Derivatives Hedging, Risk Appetite, and Managerial Compensation Incentives in U.S. Property-Liability Insurance Companies

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ABSTRACT

We examine the relationship between derivatives hedging, risk-taking, and managerial compensation incentives from an enterprise risk management perspective in U.S. publicly traded property-liability insurance companies. We find that derivatives usage is negatively related to various risks, supporting the stabilizing effect of derivatives use for hedging purposes. Our evidence also shows that derivatives hedging is negatively associated with CEOs' compensation and their equity portfolio incentives. These results suggest that board of directors may utilize derivatives as part of an overall risk management strategy to manage both underwriting and investment risks, and in turn, respond to changes in their risk appetite by structuring CEOs' incentive-compensation contracts accordingly. We provide evidence that reinsurance strengthens the risk reduction effect of derivatives usage on risk-taking, managerial compensation, and equity incentives, consistent with the "complementarity" hypothesis. Further, we show that the risk-reduction effects of derivatives hedging are weakened during the financial crisis in 2008-2009 than non-crisis period.

Keywords: Derivatives Hedging; Risk Taking; Executive Compensation

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Introduction

This paper examines the relationship between derivatives hedging, risk-taking, and managerial compensation incentives from an enterprise risk management perspective in U.S. publicly traded property-liability insurance companies. Over the last several decades, derivatives have been widely used for hedging and mitigating risk exposures, thereby helping firms promote financial stability and reduce expected costs of financial distress. In particular, financial firms, such as banks and insurance companies have been active in derivatives markets in an effort to manage various financial risks in their business activities (Gunther and Siems, 1995; Shanker, 1996; Colquitt and Hoyt, 1997; Cummins et al., 1997, 2001).[1] The use of derivatives in the insurance sector has substantially grown in recent years.[2] For the property-liability insurance companies that face the potential of a substantial loss variability,[3] the total notional value of derivatives increased from $32.2 billion to $104.2 billion over the period 2001-2015.

One main role of the board of directors is to provide oversight of corporate risk management, especially, after financial crisis in 2008-2009. The reputation of companies and their boards was severely damaged during and after financial crisis. Gupta and Leech (2015) state that the board of directors need to "hold the CEO accountable for building and maintaining effective risk appetite frameworks, and providing the board with periodic consolidated reports on the

[1] Financial firms including insurers and banks are highly motivated to hedge risks because their customers are particularly sensitive to insolvency risk (Merton and Perold, 1993). Previous studies document that insurers rely on financial derivatives to manage various sources of risk, such as interest rate risk, equity market risk, foreign exchange risk, and credit risk, thus ensuring the survival of them in increasingly competitive environments (e.g., Hoyt, 1989; Wilson and Hollman, 1995; Colquitt and Hoyt, 1997; Cummins et al., 1997).

[2] According to the National Association of Insurance Commissioners (NAIC) report in 2017, since 2010, the total notional value of the insurance industry's derivatives holdings has increased at a 17 percent compound average growth rate (CAGR), outpacing the 4.2 percent CAGR in the industry's total cash and invested assets.

[3] Property-liability insurers face volatile cash outflows due to liability lawsuits, property catastrophes, the risk of regulatory intervention, and exchange-rate risk (Cummins et al., 2001).

company's residual risk status"[4] to improve their risk governance practices. In particular, derivatives usage is closely related to risk appetite such as risk reduction. Thus, how derivatives usage is associated with firm's risk-taking behavior may be of interest from the perspective of regulators, shareholders, and insurers themselves. Although this issue has been widely studied in the literature on non-financial and banking firms (e.g., Tufano, 1996; Guay, 1999; Hentschel and Kothari, 2001; Bali et al., 2007; Bartram et al., 2011), the insurance literature related to derivatives usage typically focuses on the determinants of derivatives usage in the insurance sector (e.g., Colquitt and Hoyt, 1997; Cummins et al., 2001; Hardwick and Adams, 1999; Shiu, 2007; and Luan, 2012).

There are two major risks faced by insurance companies: underwriting risk and investment risk (Lin et al., 2011 and Ho, Lee, and Lai (2013)). Prior literature has not examined whether the underwriting and investment risks are reduced with derivatives hedging.[5] As mentioned above, board of directors are responsible for an insurer's risk appetite which includes the type of risk that an insurer is willing to take in order to meet its strategic objectives. In this paper, we explore whether insurers' risks are reduced with derivatives hedging and whether insurers hedge underwriting risk and investment risk.

The focus on the board's role in risk management has led to much more public and regulatory scrutiny of effective risk management, executive compensation, and portfolio incentives.[6] Prior literature shows how a portion of executives' annual pay consists of a risk-premium that

[4] Risk appetite is defined here as "the amount and type of risk that an organization is willing to take in order to meet its strategic objectives." There are different definitions of risk appetite. The definition of risk appetite here is from Institute of Risk Management.
[5] There are hardly any papers examining the effect of derivatives usage on firm's risk in the insurance sector. To our knowledge, the only study investigating this issue is Bierth et al. (2016), which finds that insurers with more derivatives usage exhibit lower default risk relative to non-using insurers.
[6] Risk Management and the Board of Directors, Harvard Law School Forum on Corporate Governance and Financial Regulation, July 28, 2015. (https://corpgov.law.harvard.edu/2015/07/28/risk-management-and-the-board-of-directors-3/).

compensates them for taking risk associated with their performance-based incentives and firm-specific human capital (e.g., Core et al., 2003; Core and Guay, 2010; Armstrong et al., 2017). Some empirical findings suggest that executives are exposed to less firm-specific risk with derivative hedging, and as a result, managers would demand and receive less risk premium in their compensation. In addition, some studies show that CEO risk-taking incentives derived from portfolios of stock and options are negatively associated with derivative holdings (e.g., Rogers, 2002). Motivated by these previous studies, this paper also investigates the impact of derivatives hedging on the structure of managerial compensation and equity portfolio incentives.

Both derivatives usage and reinsurance are commonly used as hedging tools for insurers. The insurance literature suggests two conflicting predictions about the relationship between reinsurance and derivatives usage. The "substitution" hypothesis asserts that insurers using reinsurance as a hedging tool are less likely to use derivatives. The hypothesis indicates that insurers that reduce their risk exposure by using reinsurance already have lower overall risk levels, and thus have less need to hedge their risks through financial derivatives. On the other hand, "complementarity" hypothesis argues that the relation between reinsurance and derivatives usage is positive, because insurers having a low risk tolerance tend to hedge their underwriting risk and financial risk by increasing the usage of both reinsurance and derivatives. The literature of the two hypotheses focuses on whether the usage of derivatives is a complement or a substitute for reinsurance and does not provide the evidence on how the interaction of derivatives usage and reinsurance affect risk-taking and structure of CEOs' incentive-compensation contracts. We examine the interaction effect between derivative hedging and reinsurance in relation to insurers' risk-taking, executive compensations, and portfolio incentives.

We compile a sample of 21 publicly traded U.S. property-liability insurance firms with 239 firm-year observations over the period 2000-2015. Our empirical results reveal that the usage of derivatives not only affects insurers' risk-taking but also has impact on the design of executives' compensation and their incentives to take risk. Specifically, we find that insurers using more derivatives to hedge risks tend to display lower levels of various risks, such as total risk, underwriting risk, investment risk, leverage risk, systematic risk, and unsystematic risk, providing the support for the stabilizing effect of derivatives usage for hedging purposes. This implies that the board of directors may utilize derivatives as part of an overall risk strategy to manage both underwriting and investment risks.

Our evidence also shows that CEOs of insurers with more derivatives hedging tend to receive less annual compensation and have lower levels of equity incentives. One possible reason for these results is that risk premium that CEOs receive for being exposed to various risks is significantly lower as an insurer uses more derivatives. These results suggest that board of directors structures CEO's compensation contracts based on insurer's risk appetite. With respect to the interaction effect of derivatives usages and reinsurance, we find that for insurers with derivative hedging, more reinsurance usage results in lower risk-taking, CEO compensation, and equity incentives. This results provide evidence that reinsurance strengthens the negative relationship between derivatives usage and risk-taking and the relationship between derivatives usage and CEO compensation-incentives, consistent with the "complementarity" hypothesis. Finally, we find that the risk-reduction effects of derivatives hedging are less pronounced during the financial crisis in 2008-2009 than non-crisis period.

This study contributes to the literature in several ways. First, our study is the first to examine the relationship between derivatives hedging, risk-taking, and managerial compensation incentives from an enterprise risk management perspective in the property-liability insurance industry. Bierth et al. (2016) investigate the relationship between derivatives usage and insurer's default risk from an investor's perspective. While their focus is stock market volatility and default risk, our study focuses mainly on underwriting and investment risks from the risk appetite approach.

Second, unlike studies in non-financial and banking industries, our study can effectively reduce the possibility of misleading results from combining different purposes of derivatives usage. The insurance industry provides a good testing ground to analyze the issues related to derivative usage because insurers are required to disclose more information about their derivatives transactions than firms in other industries.[7] We utilize the data on insurers' derivatives usages for only hedging purposes, thus providing more reliable result of the effects of derivative hedging on insurers' risk-taking and managerial compensation-incentives.

Third, we identify a potential channel behind the negative relationship between derivatives usage and CEO compensation-incentives. Our results indicate that derivative hedging could reduce insurer's risk-taking, thus leading to a reduction in CEOs' annual compensation-incentives. Therefore, we contribute to the literature by providing evidence that changes in risk appetite of a firm resulting from hedging activities can affect the design of CEOs' incentive-compensation contracts. Finally, previous studies report mixed results about whether the substitution hypothesis or the complementarity hypothesis holds in the relationship between reinsurance and derivatives usage. Our findings suggest that the usage of reinsurance strengthens the negative impact of derivative hedging on risk taking, CEO compensation, and equity portfolio incentives, which is consistent with the complementarity hypothesis. In this way, we shed light on how reinsurance

[7] Insurers' derivatives activities are highly transparent. All derivative transactions of insurance companies must be reported in the publicly disclosed regulatory filings (i.e., Schedule DB of the quarterly and annual statutory financial statements).

affects insurers' decisions to engage in derivatives hedging in relation to risk-taking, managerial compensation, and equity incentives.

The reminder of this paper proceeds as follows. Hypothesis Development section formulates the hypotheses about the expected associations between derivatives hedging and insurer's risk-taking and managerial compensation-incentives. In addition, the section also develops hypotheses related to reinsurance and financial crisis. Data and Methodology section details the sample selection criteria and the model. The definitions of variables are presented in the Variables section. Results section provides descriptive statistics of the data and presents the empirical results, and the Conclusion section concludes.

Hypothesis Development

Derivatives usage and risk taking

We first discuss the relationship between derivatives usage and insurers' risk-taking. The relationship has been long discussed in the literature for non-financial and banking firms (e.g., Gunther and Siems, 1995; Tufano, 1996; Shanker, 1996; Guay, 1999; Hentschel and Kothari, 2001; Bali et al., 2007; Bartram et al., 2011),

On the one hand, the usage of derivatives may be associated with lower risk-taking. Prior literature finds that derivatives reduce the possibility of financial distress by decreasing the variability in firm value (e.g., Smith and Stulz, 1985; Mayers and Smith, 1987). Tufano (1996) presents evidence that firms in the gold-mining industry use derivatives to reduce various risks. Choi and Elyasiani (1997) find that derivatives contracts are negatively related to banks' risk exposures. Guay (1999) and Bartram et al. (2011) shows that firm risk is significantly reduced after using derivatives. Chen (2011) reveals that firms using more derivatives exhibit lower levels of risk in the hedge fund industry.

