05 | 1.27 | 1.87 | 2.57 |
| RMI | 4001 | 0.66 | 0.31 | 0.41 | 0.62 | 0.90 |
| **D. Macroeconomic State Measures** | | | | | | |
| GDP Growth Rate | 5890 | 2.46 | 2.17 | 1.40 | 2.50 | 3.70 |
| Chicago Fed Index | 5890 | -0.25 | 0.84 | -0.38 | -0.06 | 0.28 |
| Confidence Index | 5890 | 0.01 | 1.00 | -0.77 | -0.07 | 0.54 |
| Economic Policy Uncertainty Index | 5890 | 0.12 | 1.04 | -0.72 | -0.11 | 0.72 |
| NBER Recession Indicator | 5890 | 0.33 | 0.47 | 0.00 | 0.00 | 1.00 |
| Yield on 3-month Treasury Bills | 5890 | 2.46 | 2.15 | 0.14 | 1.73 | 4.74 |

**Table 2. CEO Risk Taking Incentives and Bank Risk**

This table presents the results for the estimation of Equation 1 in the text. The dependent variables are total equity risk, tail risk, systematic risk and unsystematic risk. The main variable of interest is Vega/Cash Compensation, and represents the managerial risk taking incentives. The definitions of the rest of the variables are provided in Appendix 2. All regressions control for bank-ceo fixed effects and year fixed effects. Robust standard errors are clustered at the bank-ceo level. P-values are provided in brackets. *, **, *** mark the 10%, 5% and 1% statistical significance for the estimated coefficients.

| | **Total Risk** | **Tail Risk** | **Systematic Risk** | **Unsystematic Risk** |
|---|---|---|---|---|
| Vega / Cash Compensation $_{-1}$ | 0.030 | 0.006 | 0.050 | -0.012 |
| | [0.261] | [0.626] | [0.109] | [0.685] |
| Delta / Cash Compensation $_{-1}$ | -0.121 | -0.059 | 0.002 | -0.129 |
| | [0.000]*** | [0.000]*** | [0.938] | [0.000]*** |
| Cash Compensation $_{-1}$ | -0.208 | -0.129 | -0.049 | -0.304 |
| | [0.000]*** | [0.000]*** | [0.199] | [0.000]*** |
| CEO Tenure | -0.040 | -0.026 | -0.243 | 0.002 |
| | [0.708] | [0.625] | [0.104] | [0.989] |
| CEO Age | -1.136 | -0.003 | 4.408 | -0.967 |
| | [0.631] | [0.998] | [0.265] | [0.714] |
| CEO Turnover | -0.038 | -0.012 | -0.002 | -0.018 |
| | [0.528] | [0.708] | [0.982] | [0.786] |
| CEO is a Board Member | 0.152 | 0.088 | 0.152 | 0.158 |
| | [0.057]* | [0.050]** | [0.138] | [0.052]* |
| Log(Total Assets) | 0.068 | 0.030 | 0.297 | 0.034 |
| | [0.380] | [0.421] | [0.005]*** | [0.697] |
| ROA | -42.745 | -25.479 | -43.830 | -48.657 |
| | [0.000]*** | [0.000]*** | [0.000]*** | [0.000]*** |
| Deposits / Assets | 0.133 | 0.142 | -0.336 | 0.502 |
| | [0.699] | [0.391] | [0.397] | [0.149] |
| Tier 1 Capital / Assets | -0.222 | 0.861 | 5.359 | 0.343 |
| | [0.850] | [0.123] | [0.002]*** | [0.774] |
| Loans / Assets | -0.105 | -0.173 | 0.079 | -0.439 |
| | [0.748] | [0.242] | [0.818] | [0.163] |
| Bad Loans / Assets | 8.713 | 3.616 | 2.969 | 10.863 |
| | [0.002]*** | [0.007]*** | [0.346] | [0.000]*** |
| Non-interest Income / Assets | -0.264 | -0.033 | -0.483 | 0.042 |
| | [0.230] | [0.785] | [0.029]** | [0.864] |
| Insurance Assets / Assets | 9.269 | 1.317 | 15.874 | 12.072 |
| | [0.628] | [0.864] | [0.456] | [0.468] |
| Derivative Trading / Assets | 0.019 | 0.002 | -0.001 | 0.026 |
| | [0.242] | [0.754] | [0.952] | [0.098]* |
| Derivative Hedging / Assets | -0.127 | -0.044 | -0.291 | -0.012 |
| | [0.406] | [0.564] | [0.071]* | [0.944] |
| Underwriting Assets / Assets | -1.488 | -0.583 | -2.170 | -1.285 |
| | [0.026]** | [0.076]* | [0.005]*** | [0.092]* |
| Constant | 6.614 | 1.331 | -21.672 | 6.791 |
| | [0.478] | [0.790] | [0.151] | [0.512] |
| N | 5890 | 5890 | 5890 | 5890 |
| R-sq | 0.578 | 0.577 | 0.487 | 0.624 |
| adj. R-sq | 0.576 | 0.575 | 0.484 | 0.621 |

