

# Systemic Importance of Insurance Companies—An Empirical Analysis

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## Abstract

Insurance companies are increasingly being regulated under the assumption that, like banks, they pose systemic risk to the overall economy and especially the financial system. This analysis investigates this premise by comparing the systemic importance of insurance companies and the insurance industry with that of banks, brokers, real estate firms, and their respective industries. Empirical results suggest that intra-industry linkages exist among insurance firms, although they are comparatively weaker than those in banking and real estate. Moreover, systemic risks arising from the effects of distress in other economic sectors are lower for insurance companies—although not negligible. Given its size, systemic problems arising over time from the insurance industry would have a very disruptive macroeconomic impact.

**Keywords:** Insurance companies, Systemic risk, Banks

## 1. Introduction

*“The risk that the inability of one institution to meet its obligations when due will cause other institutions to be unable to meet their obligations when due. Such a failure may cause significant liquidity or credit problems and, as a result, could threaten the stability of or confidence in markets.” (European Central Bank 2004)*

The financial crisis of 2007-2009 has brought the insurance industry under the radar of regulatory authorities. Many consider insurance companies as a source of systemic risk (in the conventional banking sense) and believe they should fall under the same regulatory umbrella as banking and other systemically important institutions.

The 2010 Dodd-Frank Wall Street Reform and Consumer Protection Act, a U.S. federal statute, aims to make financial institutions more accountable by imposing stringent regulatory requirements on “systemically important institutions.” And according to Dodd-Frank, this includes insurance companies.

This analysis investigates whether U.S. insurance companies pose systemic risk to other sectors in the financial economy at the timescales and magnitude of risks posed by the banking industry. The systemic risks of banks, brokers, insurance companies, and real estate companies in the U.S. financial sector are compared using  $\Delta CoVaR$  (conditional value at risk) methodology by Adrian & Brunnermeier (2010).

$CoVaR$  is defined as the  $Var$ (value at risk) (Note 1) of one institution  $i$  conditional on the other institution  $j$  being in distress.  $\Delta CoVaR$  then captures the difference between the  $CoVaR$  of institution  $i$  when  $j$  is in distress and the  $CoVaR$  of institution  $i$  when  $j$  is operating at its median state. The logic behind this measure is that, rather than treating risk in isolation, it is important to capture interdependencies as well as direction of risk.

The analysis categorizes the top U.S. financial firms from October 2002 to April 2011 into four broad sectors: banking, brokerage, insurance, and real estate. These four sectors are defined as the financial system. The analysis calculates the systemic risk of 1) individual companies on their respective industry, and 2) one industry on the others (industry interlinkages). It then measures size effects by dividing the sample into small, medium, and large companies by market capitalization, and capturing the systemic risk of individual companies on their respective industry by size.

While the study covers multiple aspects of systemic risk, its use of traditional analytical techniques has a few shortcomings. It fails to consider the wide range of scenarios that could impact the insurance industry over a longer term. Moreover, it looks at insurance companies as a whole but not at specific business activities. Still, in applying conventional methodology on systemic risk to the insurance industry, there are benefits in being able to directly compare its impact with that of banking and other sectors.

The results show that:

- **Systemic risk contribution.** If an insurance firm were to collapse, its systemic risk contribution in the worst-case scenario (1 percentile) to the insurance sector would be 6.2%,

compared with risk contributions of 9.1% from banks and 22.1% from real estate companies to their respective sectors. Thus, while intra-industry interlinkages are weaker in the insurance sector compared with banks and real estate, the risks are not negligible in absolute terms.

- **Size effect.** Systemic risk contribution averages 0.85% for large banks versus 0.69% for small banks, and 0.63% for large insurers versus 0.46% for small insurers. This indicates a positive correlation of firm size to systemic risk.
- **Inter-industry interlinkages.** If a banking, brokerage, or real estate firm were to undergo distress or crisis, the impact on the insurance industry would be weaker compared with the impact on the other sectors. Nonetheless, in absolute terms, the numbers are not marginal. The findings suggest that, given the existing regulatory framework and current core insurance activities and liability characteristics, the insurance sector is relatively insulated. But we cannot ignore the interdependencies posed by increased financial intermediation and the blurring distinction between insurers and other players in the financial economy.
- **Impact on other sectors.** If the insurance industry were to undergo similar levels of duress, the impact on other sectors, including banking, would be significant. This could arise longer term through liability changes, such as increased longevity or declining interest rates. It could also happen in the shorter term through a series of catastrophic climate or other claims, such as terrorism and cyber-attack.