In contrast, several studies provide the evidence that derivatives usage is not related to lower risk-taking even if it is utilized for hedging purposes. For example, Koski and Pontiff (1999) find that derivatives usage does not affect the level of firm's risk exposure and return performance. Hentschel and Kothari (2001) find no evidence that derivatives usage increases or decreases a firm's stock return volatility. Bali et al. (2007) reveal that the usage of financial derivatives does not reduce corporate risk-taking. Shiu (2010) finds that life insurers' derivative hedging is not related to insurer solvency, but non-life insurers using more derivatives tend to show a lower level of solvency in the Taiwanese insurance sector. Trapp and Weiss (2014) show a positive association between derivatives usage and the systemic equity tail risk in the banking industry. Given the conflicting views and inconsistent empirical results in the literature on the effect of derivatives usage on firm's risk-taking, we suggest the following null hypothesis:

Hypothesis 1: Derivatives usage is not associated with risk-taking in property-liability insurance companies.

Derivatives usage, executive compensation, and equity portfolio incentives

Oldfield and Santomero (1997) point out that managers are inefficient at diversifying risks because they have a concentrated and nontransferable human capital stake in their firm. Prior studies also indicate that managers whose wealth is closely tied to their firm's performance tend to reduce the riskiness of the firm to preserve their personal wealth (e.g., Smith and Stulz, 1985; Jensen et al., 2004). The inability of managers to take appropriate level of risk could cause them to forgo some positive net present value (NPV) projects, and thus, negatively affect firm performance (Coles et al., 2006).

In an effort to address this problem, firms can provide proper incentives for managers to align their interests with those of shareholders and motivate their managers to bear risks by offering them proper compensation packages (Holmstrom, 1979; Holmstrom and Milgrom, 1987; Kleffner and Doherty, 1996). Smith and Stulz (1985) point out that mangers are likely to require extra compensation to take more risk when they are risk averse and under-diversified with respect to their compensation and firm-specific wealth. Stulz (1996) and Aggarwal and Samwick (1999) note that CEOs of a riskier firm tend to require a higher risk premium and exhibit lower pay performance sensitivity.

The literature provides evidence that risk premiums to compensate managers for having risk is an important part of the executive annual compensation (e.g., Core et al, 2003; Core and Guay, 2010; Armstrong et al., 2017). Armstrong et al. (2017) find that managers receive less cash and equity compensation after the introduction of weather derivatives, suggesting that the usage of weather derivatives enables CEOs to hedge uncontrollable risk, thereby leading them to demand a lower risk premium in their annual compensation which they would otherwise require in exchange for bearing risk. With respect to derivatives usage and CEO's equity portfolio incentives, Core and Guay (2010) find a positive relationship between risk premium that CEOs demand for having their personal wealth exposed to various risks and amount of incentives relative to their wealth. Rogers (2002) documents that CEO risk-taking incentives derived from portfolios of stock and options are negatively related to derivatives holdings.

In line with these empirical evidence and arguments, we expect a negative relationship between derivatives usage and CEO compensation-incentives. The reason is that the required risk premium in exchange for exposure to various risks declines as a firm use more derivatives to hedge risks, and as a result, CEOs receive less annul compensation and have lower equity incentives. Therefore, we propose the following hypothesis:

Hypothesis 2: Derivatives usage is negatively associated with CEOs' compensation incentives in property-liability insurance companies.

Interaction Effects between reinsurance and derivatives usage

The insurance literature suggests two conflicting predictions about the relationship between reinsurance and insurer's derivatives usage. The "substitution" hypothesis asserts that insurers using reinsurance as a hedging tool are less likely to use derivatives because firms that reduce their risk exposure by using reinsurance have lower overall risk levels, and thus have less need to hedge their underwriting and investment risks through financial derivatives. Hardwick and Adams (1999) demonstrate that derivatives usage is negatively associated with the extent of reinsurance in the U.K. life insurance industry. Cummins et al. (2001) point out that to the extent that underwriting risk and financial risk are correlated, reinsurance that limit the volatility of loss ratios can serve as a substitute for hedging with derivatives. Shiu (2016) provides empirical evidence that insurers purchasing more reinsurance tend to use less derivatives in the U.K. non-life insurance sector.

On the contrary, the "complementarity" hypothesis states a positive relationship between reinsurance and derivatives usage, arguing that insurers having a low risk tolerance tend to hedge their underwriting risk and financial risk by increasing the usage of both reinsurance and derivatives. Colquitt and Hoyt (1997) show that insurer's reinsurance purchase is positively related to the insurers' decision to use derivatives, indicating that reinsurance could serve as a signal that a firm is predisposed for hedging activities. Cummins et al. (2001) document that insurers using reinsurance to hedge underwriting risk are more likely to use derivatives to hedge financial risk for U.S. life and property-casualty insurers. They state that insurers may use both reinsurance and derivatives to manage different risks or different loss ranges for the same risks. Shi (2011) finds evidence in supporting of the complementarity hypothesis in the U.K. life insurance industry.

Based on the above discussions, we predict that the usage of reinsurance weakens the negative effect of derivatives hedging on insurer's risk-taking, CEO compensation, and equity portfolio incentives if the substitution hypothesis holds. On the other hand, we expect that reinsurance strengthens the risk reduction impact of derivative hedging on risk-taking, managerial compensation, and equity incentives if the complementarity hypothesis is valid. Thus, we suggest our Hypothesis 3 as the null form:

Hypothesis 3A: Reinsurance does not affect the relation between derivatives usage and risk-taking.

Hypothesis3B: Reinsurance does not affect the relation between derivatives usage and CEO compensation, and equity incentives.

Derivatives usage and Financial Crisis

The proliferation of unregulated derivatives had been considered as one of the major causes of the 2008-2009 financial crisis that resulted in the collapse and the near-failure of a number of financial institutions.[8] There is some evidence that insurers take a more conservative approach to underwriting and investment activities during the financial crisis. Luan (2012) provides evidence that the 2008-2009 financial crisis reduces the willingness of property casualty insurers to hedge risks with derivatives. The result of Luan (2012) makes sense because the more conservative approach insurance companies take, the less derivatives would be needed to manage those risks. Thus, we predict that the decreased derivatives usage during the financial crisis may

[8] For example, American Insurance Group (AIG) severely suffered from liquidity problems caused by the reckless issue of credit default swaps (CDS) and other derivatives, leading to a massive government bailout of $85 billion in 2008.

weaken the negative effects of derivatives usage on insurer's risk-taking, CEO compensation, and equity portfolio incentives. This leads to the following hypotheses:

Hypothesis 4A: Risk reduction effects of derivatives usage on risk-taking and incentives are weakened during the financial crisis in property-liability insurance companies.

Hypothesis4B: Negative effects of derivatives usage on CEO compensation and incentives are weakened during the financial crisis in property-liability insurance companies.

Data and Methodology

Data

We use several databases to generate our sample. First, we employ CEO compensation data from the ExecuComp database, which covers publicly traded insurance firms. Daily stock returns used to estimate systematic risk and unsystematic risk are extracted from the Center for Research in Security Prices (CRSP). All other insurance company-specific data are obtained from the annual statutory statements filed with the National Association of Insurance Commissioners (NAIC). We use 5-year rolling periods of data to calculate three risk-taking measures, such as total risk (i.e., standard deviation of return on assets), underwriting risk (i.e., standard deviation of loss ratios), and investment risk (i.e., standard deviation of return on investment).

We utilize the data on derivatives from Schedule DB of annual statement from the NAIC. Property-liability insurers are required to report their investment activities, including the identification of the purpose of derivative transactions in their financial statements.[9] Thus, the insurance industry provides a good testing ground to accurately identify the objective of derivative usage. To measure insurer's hedging activities, we include only the derivative value reported as a

[9] NAIC provides derivative trading data from 2000. Prior to 2010, the purpose of derivatives use had two categories, such as hedging and other. From 2010, Parts A and B of Schedule DB provide the different objectives of derivative instruments, including (1) Hedging Effective; (2) Hedging Other; (3) Replication; (4) Income Generation; (5) Other.

"hedging" transaction.[10,11] Since ExecuComp reports compensation data at the group level, we use consolidated data on insurance companies by aggregating individual insurance companies within each insurance group. Initially, we obtain 401 firm-year observations of insurers' derivatives usage from the NAIC database over the period 2000-2015. After merging the data set used to construct derivative participation decision and volume of derivatives transactions with the data required to compute risk-taking, CEO compensation, equity incentives, and control variables, our final sample includes 239 insurer-year observations from 21 publicly traded property-liability insurers from 2000 to 2015.[12]

Methodology

To explore the relationship between derivatives hedging, insurers' risk-taking, and managerial compensation-incentives while controlling for firm-specific characteristics, we utilize a two way fixed-effects model to capture unobserved heterogeneity across firms and across time.[13] Rogers (2002) states that the usage of derivatives for corporate risk management may affect CEO risk-taking incentives, and the optimal level of such incentives also have a significant impact on the hedging decision. Therefore, we employ a simultaneous equations system framework when CEO compensation and equity portfolio incentives are dependent variables in order to address the endogeneity problem that could result from the joint determination of corporate risk management

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[10] It should be noted that insurers are end-users of derivatives and use the instruments for different purposes, such as hedging, speculation or trading. In this study, we focus only on insurer's derivatives use for hedging purposes (i.e., derivatives are mainly used to reduce the volatility of firms' cash flows). This helps us to identify the true amount of derivative hedging and avoid potential problem resulting from combining different purposes of derivatives use.

[11] Derivatives are mainly used for hedging purposes in the property-liability insurance industry. According to a report from the NAIC Capital Market Bureau in 2015, over 60% of total notional value of derivatives used were for hedging purposes to manage and mitigate various risks.

[12] It is common to see small sample sizes in the insurance literature that focuses on public property-liability insurers (e.g., Eckles et al., 2011; Ma and Wang, 2014; Milidonis et al., 2017).