**Table 3. CEO Risk Taking Incentives and Bank Risk over Macroeconomic Cycles**

This table presents the results for the estimation of Equation 2 in the text. The dependent variables are total equity risk, tail risk, systematic risk and unsystematic risk. The main variable of interest is the interaction of Vega/Cash Compensation and the Macroeconomic State. The definitions of the rest of the variables are provided in Appendix 2. The estimation results for the control variables are not reported for brevity. All regressions control for bank-ceo fixed effects and year fixed effects. Robust standard errors are clustered at the bank-ceo level. P-values are provided in brackets. *, **, *** mark the 10%, 5% and 1% statistical significance for the estimated coefficients.

**Panel A. Macroeconomic State Measured with GDP Growth Rates**

| | Total Risk | Tail Risk | Systematic Risk | Unsystematic Risk |
|---|---|---|---|---|
| Vega / Cash Compensation $_{-1}$ | 0.079 | 0.022 | 0.079 | 0.036 |
| | [0.008]*** | [0.108] | [0.022]** | [0.259] |
| Delta / Cash Compensation $_{-1}$ | -0.150 | -0.068 | -0.031 | -0.158 |
| | [0.000]*** | [0.000]*** | [0.289] | [0.000]*** |
| GDP Growth $_{-1}$ | -0.072 | -0.038 | -0.105 | -0.042 |
| | [0.000]*** | [0.000]*** | [0.000]*** | [0.000]*** |
| (Vega/Cash Compensation$_{-1}$ ) * GDP Growth $_{-1}$ | -0.022 | -0.008 | -0.015 | -0.020 |
| | [0.000]*** | [0.000]*** | [0.001]*** | [0.000]*** |
| (Delta/Cash Compensation $_{-1}$) * GDP Growth $_{-1}$ | 0.013 | 0.005 | 0.016 | 0.012 |
| | [0.001]*** | [0.011]** | [0.000]*** | [0.006]*** |
| Cash Compensation $_{-1}$ | -0.205 | -0.129 | -0.052 | -0.299 |
| | [0.000]*** | [0.000]*** | [0.160] | [0.000]*** |
| CEO Tenure | -0.041 | -0.026 | -0.250 | 0.001 |
| | [0.703] | [0.620] | [0.097]* | [0.995] |
| CEO Age | -0.969 | 0.051 | 4.647 | -0.795 |
| | [0.680] | [0.967] | [0.238] | [0.762] |
| CEO Turnover | -0.034 | -0.011 | -0.002 | -0.015 |
| | [0.569] | [0.732] | [0.975] | [0.831] |
| CEO is a Board Member | 0.154 | 0.090 | 0.156 | 0.159 |
| | [0.050]* | [0.043]** | [0.121] | [0.048]** |
| Log(Total Assets) | 0.072 | 0.033 | 0.306 | 0.034 |
| | [0.349] | [0.372] | [0.004]*** | [0.696] |
| ROA | -43.784 | -26.056 | -44.892 | -49.145 |
| | [0.000]*** | [0.000]*** | [0.000]*** | [0.000]*** |
| Deposits / Assets | 0.222 | 0.188 | -0.213 | 0.554 |
| | [0.527] | [0.263] | [0.594] | [0.118] |
| Tier 1 Capital / Assets | -0.236 | 0.855 | 5.337 | 0.332 |
| | [0.837] | [0.113] | [0.002]*** | [0.780] |
| Loans / Assets | -0.148 | -0.200 | 0.013 | -0.454 |
| | [0.650] | [0.178] | [0.971] | [0.152] |
| Bad Loans / Assets | 9.389 | 3.901 | 3.427 | 11.377 |
| | [0.001]*** | [0.004]*** | [0.269] | [0.000]*** |
| Non-interest Income / Assets | -0.207 | -0.005 | -0.423 | 0.077 |
| | [0.338] | [0.966] | [0.043]** | [0.749] |
| Insurance Assets / Assets | 11.327 | 2.523 | 18.955 | 12.952 |
| | [0.549] | [0.731] | [0.376] | [0.433] |
| Derivative Trading / Assets | 0.016 | 0.001 | -0.003 | 0.024 |
| | [0.294] | [0.891] | [0.894] | [0.109] |
| Derivative Hedging / Assets | -0.159 | -0.058 | -0.320 | -0.037 |
| | [0.298] | [0.454] | [0.046]** | [0.833] |
| Underwriting Assets / Assets | -1.095 | -0.416 | -1.900 | -0.988 |
| | [0.091]* | [0.179] | [0.010]** | [0.171] |
| Constant | 6.010 | 1.144 | -22.506 | 6.153 |
| | [0.516] | [0.816] | [0.136] | [0.549] |
| N | 5890 | 5890 | 5890 | 5890 |
| R-sq | 0.595 | 0.594 | 0.507 | 0.630 |
| adj. R-sq | 0.592 | 0.592 | 0.504 | 0.628 |

**Table 4. Alternative Measures of Macroeconomic State**

This table presents the results for the estimation of Equation 2 in the text. The dependent variable is total equity risk. The main variable of interest is the interaction of Vega/Cash Compensation and the Macroeconomic State. Macroeconomic state is measured with the Chicago FED Index in column 2, Confidence Index in column 3, and Economic Policy Uncertainty (EPU) Index in column 4. The estimation results for the control variables are not reported for brevity. All regressions control for bank-ceo fixed effects and year fixed effects. Robust standard errors are clustered at the bank-ceo level. P-values are provided in brackets. *, **, *** mark the 10%, 5% and 1% statistical significance for the estimated coefficients.

| | Macroeconomic State Measure | | |
|---|---|---|---|
| | **Chicago FED Index** | **Confidence Index** | **EPU Index** |
| Vega / Cash Compensation $_{-1}$ | -0.008 | 0.024 | 0.008 |
| | [0.775] | [0.411] | [0.761] |
| Macroeconomic State$_{-1}$ | -0.520 | -0.287 | 0.301 |
| | [0.000]*** | [0.000]*** | [0.000]*** |
| (Vega/Cash Compensation $_{-1}$ ) * Macroeconomic State$_{-1}$ | -0.042 | -0.063 | 0.041 |
| | [0.001]*** | [0.000]*** | [0.000]*** |
| N | 5890 | 5890 | 5890 |
| R-sq | 0.649 | 0.605 | 0.633 |
| adj. R-sq | 0.647 | 0.602 | 0.631 |

**Table 5. Ruling out Alternative Explanations**

**Panel A. Investment Opportunity Measure (IOM)**

This table presents the results of analyses to rule out investment opportunities as an alternative explanation. The dependent variable is total equity risk. The main variable of interest is the interaction of Vega/Cash Compensation and the Macroeconomic State. Asset growth, income growth, non-interest income growth and market-to-book ratio are used as proxies for banks' investment opportunity sets in columns 2, 3, 4 and 5 respectively. The estimation results for the control variables are not reported for brevity. All regressions control for bank-ceo fixed effects and year fixed effects. Robust standard errors are clustered at the bank-ceo level. P-values are provided in brackets. *, **, *** mark the 10%, 5% and 1% statistical significance for the estimated coefficients.