[13] We perform a Hausman test to determine which model to use between fixed effects or random effects. The Hausman test indicates that the fixed effects model should be used in all our regressions.

decision and managerial risk-taking incentives. The regression models for testing the hypothesis about the relationship between derivatives usage and insurer's risk-taking can be expressed as follows:

$$Risk_{i,t} = \alpha_0 + \alpha_1\, Derivative\ Use_{i,t} + \alpha_2\, Size_{i,t} + \alpha_3\, ProdHHI_{\ i,t} + \alpha_4\, GeoHHI_{\ i,t} + \alpha_5\, Longtail_{i,t} + \alpha_6\, Reinsurance_{i,t} + \alpha_7\, Firm\ Age_{i,t} + \alpha_8\, Stock\ Return_{i,t} + \alpha_9\, ROA_{i,t} + \alpha_{10}\, Book\_to\_Market_{\ i,t} + d_t + f_t + \varepsilon_{i,t} \quad (1)$$

The framework of the models of the relationship between derivatives usage, CEO compensation, and equity portfolio incentives has a system of the following form:

$$Derivative\ Use_{i,t} = \alpha_0 + \alpha_1\ Compensation_{i,t}\,(Incentives_{i,t}) + \alpha_2\, Size_{i,t} + \alpha_3\, ProdHHI_{\ i,t} + \alpha_4\, GeoHHI_{\ i,t} + \alpha_5\, Longtail_{i,t} + \alpha_6\, Reinsurance_{i,t} + d_t + f_t + \varepsilon_{i,t} \quad (2A)$$

$$Compensation_{i,t}\ (Incentives_{i,t}) = \alpha_0 + \alpha_1\, Derivative\ Use_{i,t} + \alpha_2\, Size_{i,t} + \alpha_3\, Firm\ Age_{i,t} + \alpha_4\, Stock\ Return_{\ i,t} + \alpha_5\, ROA_{i,t} + \alpha_6\, Book\_to\_Market_{\ i,t} + \alpha_7\, Leverage_{i,t} + d_t + f_t + \varepsilon_{i,t} \quad (2B)$$

where *i* indexes the insurance company and *t* represents time (year), d_t and f_t are insurer-fixed and time-fixed effects that capture unobserved heterogeneity across insurers and across time, and ε_{it} is the error term. $Derivative\ Use_{i,t}$ is a measure of derivatives usage, and $Risk_{i,t}$, $Compensation_{i,t}$, and $Incentives_{i,t}$ are one of several types of risk, compensation, and incentives measures for firm *i* at time *t*, respectively.

Variables

Independent Variable

We use the volume of derivatives transactions and participating decisions as our key independent variables. We follow the prior literature (e.g., Colquitt and Hoyt, 1997; Cummins et al., 2001; Cummins and Song, 2008; Lantara and Takao, 2014) to measure the extent of derivatives transactions and participation decision. The extent of derivative transactions is measured by the volume of derivatives transactions (notional amounts)[14] during that year and end-of-year, or market value at the end of the year scaled by insurer's total assets if the firm uses derivatives, and zero otherwise).[15] Participation of derivative decision is measured as a binary variable. We identify insurers' all derivatives transactions taking place during the year as well as at year-end. Derivative participation is a dummy set to one if an insurer reports any derivative trading during that year or at the end of the year.

Following prior literature (e.g., Core et al., 2008; Ho et al., 2013; Armstrong et al., 2017), we control for a variety of firm-specific characteristics by including insurer size, business line diversification, geographical diversification, proportion of long-tail line, reinsurance ratio, firm age, stock return, return on assets, book-to-market, and leverage in our regression analyses. Insurer size (*Size*) is defined as the natural log of net admitted assets. Business line diversification (*ProdHHI*) and geographical diversification (*GeoHHI*) are calculated by the sum of squares of value of net written premiums in line *i* or state *i* divided by total net written premiums, respectively. We compute the proportion of long-tail line (*Longtail*) as the premiums of long-tail lines divided by total net written premiums. For reinsurance ratio (*Reinsurance*), we employ the ratio of reinsurance ceded to total direct premium plus reinsurance assumed. Firm age (*Firm Age*) is measured by the log of the number of years since the firm first appears in CRSP. Stock return (*RET*) is defined as the log of one plus stock return over the fiscal year. We calculate return on

[14] If notional amount is missing data from Schedule DB, notional amount for equity options is calculated by multiplying the number of contracts strike price by 100, and notional amount for bond options is estimated by multiplying the number of contracts by par value per contract (Cummins and Song, 2008).

[15] It should be noted that we only use derivatives positions for hedging purposes.

assets (*ROA*) by dividing net income plus taxes and interest expenses by net admitted assets. Book-to-market (*Book_to_Market*) is measured as book value divided by market value of equity.

Dependent Variable

To examine how derivatives hedging affects insurer's risk-taking, we employ a variety of accounting and market-based risk-taking measures, such as total risk, underwriting risk, investment risk, leverage risk, systematic risk, and unsystematic risk in an effort to investigate insurer's risk-taking in a comprehensive way.[16] Total risk is measured by the standard deviation of return on assets (ROA). Underwriting risk is calculated as the standard deviation of the firm's loss ratios. We compute investment risk as the standard deviation of return on investment (ROI). Leverage risk is defined as one minus the surplus-to-asset ratio. For market-based measures of risk, we employ a single index model to calculate systematic risk (β) and unsystematic risk (mean squared error), using daily stock returns over the year.

With respect to compensation variables, we use four measures for CEO annual compensation: total compensation, cash compensation, equity compensation, and equity mix. We calculate total compensation as the natural log of the sum of salary, bonus, restricted stock and option grants, and long-term incentive payouts. Cash compensation is measured by the natural log of salary and bonus. Equity compensation is computed as the natural log of value of restricted stock grants plus value of option grants. We calculate equity mix by dividing equity compensation by total compensation.

In addition, we utilize three measures of equity incentives relating to CEOs' equity portfolio. The first proxy, vega, measures the CEO incentive to take more risk, indicating the change in the

[16] Ho et al. (2013) state that using different risk measures is better than using one proxy for risk in measuring insurer's risk-taking.

value of the CEO's option portfolio in response to a one percent increase in the annualized standard deviation of the firm's stock return. Higher vega implies that the value of the CEO's wealth increases with an increase in the stock return volatility. The second proxy, delta, measures the CEO's incentive to increase the stock price, meaning the change in the value of the CEO's stock and option portfolio in response to a one percent increase in the price of the firm's common stock. A higher delta increases a manager's exposure to risk and variance of wealth. We adopt the method of Core and Guay (2002) to compute the sensitivity of CEO wealth to stock volatility and that of CEO wealth to stock price. In addition, following Rogers (2002), we use the ratio of vega-to-delta to measure CEO risk-taking incentives per dollar of value-increasing incentives from stock and option holdings. Table 1 summarizes the definition of all variables used in our regression models.

Results

Descriptive statistics

Table 2 reports descriptive statistics for all variables. The mean values of derivative participation are 0.764, 0.770, and 0.775, for end-of-year, within-year, and market value end-of-year, respectively. For the volumes of derivative transactions, notional value end-of-year, notional value within-year, and market value end-of-year are 0.025, 0.072, and 0.001 respectively. Cummins et al. (1997) shows that the participation rate of derivatives usage for U.S. property casualty insurers is about 7%. The reason for the difference in participation rate of derivatives usage is that our sample includes only large publicly traded property-liability insurers which can afford large fixed startup costs of hedging with derivatives. For our sample, the insurers are large (mean of net admitted assets is $8,131 million)[17] and profitable (mean return on assets is 0.035).

[17] Although we use the natural log of net admitted assets in the regression analyses, the actual value of net admitted assets are reported here.

Finally, the majority of total net written premiums (about 67%) consists of longer tailed lines of business. Table 3 presents the Pearson correlation between the variables included in the regression model. The results show that the correlations between derivatives usage variables and various risk-taking variables are significantly negative. We also find that derivatives usage variables are negatively correlated with CEO compensation and equity portfolio incentives variables, which is in line with the view of low executive compensation and equity incentives due to a reduced risk premium. To check for the possibility of multicollinearity among the independent variables, we compute the variance inflation factors (VIF) in our regressions. All VIFs range between 1.07 and 2.04, indicating that multicollinearity does not adversely affect our regression results.

Empirical Analyses

Table 4.1 reports the estimations of parameters for the effect of the extent of derivative transactions on insurers' risk-taking.[18] The coefficients on volume of derivatives transactions are significantly negative for both accounting (total risk, underwriting risk, investment risk, and leverage risk) and market-based (systematic risk and unsystematic risk) measures of risk. These results confirm the findings of Bartram et al. (2011), implying that usage of derivatives for hedging purposes helps firms reduce corporate risk.[19] Table 4.2 presents the results of regression of the relationship between derivative participation decision and risk-taking variables. We find the results are generally consistent with those in Table 4.1. Tone difference is that the coefficient of investment risk on participation decision is significant and negative in in Table 4.1, but is not significant in Table 4.2. We are not alarmed by the different results because volume variable conveys more information than participation variable. The oval results of Table 4 suggest that the

[18] We used several measures of volume of derivatives transactions, such as end-of-year or within-year volume as measured by notional amount, and end-of-year volume as measured by market value. Since we obtain qualitatively similar results with different measures, we only report the results with volume of transactions at the end of year (notional value) to save space.

[19] Bartram et al. (2014) use non-financial firms from 47 countries as a sample.

board of directors may utilize derivatives as part of an overall risk management strategy to manage both underwriting and investment risks.

We discuss only important results of control variables in Table 4. Insurer size is found to be negatively related to risk measures, implying that larger insurers tend to take less risk. The coefficients on both product and geographical concentration are significantly negative in risk measures, indicating that insurers operating diversified lines of business and over wider geographical areas may have greater risk because of the complexity of diversified firms. We also find that reinsurance ratio is negatively associated with various measures of risk. This suggests that using more reinsurance help firms reduce their exposure to the risk, consistent with Cummins and Song (2008).

Table 5 and 6 report the results of our simultaneous equations models of derivative usage and compensation and incentive, respectively. Panel A, Table 5 shows that the coefficients of compensation (Log Total Comp, Log Cash Comp, Log Equity Comp and Equity Mix) are significantly negative, respectively. The evidence indicates firms with more CEOs' compensation have less derivative usage or more risk. The results are not surprising because CEOs are likely to take more risk when their compensation is contingent on risk-taking.

The results of Panel B, Table 5.1 show that the extent of derivative transaction is significantly and negatively related to CEO's total annual compensation, cash compensation, and equity compensation. This negative relationship between derivative usage and total annual compensation as well as its individual components suggests that more derivatives usage allows CEOs to hedge risk that they would have otherwise had to bear, and as a consequence, CEOs receive less of a risk premium in their annual compensation. For example, we find the coefficient of equity mix is significantly negative, implying that the proportion of CEOs' compensation paid in the form of stock and options decreases as a firm increases the usage of derivatives. The result is consistent with Armstrong et al. (2017) that firms are likely to move away from equity incentives after a reduction in firm risks. The coefficients on derivative participation decision are significant and negative for total annual compensation and equity compensation in Table 5.2.

We next examine the relation between derivative usage and CEOs' equity portfolio incentives measured by vega and delta (the sensitivity of CEOs' equity portfolio values to changes in stock return volatility and stock price, respectively), and vega-to-delta ratio (relative risk-taking incentives of CEOs). Panel A, Table 6.1 show that all three measures are negatively related to derivative usage, implying firms with higher CEO equity incentive are less likely to use derivatives to hedge risks. In other words, these firm take higher risk.

Panel B, Table 6.1 shows the coefficients of portfolio delta, portfolio vega, and the ratio of vega-to-delta are significant and negative, respectively. These results suggest that CEO's equity incentives are lower for firms use more derivatives, indicating that the magnitude of CEOs' equity incentives decreases as a firm increases derivatives usage to hedge risks, confirming the findings of Rogers (2002) that CEOs' risk-taking incentives are negative related to derivatives holdings.

The results of participation decision related to CEOs' equity incentives are reported in Table 6.2. These results are similar to those of Table 6.1, but some of the variables are not statistically significant. Overall, our findings suggest that derivatives hedging significantly reduces the risk premium that CEOs receive, therefore leading to low levels of CEOs' equity incentives.

In summary, the results in Tables 4, 5, and 6 imply that firms using more derivatives for hedging purposes tend to exhibit lower levels of risk, and that CEOs of those firms are more likely to receive a smaller amount of annual compensation. The evidence suggests that risk premium that CEOs require in exchange for their exposure to various risks declines as a firm uses more derivatives as a risk management tool, and as a consequence, board of directors may modify the design of CEO incentive-compensation contracts based on firms' risk appetite.

Tables 7 provide the regression results for the interaction effect of reinsurance and derivative hedging on risk-taking. The results of Tables 7.1 and 7.2 show that the interaction terms between derivatives usage and reinsurance are significantly and negatively related to four risk-taking variables (total risk, underwriting risk, Investment risk, and leverage risk) for the extent of derivative transaction, and five risk measures (except for unsystematic risk) for derivatives participation decisions, respectively. The results indicate that the risk reduction effect of derivative hedging is more pronounced for insurers using more reinsurance, supporting the complementarity hypothesis.

With regard to CEO compensation models in Tables 8.1 and 8.2, the coefficients of the interaction terms are significantly negative for total compensation, cash compensation, and equity compensation for the extent of derivative transactions, and for total compensation and equity compensation in participation decision, indicating that the usage of reinsurance strengthens the negative effect of derivatives hedging on CEO compensation.

Table 9 shows that the coefficient on *Volume* × *Reinsurance* is negative and significant in portfolio vega and vega-to-delta ratio, and the coefficients on *Participation* × *Reinsurance* are significant and negative for all equity incentives variables.

The overall findings of Tables 7, 8, and 9 indirectly support the complementarity hypothesis, suggesting that insurers using more reinsurance tend to use more derivatives, and as a result, the usage of derivatives and reinsurance significantly reduces risk-taking, CEOs' compensation, and their equity portfolio incentives.

Lastly, we examine how the financial crisis in 2008-2009 affects the relationship between the usage of derivatives, firm's risks, CEO compensation, and equity incentives. We add interaction term of *Crisis* and *Volume* (*Participation*) in the regression models. We use a dummy variable (*Crisis*) equal to one if the observation occurs in 2008-2009, and zero otherwise. The results are reported in Tables 10-12. Table 10.1 and 10.2 show that the coefficients of the interaction terms, *Volume* (*Participation*) × *Crisis,* are significantly positive in total risk, underwriting risk, investment risk, systematic risk (only for participation decision), and unsystematic risk, implying that the risk reduction effects of derivatives hedging are smaller during the financial crisis in 2008-2009 than the rest of sample period. One possible explanation is that insurers probably did not expect such a volatile market, and as a result, did not hedge risks properly during the financial crisis. The interaction effects on leverage risk are not significant in both Tables 10.1 and 10.2.

In Tables 11.1 and 11.2, the coefficient of interaction terms are significantly positive in total compensation and equity compensation, implying that CEO compensation is higher during the 2008-2009 financial crisis period than non-crisis period for insurers with derivatives hedging. These results are consistent with the smaller risk-reduction effects of derivatives usage during the financial crisis period. The potential reason for higher compensation during the crisis period is that the risk-reduction of derivatives usage is less effective, and therefore, risk premium required is higher during the crisis period. Finally, Table 12 presents the results of interaction effect between derivatives usage and crisis on CEOs' equity portfolio incentives. The coefficients of *Derivatives Use* × *Crisis* is significantly positive in delta and vega-to-delta ratio for the extent of derivatives transactions and the interaction term is positively related to vega and the ratio of vega-to-delta in derivatives participation decision, implying that the negative effects of derivative hedging on mangers' equity portfolio incentives are less pronounced during the 2008-2009 financial crisis relative to non-crisis period. These results imply that derivatives hedging is less effective during the crisis period, and thus, mangers have more incentives to increase equity risk and price during the financial crisis.

Conclusion

This study uses derivatives transaction data set of insurers to examine the effects of derivatives hedging on the insurers' risk-taking, managerial compensation, and equity incentives in U.S. property-liability insurance companies. Our evidence shows that insurers using more derivatives for hedging purposes tend to have lower levels of risk, and their CEOs tend to receive less annual compensation and have lower equity incentives to take risk. These findings indicate that risk premium that CEOs receive for having their personal wealth exposed to various risks may significantly decrease as the insurers use more derivatives hedging. In other words, our results suggest that the board of directors may utilize derivatives as part of an overall risk management strategy to manage both underwriting and investment risks, and in turn, respond to changes in their risk appetite by structuring CEOs' incentive-compensation contracts accordingly.

We also find that for insurers using more reinsurance, negative effects of derivative hedging on insurers' risks, managerial compensation, and portfolio incentives are more pronounced. These results are consistent with the complementarity hypothesis between reinsurance and derivatives usage. We also provide evidence that the risk-reduction effects of derivatives hedging are smaller during the financial crisis in 2008-2009 than the rest of sample period. Overall, our results have important implications for regulators and industry practitioners by demonstrating how derivative hedging affects insurers' risk-taking behavior, the structure of CEOs' compensation contracts, and their equity portfolio incentives from an enterprise risk management perspective.

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Table 1: Variable Definition

Variable Description	Definition
Derivatives Participation	1= if an insurer reports any derivative trading during that year or at the end of the year, and states that these derivative positions are for hedging purpose, 0= otherwise
Extent of Derivative Transaction	Volume of derivatives transactions (notional amounts during that year or at the end of the year or market value at the end of the year scaled by insurer's total assets if the firm uses derivatives, and zero otherwise
Total Risk	Standard deviation of return on assets (ROA)
Underwriting Risk	Standard deviation of the firm's loss ratios
Investment Risk	Standard deviation of return on investment (ROI)
Leverage Risk	1 minus the surplus-to-asset ratio
Systematic Risk	Firm's beta (β) estimated by a single index model using daily stock returns over the year
Unsystematic Risk	Log of mean squared error (MSE) estimated by the single index model over the year
Log Total Comp	Log of total compensation
Log Cash Comp	Log of salary and bonus
Log Equity Comp	Log of value of restricted stock grants plus value of option grants
Equity Mix	Value of restricted stock grants plus value of option grants divided by total compensation
Portfolio Vega	Log of the change in the Black-Scholes value of the CEO's equity portfolio with respect to 1% change in standard deviation of the firm's stock
Portfolio Delta	Log of the change in the Black-Scholes value of the CEO's equity portfolio in response to 1% change in the firm's stock price
Insurer Size	Natural log of net admitted assets

Table 1: Variable Definition (Continued)

Variable Description	Definition
Product Concentration	Sum of squares of value of net written premiums in line *i* divided by total net written premiums
Geographic Concentration	Sum of squares of value of net written premiums in state *i* divided by total net written premiums
Long Tail	Premiums of long-tail lines divided by total net written premiums
Reinsurance	Ratio of reinsurance ceded to total direct premium plus reinsurance assumed
Firm Age	Log of the number of years since the firm first appears in CRSP
Stock Return	Log of one plus stock return over the fiscal year
ROA	Ratio of net income plus taxes and interest expenses to net admitted assets
Book to Market	Book value divided by market value of equity

Table 2: Descriptive Statistics

Variables	N	Mean	SD	Min	Max
Derivative Participation end-of-year	239	0.764	0.343	0.000	1.000
Derivative Participation within-year	239	0.770	0.337	0.000	1.000
Derivative Participation market value	239	0.775	0.331	0.000	1.000
Derivative Volume end-of-year	239	0.025	0.136	0.000	0.667
Derivative Volume within-year	239	0.072	0.199	0.000	0.663
Derivative Volume market value	239	0.001	0.003	0.000	0.032
Total Risk	239	0.030	0.033	0.002	0.202
Underwriting Risk	239	0.125	0.228	0.011	1.919
Investment Risk	239	0.024	0.032	0.002	0.170
Leverage Risk	239	0.647	0.113	0.156	0.884
Systematic Risk	239	1.144	0.811	0.131	1.883
Unsystematic Risk	239	0.076	0.096	0.015	0.812
Log Total Comp	239	3.790	0.481	1.518	4.573
Log Cash Comp	239	3.160	0.270	2.641	4.046
Log Equity Comp	239	2.461	0.662	1.574	3.997
Equity Mix	239	0.394	0.272	0.000	0.916
Portfolio Vega	239	1.559	1.012	0.932	2.597
Portfolio Delta	239	2.286	0.661	0.492	3.467
Insurer Size	239	22.819	1.320	19.429	24.587
Product Concentration	239	0.296	0.280	0.087	1.000
Geographic Concentration	239	0.189	0.271	0.035	1.000
Long Tail	239	0.667	0.297	0.000	1.000
Reinsurance	239	0.264	0.499	0.000	0.873
Firm Age	239	1.481	0.159	1.000	1.681
Stock Return	239	0.170	0.569	-1.550	2.695
ROA	239	0.035	0.061	-0.323	0.328
Book to Market	239	0.898	0.927	0.102	1.507