| | **Investment Opportunity Measure (IOM)** | | | |
|---|---|---|---|---|
| | **Asset Growth** | **Income Growth** | **Non-interest Income Growth** | **Market-to-Book Ratio** |
| Vega / Cash Compensation $_{-1}$ | 0.078 | 0.078 | 0.076 | 0.202 |
| | [0.009]*** | [0.009]*** | [0.011]** | [0.001]*** |
| GDP Growth $_{-1}$ | -0.074 | -0.073 | -0.073 | -0.130 |
| | [0.000]*** | [0.000]*** | [0.000]*** | [0.000]*** |
| (Vega/Cash Compensation$_{-1}$ ) * GDP Growth $_{-1}$ | -0.023 | -0.022 | -0.022 | -0.029 |
| | [0.000]*** | [0.000]*** | [0.000]*** | [0.006]*** |
| IOM | -0.957 | 0.003 | 0.012 | -0.573 |
| | [0.047]** | [0.194] | [0.389] | [0.000]*** |
| IOM*GDP | 0.206 | -0.002 | 0.002 | 0.061 |
| | [0.076]* | [0.042]** | [0.782] | [0.000]*** |
| IOM*(Vega/Cash Compensation$_{-1}$ ) | -0.013 | 0.006 | 0.019 | -0.092 |
| | [0.931] | [0.096]* | [0.039]** | [0.001]*** |
| IOM*(Vega/Cash Compensation$_{-1}$ )*GDP | 0.041 | -0.002 | -0.002 | 0.009 |
| | [0.518] | [0.292] | [0.559] | [0.094]* |
| N | 5890 | 5890 | 5890 | 5890 |
| R-sq | 0.596 | 0.595 | 0.596 | 0.612 |
| adj. R-sq | 0.593 | 0.592 | 0.593 | 0.609 |

**Table 5. Ruling out Alternative Explanations**

**Panel B. Reaching for Yield in Low Interest Rate Environments**

This table presents the results of analyses to rule out low interest rates as an alternative explanation. The dependent variable is total equity risk. The main variable of interest is the interaction of Vega/Cash Compensation and the Macroeconomic State. The estimation results for the control variables are not reported for brevity. All regressions control for bank-ceo fixed effects and year fixed effects. Robust standard errors are clustered at the bank-ceo level. P-values are provided in brackets. *, **, *** mark the 10%, 5% and 1% statistical significance for the estimated coefficients.

| **Low Interest Rate Environment Definition** | **$R_f$<p20** | **$R_f$<p15** | **$R_f$<p10** |
|---|---|---|---|
| Vega / Cash Compensation $_{-1}$ | 0.081 | 0.080 | 0.080 |
| | [0.008]*** | [0.008]*** | [0.008]*** |
| GDP Growth $_{-1}$ | -0.078 | -0.043 | -0.037 |
| | [0.000]*** | [0.000]*** | [0.000]*** |
| (Vega/Cash Compensation$_{-1}$ ) * GDP Growth $_{-1}$ | -0.023 | -0.022 | -0.021 |
| | [0.000]*** | [0.000]*** | [0.000]*** |
| Low Interest Rate Environment Dummy | 0.020 | 0.784 | 0.884 |
| | [0.772] | [0.000]*** | [0.000]*** |
| Low Interest Rates*GDP | 0.054 | -0.287 | -0.341 |
| | [0.039]** | [0.000]*** | [0.000]*** |
| Low Interest Rates*(Vega/Cash Compensation$_{-1}$ ) | -0.030 | -0.037 | -0.054 |
| | [0.335] | [0.301] | [0.128] |
| Low Interest Rates*(Vega/Cash Compensation$_{-1}$ )*GDP | 0.008 | 0.004 | 0.002 |
| | [0.464] | [0.817] | [0.888] |
| N | 5890 | 5890 | 5890 |
| R-sq | 0.596 | 0.613 | 0.616 |
| adj. R-sq | 0.593 | 0.610 | 0.613 |

**Table 5. Ruling out Alternative Explanations**

**Panel C. Correlations between Compensation Components and GDP Growth**

| | Total Compensation | Cash Compensation | Delta | Vega | Delta/Cash Compensation | Vega/Cash Compensation | GDP Growth |
|---|---|---|---|---|---|---|---|
| Total Compensation | 1.00 | | | | | | |
| Cash Compensation | 0.89 | 1.00 | | | | | |
| Delta | 0.85 | 0.72 | 1.00 | | | | |
| Vega | 0.75 | 0.58 | 0.83 | 1.00 | | | |
| Delta/Cash Compensation | 0.78 | 0.59 | 0.95 | 0.78 | 1.00 | | |
| Vega/Cash Compensation | 0.57 | 0.30 | 0.68 | 0.92 | 0.73 | 1.00 | |
| GDP Growth Rate | 0.53 | 0.54 | 0.41 | 0.18 | 0.39 | **0.01** | 1.00 |