Table 3. Pearson Correlation Matrix

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.
1.Derivative Participation	1																						
2 Derivative Volume	0.141	1																					
	0.062																						
3. Total Risk	-0.253	-0.039	1																				
	0.001	0.602																					
4. Underwriting Risk	-0.141	-0.385	0.414	1																			
	0.060	<0.0001	<0.0001																				
5. Investment Risk	-0.187	-0.287	0.151	0.025	1																		
	0.012	<0.0001	<0.0001	0.743																			
6. Leverage Risk	-0.125	-0.144	0.154	0.113	0.023	1																	
	0.098	0.056	0.041	0.133	0.759																		
7.Systematic Risk	-0.217	-0.214	0.029	0.007	0.034	0.103	1																
	0.004	0.004	0.705	0.921	0.654	0.169																	
8. Unsystematic Risk	-0.221	-0.038	0.180	0.385	0.061	0.008	0.498	1															
	0.003	0.612	0.016	<0.0001	0.414	0.916	<0.0001																
9. Log Total Comp	-0.524	-0.175	0.014	0.087	0.093	0.061	0.016	0.099	1														
	<0.0001	0.020	0.850	0.247	0.215	0.420	0.833	0.188															
10. Log Cash Comp	-0.197	-0.150	0.158	0.052	0.187	0.094	0.018	0.116	0.199	1													
	0.009	0.047	0.036	0.489	0.013	0.213	0.814	0.123	0.008														
11. Log Equity Comp	-0.125	-0.261	0.403	0.099	0.011	0.077	0.003	0.077	0.397	0.235	1												
	0.097	0.001	<0.0001	0.187	0.889	0.307	0.973	0.309	<0.0001	0.002													
12. Equity Max	-0.135	-0.277	0.532	0.042	0.015	0.144	0.092	0.071	0.350	0.027	0.430	1											
	0.073	<0.0001	<0.0001	0.577	0.842	0.056	0.225	0.343	<0.0001	0.726	<0.0001												
13. Portfolio Vega	-0.139	-0.181	0.085	0.189	0.030	0.065	0.278	0.007	0.291	0.137	0.271	0.079	1										
	0.065	0.016	0.258	0.012	0.689	0.383	<0.0001	0.919	<0.0001	0.069	0.000	0.294											
14. Portfolio Delta	-0.207	-0.110	0.185	0.062	0.224	0.040	0.105	0.055	0.320	0.131	0.241	0.330	0.487	1									
	0.006	0.145	0.013	0.407	0.003	0.594	0.164	0.470	<0.0001	0.082	0.002	<0.0001	<0.0001										
15. Insurer Size	0.489	0.294	-0.043	-0.135	0.133	0.101	0.103	-0.063	0.302	0.179	-0.004	0.068	-0.089	0.057	1								
	<0.0001	<0.0001	0.565	0.073	0.078	0.181	0.174	0.408	<0.0001	0.017	0.954	0.370	0.241	0.453									
16. Product HHI	-0.623	-0.124	0.020	0.489	0.065	-0.183	0.341	0.360	-0.139	-0.144	0.031	-0.023	-0.172	-0.075	-0.020	1							
	<0.0001	0.099	0.791	<0.0001	0.387	0.014	<0.0001	<0.0001	0.064	0.055	0.673	0.762	0.022	0.322	0.789								
17. Geographic HHI	-0.195	-0.163	-0.071	0.083	-0.107	-0.485	-0.028	0.051	-0.228	-0.065	-0.096	-0.374	0.115	-0.145	0.014	0.267	1						
	0.009	0.030	0.351	0.268	0.156	<0.0001	0.708	0.501	0.002	0.384	0.202	<0.0001	0.126	0.055	0.852	0.001							
18. Long Tail	0488	0.115	-0.018	-0.360	0.081	0.119	-0.420	-0.308	0.072	0.146	0.075	0.135	0.085	0.083	0.228	-0.638	-0.013	1					
	<0.0001	0.127	0.811	<0.0001	0.281	0.115	<0.0001	<0.0001	0.344	0.052	0.320	0.073	0.259	0.271	0.002	<0.0001	0.865						
19. Reinsurance	-0.048	-0.004	-0.002	-0.522	0.189	0.126	-0.074	0.106	0.085	0.276	0.031	0.082	-0.030	-0.095	0.113	-0.368	0.144	0.226	1				
	0.523	0.955	0.974	<0.0001	0.011	0.094	0.327	0.159	0.261	0.000	0.685	0.278	0.688	0.208	0.134	<0.0001	0.055	0.003					
20. Firm Age	0.400	0.064	0.014	0.109	0.160	0.029	0.036	-0.225	0.114	-0.056	-0.161	-0.238	0.056	-0.084	0.160	-0.717	0.057	0.424	0.196	1			
	<0.0001	0.394	0.849	0.148	0.032	0.697	0.623	0.003	0.129	0.463	0.033	0.001	0.457	0.265	0.033	<0.0001	0.450	<0.0001	0.009				
21. RET	0.083	-0.006	0.068	0.010	0.015	0.067	-0.083	0.073	-0.119	-0.014	-0.066	-0.099	0.058	-0.022	0.075	0.022	0.008	-0.036	-0.031	-0.104	1		
	0.272	0.936	0.370	0.891	0.838	0.371	0.272	0.334	0.116	0.856	0.382	0.189	0.446	0.768	0.322	0.776	0.920	0.630	0.680	0.170			
22. ROA	-0.019	-0.047	-0.227	0.053	0.217	-0.238	-0.016	-0.179	0.061	-0.032	0.046	0.020	0.121	0.028	0.127	-0.074	-0.014	-0.032	0.149	0.024	-0.272	1	
	0.767	0.530	0.002	0.485	0.004	0.001	0.841	0.017	0.416	0.671	0.545	0.787	0.109	0.711	0.092	0.324	0.850	0.067	0.048	0.752	0.719		
23. Book to Market	0.029	0.163	-0.096	-0.034	-0.097	-0.043	0.137	-0.041	-0.126	-0.010	-0.113	-0.086	-0.081	-0.003	0.162	-0.022	-0.057	-0.003	0.006	-0.009	0.007	-0.023	1
	0.700	0.030	0.203	0.655	0.198	0.573	0.068	0.588	0.096	0.891	0.132	0.257	0.282	0.968	0.031	0.767	0.448	0.971	0.935	0.901	0.930	0.764	

The table presents the Pearson correlation matrix for all variables. See Table 1 for variable definitions.

Table 4.1. Derivatives Use and Risk Taking (Extent of Derivative Transaction)

	Total Risk	Underwriting Risk	Investment Risk	Leverage Risk	Systematic Risk	Unsystematic Risk
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	-0.578***	-1.274***	-0.167**	1.125***	-1.837***	-0.650**
	(0.098)	(0.409)	(0.071)	(0.207)	(0.562)	(0.258)
Volume	**-0.832****	**-0.580****	**-0.970*****	**-0.841****	**-0.710***	**-0.522****
	(0.394)	**(0.247)**	**(0.152)**	**(0.382)**	**(0.418)**	**(0.240)**
Size	-0.020***	-0.020*	-0.003***	-0.017***	-0.233***	-0.017**
	(0.004)	(0.011)	(0.001)	(0.005)	(0.072)	(0.007)
ProdHHI	-0.014	-0.433***	-0.017	-0.107**	-2.141***	-0.185***
	(0.039)	(0.098)	(0.014)	(0.045)	(0.586)	(0.050)
GeoHHI	-0.065**	-0.177***	-0.012**	-0.260***	-0.456	-0.013
	(0.027)	(0.048)	(0.005)	(0.038)	(0.280)	(0.020)
Longtail	0.100***	0.171***	0.008	0.073***	1.267***	0.056**
	(0.029)	(0.055)	(0.006)	(0.022)	(0.340)	(0.022)
Reinsurance	-0.007**	-0.184***	-0.007	-0.012	-0.257**	-0.021
	(0.003)	(0.041)	(0.008)	(0.015)	(0.121)	(0.018)
Firm Age	0.015	0.630***	0.069***	0.045	2.534***	0.189***
	(0.039)	(0.135)	(0.024)	(0.067)	(0.780)	(0.064)
RET	0.002	0.013	0.006	0.003	0.127	0.001
	(0.003)	(0.018)	(0.005)	(0.012)	(0.151)	(0.010)
ROA	-0.074	-1.528***	-0.109	-0.477***	-0.611	-0.101
	(0.107)	(0.403)	(0.073)	(0.147)	(1.011)	(0.072)
Book-to-Market	0.001	0.005***	0.010***	0.003	0.008	0.002**
	(0.003)	(0.001)	(0.003)	(0.002)	(0.026)	(0.001)
Observations	239	239	239	239	239	239
Adjusted R^2	0.361	0.659	0.284	0.393	0.423	0.473

The table reports the results of two-way fixed effects regressions. Standard errors that adjust for heteroskedasticity and within-panel serial correlation are reported in parentheses. ***, ** and * represent statistical significance at 0.01, 0.05, and 0.10 level, respectively.

Table 4.2. Derivatives Use and Risk Taking (Participation Decision)

	Total Risk	Underwriting Risk	Investment Risk	Leverage Risk	Systematic Risk	Unsystematic Risk
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	0.575***	1.597***	0.300**	1.392**	-1.589***	-0.658**
	(0.130)	(0.496)	(0.132)	(0.663)	(0.553)	(0.264)
Participation	**-0.098****	**-0.103****	-0.010	**-0.044****	**-0.509****	**-0.026****
	(0.041)	**(0.044)**	(0.008)	**(0.020)**	**(0.215)**	**(0.012)**
Size	-0.019***	-0.054***	-0.011**	-0.017	-0.269***	-0.018**
	(0.005)	(0.019)	(0.005)	(0.015)	(0.073)	(0.007)
ProdHHI	-0.015	-0.067	-0.038	-0.125	-2.182***	-0.187***
	(0.052)	(0.198)	(0.053)	(0.107)	(0.540)	(0.052)
GeoHHI	-0.062***	-0.018	-0.024	-0.243***	-0.319	-0.006
	(0.020)	(0.078)	(0.021)	(0.040)	(0.337)	(0.021)
Longtail	0.102***	0.199	0.083**	0.040	1.188***	0.053**
	(0.035)	(0.134)	(0.035)	(0.069)	(0.302)	(0.020)
Reinsurance	-0.008	-0.205***	-0.005	-0.015	-0.251	-0.020
	(0.006)	(0.023)	(0.006)	(0.012)	(0.154)	(0.018)
Firm Age	0.014	0.038	0.039	0.240***	2.469***	0.187***
	(0.039)	(0.151)	(0.041)	(0.075)	(0.866)	(0.068)
RET	0.003	0.006	0.001	0.004	0.118	0.001
	(0.004)	(0.016)	(0.004)	(0.009)	(0.138)	(0.009)
ROA	-0.054	-0.952***	-0.101**	-0.106	-1.409	-0.065
	(0.047)	(0.179)	(0.048)	(0.099)	(1.312)	(0.057)
Book-to-Market	0.001	0.003	0.001	0.001	0.010	0.003***
	(0.002)	(0.003)	(0.007)	(0.001)	(0.018)	(0.001)
Observations	239	239	239	239	239	239
Adjusted R^2	0.380	0.614	0.348	0.335	0.443	0.475

The table reports the results of two-way fixed effects regressions. Standard errors that adjust for heteroskedasticity and within-panel serial correlation are reported in parentheses. ***, ** and * represent statistical significance at 0.01, 0.05, and 0.10 level, respectively.

Table 5.1. Derivatives Use and CEO Compensation (Extent of Transaction)
Panel A

Dependent variables	Derivatives use	Derivatives use	Derivatives use	Derivatives use
Intercept	-0.016 (0.065)	-0.324 (0.262)	-0.010 (0.019)	-0.012 (0.019)
Log Total Comp	-0.021*** (0.006)			
Log Cash Comp		-0.089** (0.042)		
Log Equity Comp			-0.030** (0.012)	
Equity Mix				-0.084*** (0.031)
Size	0.048** (0.023)	0.025** (0.010)	0.005 (0.007)	0.067*** (0.015)
ProdHHI	0.004 (0.015)	0.063 (0.056)	0.067 (0.041)	0.065 (0.041)
GeoHHI	0.014 (0.012)	0.036 (0.049)	0.013 (0.035)	0.017 (0.038)
Reinsurance	0.032 (0.060)	0.035 (0.024)	0.025 (0.017)	-0.024 (0.017)
Longtail	-0.017 (0.012)	-0.056 (0.048)	-0.031 (0.035)	-0.035 (0.039)
Observations	239	239	239	239
Adjusted R^2	0.102	0.208	0.171	0.284

Panel B

Dependent variables	Log Total Comp	Log Cash Comp	Log Equity Comp	Equity Mix
Intercept	1.732*** (0.547)	2.776*** (0.498)	3.038*** (0.971)	0.385 (0.384)
Derivative Use	**-0.841*** (0.226)**	**-0.768* (0.408)**	**-0.907** (0.453)**	**-0.827** (0.391)**
Size	0.116*** (0.027)	0.049*** (0.017)	0.030 (0.040)	0.018 (0.016)
Firm Age	0.042 (0.215)	0.163 (0.128)	0.696** (0.313)	0.449*** (0.124)
RET	0.051 (0.060)	0.005 (0.032)	0.090 (0.088)	0.054 (0.035)
ROA	0.111 (0.570)	0.652 (0.764)	2.430 (1.870)	1.292** (0.642)
Book-to-Market	-0.023*** (0.009)	-0.003 (0.005)	-0.017 (0.013)	-0.006 (0.005)
Leverage	0.087 (0.308)	0.120 (0.189)	0.537 (0.455)	0.375** (0.181)
Observations	239	239	239	239
Adjusted R^2	0.196	0.173	0.185	0.150

The table reports the results of the simultaneous equation results relating to the effect of CEO compensation on derivatives use and the effect of derivatives use on CEO compensation. Standard errors are reported in parentheses. ***, ** and * represent statistical significance at 0.01, 0.05, and 0.10 level, respectively.

Table 5.2. Derivatives Use and CEO Compensation (Participation Decision)

Panel A

Dependent variables	Derivatives use	Derivatives use	Derivatives use	Derivatives use
Intercept	-1.042**	-1.098**	-0.860**	-1.062**
	(0.492)	(0.449)	(0.414)	(0.453)
Log Total Comp	-0.079*			
	(0.043)			
Log Cash Comp		-0.013		
		(0.071)		
Log Equity Comp			-0.219***	
			(0.074)	
Equity Mix				-0.019
				(0.028)
Size	0.097***	0.086***	0.081***	0.087***
	(0.020)	(0.017)	(0.018)	(0.020)
ProdHHI	0.627***	0.557***	0.530***	0.544***
	(0.095)	(0.094)	(0.095)	(0.097)
GeoHHI	0.169**	0.134	0.037	0.133
	(0.082)	(0.083)	(0.090)	(0.085)
Reinsurance	0.121***	0.118***	0.129***	0.117***
	(0.042)	(0.041)	(0.040)	(0.041)
Longtail	-0.255***	-0.206**	-0.237***	-0.220***
	(0.080)	(0.080)	(0.081)	(0.083)
Observations	239	239	239	239
Adjusted R^2	0.552	0.498	0.537	0.496

Panel B Dependent variables	Log Total Comp	Log Cash Comp	Log Equity Comp	Equity Mix
Intercept	0.754	2.204***	0.281	2.785**
	(0.879)	(0.451)	(0.515)	(1.301)
Derivative Use	**-0.255****	-0.012	**-0.132****	-0.036
	(0.126)	(0.076)	**(0.056)**	(0.192)
Size	0.115***	0.045**	0.048**	0.003
	(0.036)	(0.018)	(0.021)	(0.054)
Firm Age	0.317	0.225	0.355**	0.682*
	(0.248)	(0.136)	(0.141)	(0.357)
RET	0.036	0.039	0.041	0.128
	(0.062)	(0.036)	(0.037)	(0.094)
ROA	0.653	0.463	0.998	1.682***
	(0.571)	(0.338)	(1.171)	(0.596)
Book-to-Market	-0.022	-0.001	-0.007	-0.018
	(0.014)	(0.005)	(0.005)	(0.013)
Leverage	0.232	0.354*	0.336	1.007*
	(0.320)	(0.188)	(0.206)	(0.520)
Observations	239	239	239	239
Adjusted R^2	0.226	0.124	0.207	0.189

The table reports the results of the simultaneous equation results relating to the effect of CEO compensation on derivatives use and the effect of derivatives use on CEO compensation. Standard errors are reported in parentheses. ***, ** and * represent statistical significance at 0.01, 0.05, and 0.10 level, respectively.

Table 6.1. Derivatives Use and Equity Portfolio Incentives (Extent of Transaction)

Panel A

Dependent variables	Derivatives use	Derivatives use	Derivatives use
Intercept	-0.165**	-0.074	-1.226***
	(0.067)	(0.185)	(0.365)
Portfolio Delta	-0.005		
	(0.004)		
Portfolio Vega		-0.017**	
		(0.007)	
Vega-to-Delta Ratio			-0.040***
			(0.013)
Size	0.069***	0.043	0.056***
	(0.025)	(0.075)	(0.012)
ProdHHI	0.027**	0.047	0.017
	(0.013)	(0.040)	(0.079)
GeoHHI	0.018	0.011	0.029
	(0.012)	(0.036)	(0.078)
Reinsurance	0.089	0.022	0.141
	(0.060)	(0.018)	(0.252)
Longtail	-0.024**	-0.019	-0.047
	(0.012)	(0.012)	(0.068)
Observations	239	239	239
Adjusted R^2	0.108	0.075	0.172

Panel B Dependent variables	Portfolio Delta	Portfolio Vega	Vega-to- Delta Ratio
Intercept	2.491**	0.942	2.655**
	(0.973)	(1.504)	(1.287)
Derivative Use	**-0.871****	**-0.903****	**-0.714****
	(0.389)	**(0.418)**	**(0.324)**
Size	0.018	0.041	0.068
	(0.041)	(0.062)	(0.053)
Firm Age	0.337	0.469	0.241
	(0.314)	(0.495)	(0.410)
RET	0.071	0.014	0.025
	(0.088)	(0.137)	(0.101)
ROA	-1.086**	-1.996***	-1.582***
	(0.465)	(0.402)	(0.364)
Book-to-Market	-0.010	-0.004	-0.002
	(0.013)	(0.019)	(0.017)
Leverage	0.551	0.353	0.147
	(0.506)	(0.705)	(0.543)
Observations	239	239	239
Adjusted R^2	0.215	0.138	0.213

The table reports the results of the simultaneous equation results relating to the effect of equity incentives on derivatives use and the effect of derivatives use on equity incentives. Standard errors are reported in parentheses. ***, ** and * represent statistical significance at 0.01, 0.05, and 0.10 level, respectively.

Table 6.2. Derivatives Use and Equity Portfolio Incentives (Participation Decision)

Panel A Dependent variables	Derivatives use	Derivatives use	Derivatives use
Intercept	-1.332***	-1.068**	-1.343***
	(0.492)	(0.433)	(0.355)
Portfolio Delta	-0.040		
	(0.032)		
Portfolio Vega		-0.015	
		(0.018)	
Vega-to-Delta Ratio			-0.038**
			(0.018)
Size	0.093***	0.086***	0.059***
	(0.020)	(0.017)	(0.014)
ProdHHI	0.598***	0.556***	0.035
	(0.097)	(0.094)	(0.077)
GeoHHI	0.171**	0.135	0.017
	(0.083)	(0.084)	(0.068)
Reinsurance	0.120***	0.116***	0.131
	(0.043)	(0.041)	(0.334)
Longtail	-0.262***	-0.208***	-0.067
	(0.081)	(0.075)	(0.065)
Observations	239	239	239
Adjusted R^2	0.572	0.515	0.122

Panel B Dependent variables	Portfolio Delta	Portfolio Vega	Vega-to- Delta Ratio
Intercept	3.131**	2.363	2.527**
	(1.220)	(1.757)	(1.256)
Derivative Use	**-0.461*** **	-0.388	**-0.640** **
	(0.175)	(0.296)	**(0.293)**
Size	0.053	0.060	0.064
	(0.050)	(0.073)	(0.054)
Firm Age	0.742**	0.864**	0.404**
	(0.344)	(0.337)	(0.201)
RET	0.038	0.095	0.011
	(0.086)	(0.144)	(0.112)
ROA	-1.124	-1.492	-0.243
	(0.791)	(1.763)	(1.074)
Book-to-Market	-0.016	-0.013	-0.005
	(0.019)	(0.020)	(0.016)
Leverage	0.373	0.508	0.145
	(0.447)	(0.738)	(0.576)
Observations	239	239	239
Adjusted R^2	0.199	0.152	0.165

The table reports the results of the simultaneous equation results relating to the effect of equity incentives on derivatives use and the effect of derivatives use on equity incentives. Standard errors are reported in parentheses. ***, ** and * represent statistical significance at 0.01, 0.05, and 0.10 level, respectively.

Table 7.1. Effect of Reinsurance on the Relation between Derivatives Use and Insurer's Risk (Extent of Derivative Transaction)

	Total Risk	Underwriting Risk	Investment Risk	Leverage Risk	Systematic Risk	Unsystematic Risk
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	0.571***	1.507***	0.300**	1.025***	-1.111***	0.343
	(0.100)	(0.478)	(0.134)	(0.284)	(0.373)	(0.318)
Volume	-0.763*	-0.684**	-0.807***	-0.894*	-0.621**	-0.437
	(0.449)	(0.327)	(0.171)	(0.509)	(0.304)	(0.379)
Reinsurance	-0.003	-0.179***	-0.002	-0.016**	-0.065	-0.008
	(0.004)	(0.051)	(0.002)	(0.007)	(0.181)	(0.019)
Volume × Reinsurance	**-0.956*** **	**-0.816** **	**-0.855** **	**-0.803*** **	-0.308	-0.364
	(0.302)	**(0.321)**	**(0.422)**	**(0.149)**	(0.281)	(0.698)
Size	-0.021***	-0.059**	-0.011**	-0.005	-0.127	-0.005
	(0.004)	(0.026)	(0.005)	(0.012)	(0.149)	(0.011)
ProdHHI	-0.012	-0.003	-0.038	-0.152*	-1.471	-0.084
	(0.040)	(0.242)	(0.037)	(0.089)	(1.476)	(0.089)
GeoHHI	-0.067**	-0.046	-0.026**	-0.231***	-0.021	-0.065
	(0.027)	(0.113)	(0.011)	(0.074)	(0.584)	(0.077)
Longtail	0.100***	0.201**	0.082**	0.014	0.381	0.048
	(0.030)	(0.098)	(0.035)	(0.038)	(1.006)	(0.045)
Firm Age	0.023	0.113	0.045	0.266***	3.123***	0.118
	(0.041)	(0.195)	(0.043)	(0.091)	(1.158)	(0.081)
RET	0.002	0.002	0.001	0.006	0.104	0.021**
	(0.004)	(0.016)	(0.003)	(0.007)	(0.122)	(0.010)
ROA	-0.076	-1.199***	-0.096	-0.158	-1.536	-0.212*
	(0.107)	(0.390)	(0.080)	(0.148)	(1.318)	(0.109)
Book-to-Market	0.002**	0.004	0.001	0.005	0.037*	0.003
	(0.001)	(0.008)	(0.005)	(0.008)	(0.022)	(0.004)
Observations	239	239	239	239	239	239
Adjusted R^2	0.375	0.593	0.359	0.612	0.539	0.308

The table reports the results of two-way fixed effects regressions. Standard errors that adjust for heteroskedasticity and within-panel serial correlation are reported in parentheses. ***, ** and * represent statistical significance at 0.01, 0.05, and 0.10 level, respectively.