**Table 6. Robustness Tests**

This table presents the results of several robustness checks. The dependent variable is total equity risk. The main variable of interest is the interaction of Vega/Cash Compensation and the Macroeconomic State. In column 2, we control for banks' risk management practices. In column 3, we use bank fixed effects instead of bank-ceo fixed effects. In columns 4 and 5, we perform a subsample analysis for periods before and after 2007. In column 6, the dependent variable is asset risk instead of equity risk. In column 7, we control for bank leverage and its interaction with GDP growth. In column 8, we estimate the regression equation with annual data. The estimation results for the control variables are not reported for brevity. All regressions (except column 3) control for bank-ceo fixed effects and year fixed effects. Robust standard errors are clustered at the bank-ceo level. P-values are provided in brackets. *, **, *** mark the 10%, 5% and 1% statistical significance for the estimated coefficients.

| | **Risk Management** | **Bank Fixed Effects** | **Before 2007** | **After 2007** | **Asset Risk** | **Bank Leverage** | **Annual Data** |
|---|---|---|---|---|---|---|---|
| Vega / Cash Compensation $_{-1}$ | 0.075 | 0.042 | 0.110 | 0.085 | 0.110 | 0.084 | -0.045 |
| | [0.023]** | [0.126] | [0.003]*** | [0.065]* | [0.000]*** | [0.005]*** | [0.110] |
| GDP Growth $_{-1}$ | -0.065 | -0.075 | -0.020 | -0.080 | -0.076 | -0.126 | -0.465 |
| | [0.000]*** | [0.000]*** | [0.191] | [0.000]*** | [0.000]*** | [0.026]** | [0.001]*** |
| (Vega/Cash Compensation$_{-1}$ ) * GDP Growth $_{-1}$ | -0.023 | -0.022 | -0.017 | -0.021 | -0.022 | -0.023 | -0.022 |
| | [0.000]*** | [0.000]*** | [0.005]*** | [0.000]*** | [0.000]*** | [0.000]*** | [0.000]*** |
| Risk Management Index (RMI) | -0.416 | | | | | | |
| | [0.057]* | | | | | | |
| Leverage Ratio | | | | | | 3.433 | |
| | | | | | | [0.001]*** | |
| Leverage Ratio * GDP Growth $_{-1}$ | | | | | | 0.060 | |
| | | | | | | [0.328] | |
| N | 4001 | 5890 | 3327 | 2563 | 5890 | 5890 | 1407 |
| R-sq | 0.622 | 0.622 | 0.492 | 0.586 | 0.581 | 0.596 | 0.875 |
| adj. R-sq | 0.619 | 0.620 | 0.487 | 0.582 | 0.579 | 0.594 | 0.872 |

**Table 7. Cross Sectional Tests**

This table presents the results for the estimation of Equation 2 in the text for banks that hold different levels of regulatory capital. The dependent variable is total equity risk.The main variable of interest is the interaction of Vega/Cash Compensation and GDP Growth Rate. Regulatory capital is measured with Tier 1 capital (reported) scaled by total assets. All regressions control for bank-ceo fixed effects and year fixed effects. Robust standard errors are clustered at the bank-ceo level. P-values are provided in brackets. *, **, *** mark the 10%, 5% and 1% statistical significance for the estimated coefficients.

| | **Tier 1 Capital / Assets** | | **Bank Size** | | **CEO Control** | |
|---|---|---|---|---|---|---|
| | **<10%** | **>10%** | **Large** | **Small** | **High** | **Low** |
| Vega / Cash Compensation $_{-1}$ | 0.101 | 0.002 | 0.188 | 0.067 | 0.075 | 0.221 |
| | [0.002]*** | [0.978] | [0.018]** | [0.036]** | [0.018]** | [0.124] |
| GDP Growth $_{-1}$ | -0.054 | -0.153 | -0.121 | -0.071 | -0.077 | -0.088 |
| | [0.000]*** | [0.000]*** | [0.000]*** | [0.000]*** | [0.000]*** | [0.029]** |
| (Vega/Cash Compensation$_{-1}$ ) * GDP Growth $_{-1}$ | -0.028 | -0.009 | -0.047 | -0.014 | -0.023 | -0.000 |
| | [0.000]*** | [0.345] | [0.025]** | [0.003]*** | [0.000]*** | [0.993] |
| | **Difference significant at 1% (p-value=0.007)** | | **Difference significant at 5% (p-value=0.013)** | | **Difference significant at 10% (p-value=0.08)** | |
| N | 4894 | 996 | 684 | 5206 | 5104 | 786 |
| R-sq | 0.585 | 0.594 | 0.653 | 0.586 | 0.596 | 0.268 |
| adj. R-sq | 0.582 | 0.578 | 0.633 | 0.583 | 0.593 | 0.233 |

**Table 8. High Bailout versus Low Bailout Periods**

This table presents the results for the estimation of Equation 2 in the text for banks that hold different levels of regulatory capital. The dependent variable is total equity risk. The main variable of interest is the interaction of Vega/Cash Compensation and GDP Growth Rate. If a quarter includes a month during which the bailout probability estimated by Hett and Schmidt (2017) was substantially higher than the pre-crisis level (March 2008 – July 2010), the High Bailout indicator is equal to one, and zero otherwise. All regressions control for bank-ceo fixed effects and year fixed effects. Robust standard errors are clustered at the bank-ceo level. P-values are provided in brackets. *, **, *** mark the 10%, 5% and 1% statistical significance for the estimated coefficients.

| | **High Bailout Periods** | **Low Bailout Periods** | **Full Sample** |
|---|---|---|---|
| Vega / Cash Compensation $_{-1}$ | 0.045 | 0.049 | -0.017 |
| | [0.606] | [0.356] | [0.720] |
| GDP Growth $_{-1}$ | -0.159 | 0.180 | 0.165 |
| | [0.000]*** | [0.000]*** | [0.000]*** |
| (Vega/Cash Compensation-1 ) * GDP Growth $_{-1}$ | -0.017 | 0.011 | 0.009 |
| | [0.000]*** | [0.309] | [0.381] |
| High Bailout | | | 1.058 |
| | | | [0.000]*** |
| High Bailout*(Vega/Cash Compensation$_{-1}$ ) | | | 0.074 |
| | | | [0.085]* |
| High Bailout * GDP | | | -0.310 |
| | | | [0.000]*** |
| High Bailout*(Vega/Cash Compensation$_{-1}$ )*GDP | | | -0.028 |
| | | | [0.026]** |
| N | 881 | 2619 | 3500 |
| R-sq | 0.524 | 0.497 | 0.693 |
| adj. R-sq | 0.512 | 0.491 | 0.690 |

**Internet Appendix:**

**Comparison of Results to Savaser and Sisli-Ciamarra (2017)**

The closest study in spirit to our analysis is Savaser and Sisli-Ciamarra (2017), which focuses on the non-financial sector. Unlike our finding, they do not find a state-dependent link between managerial risk-taking incentives (vega) and firm risk in the non-financial sector. Incentives may work differently in financial and non-financial sectors because aligning managerial incentives with shareholders' incentives through stock and option-based pay, a practice that is normally considered as good governance behavior in non-financial firms, may in fact exacerbate risk-taking in the banking sector due to the moral hazard resulting from implicit and explicit government guarantees (Bolton et al., 2015; Eufinger and Gill, 2016; Thanassoulis and Tanaka, 2018; Kolm et al., 2017). Given the difference in the prominence of moral hazard incentives across the two sectors and the differences in our results, we run a series of robustness tests using similar methods as in Savaser and Sisli-Ciamarra (2017) and compare our findings.

Throughout the paper, we use continuous macroeconomic variables such as GDP growth rates as they indicate not only whether the economy is in a recession or not, but also capture the severity of economic downturns, which is critical for assessing bailout likelihood. However, Savaser and Sisli-Ciamarra (2017), in addition to the GDP growth rates, also use a binary recession indicator. Their recession dummy takes the value one if the firms' fiscal year coincides with at least 90 days of recession as identified by the NBER and zero otherwise. Similar to this approach, we create a recession dummy, which takes the value one for each bank-quarter that overlaps with the NBER recession periods (i.e. Q2-Q4 of 2001; Q1-Q4 of 2008 and Q1-Q2 of 2009).