Table 7.2. Effect of Reinsurance on the Relation between Derivatives Use and Insurer's Risk (Participation Decision)

	Total Risk	Underwriting Risk	Investment Risk	Leverage Risk	Systematic Risk	Unsystematic Risk
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	-0.127	-1.163***	1.391	1.058***	-1.394	-1.249
	(0.095)	(0.338)	(1.370)	(0.209)	(0.976)	(0.931)
Participation	-0.092**	-0.211***	-0.013	-0.048**	-0.543***	-0.067***
	(0.040)	(0.054)	(0.009)	(0.024)	(0.102)	(0.021)
Reinsurance	-0.067**	-0.261**	-0.386**	-0.125	-0.119	-0.068
	(0.030)	(0.109)	(0.174)	(0.077)	(0.117)	(0.118)
Participation × Reinsurance	**-0.621****	**-0.465*****	**-0.781****	**-0.200***	**-0.682***	-0.079
	(0.242)	**(0.158)**	**(0.380)**	**(0.117)**	**(0.383)**	(0.060)
Size	-0.001	-0.002	-0.051*	-0.019***	-0.046	-0.029
	(0.003)	(0.010)	(0.030)	(0.006)	(0.201)	(0.020)
ProdHHI	-0.062***	-0.064	-0.075	-0.049	-1.390	-0.133
	(0.023)	(0.081)	(0.223)	(0.051)	(1.494)	(0.152)
GeoHHI	-0.028**	-0.022	-0.026	-0.264***	-0.070	-0.042
	(0.012)	(0.043)	(0.083)	(0.040)	(0.554)	(0.056)
Longtail	0.013	0.138***	0.244*	0.067***	0.741	0.040
	(0.011)	(0.039)	(0.143)	(0.023)	(0.964)	(0.098)
Firm Age	0.083***	0.062	0.160	0.060	2.879	0.416
	(0.031)	(0.111)	(0.495)	(0.068)	(3.317)	(0.337)
RET	0.005	0.002	0.003	0.003	0.213*	0.001
	(0.005)	(0.018)	(0.019)	(0.013)	(0.118)	(0.013)
ROA	-0.080*	-1.332***	-1.129***	-0.452***	-1.511	-0.081
	(0.047)	(0.161)	(0.208)	(0.162)	(1.395)	(0.142)
Book-to-Market	0.001	0.002	0.004	0.003	0.025	0.005**
	(0.006)	(0.003)	(0.003)	(0.002)	(0.021)	(0.002)
Observations	239	239	239	239	239	239
Adjusted R^2	0.217	0.743	0.528	0.399	0.655	0.552

The table reports the results of two-way fixed effects regressions. Standard errors that adjust for heteroskedasticity and within-panel serial correlation are reported in parentheses. ***, ** and * represent statistical significance at 0.01, 0.05, and 0.10 level, respectively.

Table 8.1. Effect of Reinsurance on the Relation between Derivatives Use and CEO Compensation (Extent of Derivative Transaction)

	Log Total Comp	Log Cash Comp	Log Equity Comp	Equity Mix
	(1)	(2)	(3)	(4)
Intercept	-1.210	-3.088*	1.031***	2.134**
	(1.737)	(1.852)	(0.352)	(1.031)
Volume	-0.833**	-0.787**	-0.880**	-0.709*
	(0.357)	(0.382)	(0.429)	(0.385)
Reinsurance	-0.039	-0.051***	-0.122*	-0.037***
	(0.045)	(0.019)	(0.071)	(0.013)
Volume × Reinsurance	**-0.904****	**-0.451*****	**-0.821****	-0.573
	(0.387)	**(0.118)**	**(0.357)**	(0.757)
Size	0.144***	0.122***	-0.012	-0.050
	(0.045)	(0.030)	(0.059)	(0.031)
ProdHHI	-0.438*	-0.637***	-0.487	-0.469**
	(0.233)	(0.213)	(0.590)	(0.212)
GeoHHI	-0.170	-0.277***	-1.885***	-0.181**
	(0.200)	(0.089)	(0.257)	(0.083)
Longtail	0.455	0.181	0.115	0.071
	(0.298)	(0.159)	(0.397)	(0.052)
Firm Age	0.990*	1.785***	1.627***	0.849*
	(0.518)	(0.534)	(0.468)	(0.445)
RET	0.009	0.029	0.087*	0.008
	(0.050)	(0.025)	(0.048)	(0.010)
ROA	0.467	0.220	0.189	0.345
	(0.474)	(0.222)	(0.526)	(0.223)
Book-to-Market	-0.010	-0.001	-0.008	-0.005**
	(0.012)	(0.002)	(0.009)	(0.002)
Leverage	0.199	0.059	0.617	0.078
	(0.514)	(0.190)	(0.493)	(0.143)
Observations	239	239	239	239
Adjusted R^2	0.472	0.783	0.601	0.584

The table reports the results of two-way fixed effects regressions. Standard errors that adjust for heteroskedasticity and within-panel serial correlation are reported in parentheses. ***, ** and * represent statistical significance at 0.01, 0.05, and 0.10 level, respectively.

Table 8.2. Effect of Reinsurance on the Relation between Derivatives Use and CEO Compensation (Participation Decision)

	Log Total Comp	Log Cash Comp	Log Equity Comp	Equity Mix
	(1)	(2)	(3)	(4)
Intercept	2.236	2.412	1.354***	2.677***
	(1.765)	(1.930)	(0.036)	(0.790)
Participation	-0.266*	-0.093	-0.112**	-0.118
	(0.154)	(0.091)	(0.050)	(0.227)
Reinsurance	-0.472*	-0.518**	-0.071	-0.126
	(0.251)	(0.243)	(0.455)	(0.197)
Participation × *Reinsurance*	**-0.703****	-0.110	**-0.335****	-0.347
	(0.350)	(0.214)	**(0.156)**	(0.534)
Size	0.067	0.104**	-0.082	-0.028
	(0.044)	(0.042)	(0.078)	(0.020)
ProdHHI	-0.030	-0.527	-0.244	-0.417
	(0.233)	(0.342)	(0.585)	(0.180)
GeoHHI	-0.264*	-0.361***	-1.891***	-0.371***
	(0.145)	(0.127)	(0.239)	(0.092)
Longtail	0.028	0.159	0.052	0.132
	(0.093)	(0.201)	(0.376)	(0.093)
Firm Age	0.045	1.535**	2.824**	0.789***
	(0.499)	(0.693)	(1.299)	(0.241)
RET	0.040	0.025	0.096*	0.083**
	(0.068)	(0.027)	(0.051)	(0.034)
ROA	0.029	0.096	0.418	0.073
	(0.473)	(0.292)	(0.547)	(0.301)
Book-to-Market	-0.019**	-0.002	-0.002	-0.007***
	(0.008)	(0.004)	(0.008)	(0.002)
Leverage	0.122	0.184	0.987**	0.150
	(0.521)	(0.240)	(0.449)	(0.174)
Observations	239	239	239	239
Adjusted R^2	0.474	0.764	0.681	0.451

The table reports the results of two-way fixed effects regressions. Standard errors that adjust for heteroskedasticity and within-panel serial correlation are reported in parentheses. ***, ** and * represent statistical significance at 0.01, 0.05, and 0.10 level, respectively.

Table 9. Effect of Reinsurance on Derivatives Use and Equity Portfolio Incentives

	Extent of Derivative Transaction			Participation Decision		
	Delta	Vega	Vega-to-Delta	Delta	Vega	Vega-to-Delta
	(1)	(2)	(3)	(1)	(2)	(3)
Intercept	1.358	2.837	1.554	2.039***	3.141	1.784
	(2.150)	(2.302)	(1.162)	(0.578)	(2.150)	(1.152)
Derivative Use	-0.827**	-0.804*	-0.674***	-0.695***	-0.508*	-0.386**
	(0.405)	(0.432)	(0.168)	(0.208)	(0.277)	(0.160)
Reinsurance	-0.244*	-0.422	-0.152	-0.012	-0.394	-0.281**
	(0.130)	(0.354)	(0.121)	(0.110)	(0.330)	(0.116)
Derivative Use × Reinsurance	-0.546	**-0.914****	**-0.704****	**-0.493****	**-0.536***	**-0.489****
	(0.407)	**(0.401)**	**(0.325)**	**(0.241)**	**(0.320)**	**(0.228)**
Size	0.017	0.038	0.117**	0.045	0.071	0.084*
	(0.068)	(0.060)	(0.050)	(0.091)	(0.063)	(0.049)
ProdHHI	0.638***	0.649**	0.062***	0.792	0.477	0.060
	(0.177)	(0.280)	(0.015)	(0.890)	(0.401)	(0.135)
GeoHHI	-0.254	-0.922**	-0.036	-0.634	-0.753**	0.179
	(0.268)	(0.357)	(0.079)	(0.396)	(0.318)	(0.135)
Longtail	0.077	0.101	0.070	0.413	0.197	-0.076
	(0.220)	(0.242)	(0.067)	(0.612)	(0.345)	(0.115)
Firm Age	1.187**	0.218	0.297	1.848**	1.563**	-0.324
	(0.487)	(0.793)	(0.356)	(0.720)	(0.794)	(0.343)
RET	0.009	0.020	0.073	0.049	0.116	0.056
	(0.088)	(0.159)	(0.093)	(0.074)	(0.137)	(0.091)
ROA	-0.629	-0.358	-1.266*	-0.249	-0.093	-0.712
	(0.887)	(1.535)	(0.700)	(0.810)	(1.390)	(0.925)
Book-to-Market	-0.011	-0.014	-0.002	-0.015	-0.007	-0.008
	(0.013)	(0.012)	(0.013)	(0.013)	(0.020)	(0.013)
Leverage	0.331	0.655	0.167	1.829**	0.653	0.220
	(0.542)	(0.737)	(0.612)	(0.759)	(0.844)	(0.592)
Observations	239	239	239	239	239	239
Adjusted R^2	0.359	0.363	0.258	0.548	0.497	0.212

The table reports the results of two-way fixed effects regressions. Standard errors that adjust for heteroskedasticity and within-panel serial correlation are reported in parentheses. ***, ** and * represent statistical significance at 0.01, 0.05, and 0.10 level, respectively

Table 10.1. Effect of the Financial Crisis on Derivatives Use and Insurer's Risk (Extent of Derivative Transaction)

	Total Risk	Underwriting Risk	Investment Risk	Leverage Risk	Systematic Risk	Unsystematic Risk
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	-0.584***	-1.584***	0.301**	1.039***	-1.573***	-0.734**
	(0.093)	(0.480)	(0.134)	(0.246)	(0.544)	(0.346)
Volume	-0.817*	-0.576**	-0.898***	-0.929***	-0.576	-0.384
	(0.422)	(0.285)	(0.277)	(0.201)	(0.403)	(0.442)
Crisis	0.002	0.010	0.005	0.005	0.578*	0.152***
	(0.007)	(0.033)	(0.008)	(0.007)	(0.319)	(0.019)
Volume × Crisis	**0.863***	**0.949*****	**0.990****	0.492	0.408	**0.749*****
	(0.508)	**(0.314)**	**(0.391)**	(0.389)	(0.907)	**(0.256)**
Size	-0.022***	-0.059**	-0.011**	-0.005	-0.110	-0.014
	(0.003)	(0.025)	(0.005)	(0.010)	(0.102)	(0.011)
ProdHHI	-0.016	-0.354***	-0.039	-0.206**	-1.327	-0.067
	(0.036)	(0.120)	(0.038)	(0.098)	(0.947)	(0.065)
GeoHHI	-0.064**	-0.120**	-0.025**	-0.216***	-0.177	-0.036
	(0.027)	(0.051)	(0.011)	(0.039)	(0.143)	(0.053)
Longtail	0.101***	0.144**	0.016	0.031	0.755	0.071
	(0.035)	(0.058)	(0.023)	(0.067)	(0.595)	(0.074)
Reinsurance	-0.006	-0.171***	-0.005**	-0.011	-0.090	-0.015
	(0.005)	(0.052)	(0.002)	(0.012)	(0.072)	(0.013)
Firm Age	0.010	0.399***	0.031	0.175**	2.347***	0.163**
	(0.038)	(0.117)	(0.025)	(0.074)	(0.722)	(0.075)
RET	0.006	0.004	0.004	0.005	0.175	0.001
	(0.013)	(0.013)	(0.005)	(0.008)	(0.113)	(0.007)
ROA	-0.070	-1.494***	-0.100	-0.145	-0.966	-0.159
	(0.102)	(0.441)	(0.079)	(0.150)	(0.709)	(0.092)
Book-to-Market	0.002	0.002	0.004**	0.001	0.025	0.004**
	(0.005)	(0.003)	(0.002)	(0.002)	(0.021)	(0.002)
Observations	239	239	239	239	239	239
Adjusted R^2	0.366	0.590	0.358	0.406	0.574	0.509

The table reports the results of two-way fixed effects regressions. Standard errors that adjust for heteroskedasticity and within-panel serial correlation are reported in parentheses. ***, ** and * represent statistical significance at 0.01, 0.05, and 0.10 level, respectively.