We rerun our regressions using this variable and find that the results remain unchanged (Appendix Table, column 2). In particular, we find that the coefficient on the interaction of vega/cash with the recession dummy is positive and significant. Consistent with Hypothesis 2, this result indicates that the risk-inducing effect of vega/cash is stronger during downturns, providing support for the moral hazard mechanism.

In addition, the sample period in Savaser and Sisli-Ciamarra (2017) ends in 2009. Accordingly, we restrict our analysis to the pre-2010 period and rerun our regressions using the NBER recession indicator. As before, we find that our earlier results remain unchanged (Appendix Table, column 3). Another difference in methodology is that Savaser and Sisli-Ciamarra (2017) measure risk-taking incentives with unscaled vega, a common practice used in earlier CEO compensation literature. In our paper, we employ vega/cash instead because recent research suggests it is not the magnitude of incentives, but the magnitude of incentives relative to the manager's cash compensation that drives CEO's decision-making (Eufinger and Gill, 2016; Anderson and Core, 2018). However, to align our specification more closely to that of Savaser and Sisli-Ciamarra (2017), we re-estimate our regressions using unscaled vega and bank fixed effects and find that our results are robust (Appendix Table, column 4).

In sum, employing similar variable definitions and sample periods as in Savaser and Sisli-Ciamarra (2017) does not eliminate our main result that, in the banking sector, the risk-inducing impact of vega is stronger during downturns, an effect which is absent in non-financial firms as reported in Savaser and Sisli-Ciamarra (2017). Thus, the state-dependent effect we document is not simply due to differences in sample periods or variable definitions used in our analysis.

Then, what makes bank managers' reaction to risk-taking incentives so different as compared to non-financial firm managers? Compared to non-banks, financial firms are highly levered and consequently more regulated due to the systemic risk they pose in case of failure. As a result, they also receive more implicit and explicit government guarantees compared to non-bank entities. Thus, risk-shifting and moral hazard incentives are stronger in the banking sector (e.g. Eufinger and Gill, 2016; Thanassoulis and Tanaka, 2018). Due to regulatory differences, there may also be discrepancies in governance practices and available growth opportunities across these industries (Adams and Mehran, 2003). Uncovering which of these potential factors drive the differences across industries is an interesting question in its own right. However, given our within-industry approach, a direct analytical comparison of financial and non-financial firms is beyond the scope of this paper. Thus, we leave it for future research. Nonetheless, the documented state-dependent vega effect in the banking sector and its absence in the non-financial sector, where government guarantees are less prevalent, points to moral hazard as the most plausible mechanism underlying our results.

**Internet Appendix Table 1. CEO Risk Taking Incentives and Bank Risk over Macroeconomic Cycles: Macroeconomic State Measured with NBER Recession Dates**

This table presents the results for the estimation of Equation 2 in the text, where we measure the macroeconomic state with NBER recession dates . The dependent variable is total equity risk. The main variable of interest is the interaction of Vega/Cash Compensation and the Macroeconomic State. The estimation results for the control variables are not reported for brevity. Regressions in columns 2 and 3 control for bank-ceo fixed effects and year fixed effects. Regression in column 4 controls for bank fixed effects and year fixed effects to match the specification in Savaser and Sisli-Ciamarra (2017). Robust standard errors are clustered at the bank-ceo level. P-values are provided in brackets. *, **, *** mark the 10%, 5% and 1% statistical significance for the estimated coefficients.

| | Full Sample | Before 2010 | Before 2010 & Unscaled Incentives |
|---|---|---|---|
| Vega / Cash Compensation $_{-1}$ | -0.000 | -0.004 | -0.020 |
| | [0.989] | [0.900] | [0.283] |
| NBER Recession Indicator | 0.948 | 1.014 | 1.041 |
| | [0.000]*** | [0.000]*** | [0.000]*** |
| (Vega/Cash Compensation$_{-1}$ ) * NBER Recession Indicator$_{-1}$ | 0.063 | 0.079 | 0.049 |
| | [0.024]** | [0.016]** | [0.040]** |
| N | 5890 | 4495 | 4587 |
| R-sq | 0.604 | 0.614 | 0.648 |
| adj. R-sq | 0.602 | 0.611 | 0.645 |

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