Table 10.2. Effect of the Financial Crisis on the Relation between Derivatives Use and Insurer's Risk (Participation Decision)

	Total Risk	Underwriting Risk	Investment Risk	Leverage Risk	Systematic Risk	Unsystematic Risk
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	0.231**	1.728***	0.487***	1.020***	-1.225***	-0.706***
	(0.112)	(0.463)	(0.135)	(0.247)	(0.409)	(0.205)
Participation	-0.083**	-0.101**	-0.016**	-0.036*	-0.545***	-0.049**
	(0.040)	(0.046)	(0.007)	(0.021)	(0.104)	(0.020)
Crisis	0.043**	0.034	0.012	0.138***	0.918	0.240***
	(0.021)	(0.083)	(0.016)	(0.046)	(0.655)	(0.064)
Participation × Crisis	**0.834***	**0.355***	**0.124***	0.042	**0.549***	**0.133***
	(0.157)	**(0.197)**	**(0.032)**	(0.085)	**(0.313)**	**(0.040)**
Size	-0.017***	-0.072***	-0.021	-0.005	-0.232***	-0.014*
	(0.004)	(0.017)	(0.035)	(0.010)	(0.069)	(0.008)
ProdHHI	-0.038	-0.129	-0.071	-0.145	-1.861***	-0.077
	(0.026)	(0.174)	(0.049)	(0.097)	(0.487)	(0.079)
GeoHHI	-0.003	-0.041	-0.025	-0.206***	-0.218	-0.021
	(0.017)	(0.077)	(0.022)	(0.039)	(0.328)	(0.047)
Longtail	0.062***	0.202*	0.078**	0.015	1.215***	0.050
	(0.021)	(0.118)	(0.033)	(0.067)	(0.308)	(0.048)
Reinsurance	-0.011**	-0.206***	-0.008	-0.010	-0.263*	-0.009
	(0.005)	(0.021)	(0.006)	(0.012)	(0.152)	(0.015)
Firm Age	0.060*	0.037	0.094**	0.272***	1.730**	0.175***
	(0.035)	(0.140)	(0.039)	(0.074)	(0.677)	(0.059)
RET	0.001	0.001	0.006	0.002	0.070	0.002
	(0.004)	(0.014)	(0.005)	(0.008)	(0.125)	(0.006)
ROA	-0.025	-0.956***	-0.126***	-0.137	-0.920	-0.069
	(0.039)	(0.158)	(0.044)	(0.088)	(1.196)	(0.073)
Book-to-Market	0.001	0.001	0.001	0.004	0.022	0.004**
	(0.006)	(0.003)	(0.005)	(0.005)	(0.019)	(0.002)
Observations	239	239	239	239	239	239
Adjusted R^2	0.421	0.657	0.453	0.389	0.493	0.511

The table reports the results of two-way fixed effects regressions. Standard errors that adjust for heteroskedasticity and within-panel serial correlation are reported in parentheses. ***, ** and * represent statistical significance at 0.01, 0.05, and 0.10 level, respectively.

Table 11.1. Effect of Financial Crisis on the Relation between Derivatives Use and CEO Compensation (Extent of Derivative Transaction)

	Log Total Comp	Log Cash Comp	Log Equity Comp	Equity Mix
	(1)	(2)	(3)	(4)
Intercept	1.759	0.531***	0.675***	0.554
	(2.112)	(0.176)	(0.089)	(0.431)
Volume	-0.846***	-0.798**	-0.918*	-0.759**
	(0.184)	(0.314)	(0.486)	(0.357)
Crisis	-0.156	-0.153***	-0.137**	-0.005
	(0.145)	(0.047)	(0.064)	(0.012)
Volume × Crisis	**0.788****	0.309	**0.892*****	0.157
	(0.304)	(0.513)	**(0.137)**	(0.294)
Size	0.063	0.022	-0.010	-0.004
	(0.105)	(0.016)	(0.032)	(0.018)
ProdHHI	-0.244	-0.247	-0.088	-0.139
	(0.270)	(0.278)	(0.354)	(0.146)
GeoHHI	-0.165	-0.412***	-1.918***	-0.150
	(0.171)	(0.127)	(0.315)	(0.099)
Longtail	0.280	0.181	0.038	0.053
	(0.297)	(0.114)	(0.140)	(0.062)
Reinsurance	0.013	0.070	0.120***	0.018
	(0.049)	(0.121)	(0.039)	(0.043)
Firm Age	0.333	0.267**	0.621***	0.055
	(0.281)	(0.132)	(0.181)	(0.113)
RET	0.024	0.014	0.068	0.004
	(0.051)	(0.023)	(0.051)	(0.010)
ROA	0.127	0.247	0.142	0.030
	(0.517)	(0.233)	(0.367)	(0.241)
Book-to-Market	-0.001	-0.002	-0.019	-0.006***
	(0.011)	(0.004)	(0.048)	(0.002)
Leverage	0.079	0.210	0.641	0.123
	(0.384)	(0.281)	(0.542)	(0.166)
Observations	239	239	239	239
Adjusted R^2	0.253	0.578	0.413	0.488

The table reports the results of two-way fixed effects regressions. Standard errors that adjust for heteroskedasticity and within-panel serial correlation are reported in parentheses. ***, ** and * represent statistical significance at 0.01, 0.05, and 0.10 level, respectively.

Table 11.2. Effect of Financial Crisis on the Relation between Derivatives Use and CEO Compensation (Participation Decision)

	Log Total Comp	Log Cash Comp	Log Equity Comp	Equity Mix
	(1)	(2)	(3)	(4)
Intercept	1.794	1.051***	1.247***	2.478***
	(1.558)	(0.134)	(0.041)	(0.525)
Participation	-0.295**	-0.074	-0.165**	-0.180
	(0.132)	(0.087)	(0.080)	(0.239)
Crisis	-0.181*	-0.207**	-0.650*	-0.153*
	(0.106)	(0.081)	(0.364)	(0.090)
Participation × *Crisis*	**0.579****	0.053	**0.299****	0.271
	(0.258)	(0.042)	**(0.146)**	(0.403)
Size	0.122***	0.030	-0.028	-0.022
	(0.039)	(0.029)	(0.045)	(0.018)
ProdHHI	-0.073	-0.276	-0.467	-0.195***
	(0.274)	(0.309)	(0.406)	(0.046)
GeoHHI	-0.191	-0.463***	-0.842***	-0.386***
	(0.150)	(0.144)	(0.289)	(0.088)
Longtail	0.161	0.142	0.179	0.012
	(0.160)	(0.129)	(0.154)	(0.144)
Reinsurance	0.015	0.021	0.129***	0.011
	(0.080)	(0.019)	(0.033)	(0.025)
Firm Age	0.076	0.446	1.096**	0.739***
	(0.196)	(0.337)	(0.521)	(0.148)
RET	0.018	0.007	0.126	0.005
	(0.046)	(0.028)	(0.092)	(0.018)
ROA	0.022	0.283	0.209	0.205
	(0.642)	(0.246)	(0.175)	(0.296)
Book-to-Market	-0.023**	-0.046	-0.022	-0.005
	(0.009)	(0.039)	(0.016)	(0.004)
Leverage	0.005	0.211	0.828	0.016
	(0.012)	(0.282)	(0.543)	(0.181)
Observations	239	239	239	239
Adjusted R^2	0.386	0.560	0.319	0.551

The table reports the results of two-way fixed effects regressions. Standard errors that adjust for heteroskedasticity and within-panel serial correlation are reported in parentheses. ***, ** and * represent statistical significance at 0.01, 0.05, and 0.10 level, respectively.

Table 12. Derivatives Use and Equity Portfolio Incentives in Financial Crisis

	Extent of Derivative Transaction			Participation Decision		
	Delta	Vega	Vega-to-Delta	Delta	Vega	Vega-to-Delta
	(1)	(2)	(3)	(1)	(2)	(3)
Intercept	1.162***	1.329***	1.868	1.255**	1.989	0.589
	(0.385)	(0.507)	(1.243)	(0.622)	(2.378)	(0.598)
Derivative Use	-0.529*	-0.391*	-0.709**	-0.329*	-0.061	-0.576**
	(0.289)	(0.223)	(0.335)	(0.186)	(0.089)	(0.258)
Crisis	-0.514	-0.549**	0.589***	-0.351	-0.602**	0.670***
	(0.415)	(0.250)	(0.213)	(0.546)	(0.280)	(0.182)
Derivative Use × Crisis	**0.489****	0.383	**0.737****	0.076	**0.506****	**0.575****
	(0.196)	(0.276)	**(0.328)**	(0.568)	**(0.238)**	**(0.279)**
Size	0.081	0.090	0.031	0.110	0.075	0.014
	(0.025)	(0.077)	(0.047)	(0.114)	(0.137)	(0.043)
ProdHHI	0.765	0.597	0.033	0.563	0.737	0.047
	(0.587)	(0.658)	(0.075)	(1.139)	(1.532)	(0.080)
GeoHHI	-0.777	-0.732*	0.067	-0.852**	-0.847	0.034
	(0.652)	(0.416)	(0.046)	(0.396)	(0.595)	(0.079)
Longtail	0.074	0.479	0.189	0.891	1.808**	0.158
	(0.102)	(0.341)	(0.324)	(0.774)	(0.435)	(0.360)
Reinsurance	-0.051	-0.046	-0.020	-0.099	-0.011	-0.061
	(0.175)	(0.037)	(0.064)	(0.135)	(0.043)	(0.068)
Firm Age	0.943***	1.351**	0.410	1.339	0.826	0.277**
	(0.199)	(0.671)	(0.394)	(0.902)	(0.992)	(0.118)
RET	0.149	-0.050	0.068	0.113	-0.149	0.014
	(0.125)	(0.140)	(0.113)	(0.096)	(0.103)	(0.138)
ROA	-0.833	-0.038	-1.713*	-1.003	-0.754	-0.788
	(0.935)	(1.376)	(1.022)	(1.033)	(0.903)	(0.965)
Book-to-Market	-0.002	-0.002	-0.002	-0.014	-0.003	-0.006
	(0.021)	(0.019)	(0.016)	(0.017)	(0.010)	(0.013)
Leverage	0.597***	0.561	0.151	0.504	0.852	0.446
	(0.124)	(0.830)	(0.608)	(0.869)	(0.613)	(0.500)
Observations	239	239	239	239	239	239
Adjusted R^2	0.481	0.516	0.263	0.433	0.475	0.157

The table reports the results of two-way fixed effects regressions. Standard errors that adjust for heteroskedasticity and within-panel serial correlation are reported in parentheses. ***, ** and * represent statistical significance at 0.01, 0.05, and 0.10 level, respectively.