The insurance sector faces significant risks in areas such as health, technology, terrorism, and climate change (Faure & Hartlief, 2003). Moreover, sources of vulnerability are generally exogenous, residing in the macroeconomic environment or arising from non-core insurance activities. These risks differ intrinsically from those faced by banking, and while there is little debate about whether insurance should be properly regulated, its liability profile suggests that regulation intended for banking could have unintended consequences and might be unable to handle a true systemic crisis in insurance.

In the remainder of the paper, Section 2 discusses the literature around calculating systemic risk, and Section 3 looks at the data and methodology. Section 4 provides an empirical analysis, and Section 5 presents the results. Section 6 highlights the nature of insurance-sector risks and how they differ from banking risks, and Section 7 provides the conclusion.

## 2. Measuring Systemic Risk

The literature shows different ways of capturing the systemic risk of financial institutions, ranging from Granger-causality tests and marginal expected shortfall, to  $\Delta CoVaR$  and state-dependent sensitivity VaR (SDSVaR) models. These analyses use share returns and asset correlations to capture interlinkages and forecast risks, and employ stress tests to model volatility and correlations.

Acharya et al. (2010) aim to capture each banking institution's contribution to systemic risk by calculating systemic expected shortfall (SES). They try to "bridge the gap between

structural and reduced form approaches” and build a model that helps derive an “optimal policy for managing systemic risk.” In an empirical study of the 2007-2009 financial crisis, they forecast risks using stress tests, equity returns, and credit default swap spreads employing high-frequency marginal expected shortfall (MES) measures.

Following Acharya et al. (2010), Brownlees & Engle (2011) propose a measure of systemic risk that “captures the expected capital shortage of a firm given its degree of leverage and MES.” Using threshold autoregressive conditional heteroskedasticity (TARCH) and dynamic conditional correlation (DCC) to model volatility and correlations, they rank U.S. financial firms on systemic risk at different stages of the financial crisis.

Billio et al. (2010) propose several econometric measures to capture interlinkages among different financial institutions using principal components analysis and Granger-causality tests. They use equity share returns to examine interdependencies among four sectors: hedge funds, brokers, banks, and insurance companies. They find that, over time, while these sectors have become more interrelated, the impact of one sector on another varies, with the banking and insurance sector affecting brokers and hedge funds more than the other way round.

In another measure of systemic risk, Huang, Zhou, & Zhu (2009) capture the “price of insurance against financial distress” with the aim of examining the relationships among the financial sector, the real economy, and government policy. Their analysis measures systemic risk in the banking sector by calculating the “probability of default and asset correlations from CDS spreads and co-movements of equity returns” and then stress-testing using an integrated micro-macro model.

A few analyses have used the  $\Delta CoVaR$  methodology of Adrian & Brunnermeier (2010). Fong et al. (2009) capture systemic interlinkages among local, international, and mainland China banks in Hong Kong using quantile regressions to calculate  $CoVaR$ . Adams, Fuss, & Gropp (2011) extend the  $CoVaR$  methodology to include risk spillovers among financial institutions. They calculate the  $SDSVaR$ , measuring “size and duration of spillovers” for different market conditions: calm, normal, or volatile. To assess which bank activities contribute to systemic risk, Brunnermeier, Dong, & Palia (2012) first measure systemic risk using the  $CoVaR$  measure of Adrian & Brunnermeier (2010) and the SES measure of Acharya et al. (2010). They then discover that banks with higher ratios of non-interest income to interest income are larger contributors of systemic risk.

Having given an overview of academic literature on measures of calculating systemic risk, we now look at our own empirical analysis.

### **3. Data and Methodology**

The sample includes the top U.S. financial firms (top 75% by market capitalization as of December 31, 2007) classified under Standard Industrial Classification (SIC) codes 60-67. It covers depository institutions, non-depository institutions, security and commodity brokers, insurance agents and carriers, and real estate and real estate holding/other investment offices. These are classified under four broad industries: banking, brokerage, insurance, and real

estate. (Note 2) The analysis period spans October 1, 2002 to April 30, 2011, which gives a balanced panel of 252 firms. For these firms, daily share price data (calendar days) is taken from Bloomberg, and weekly share returns are calculated using log returns. Similarly, weekly S&P 500 returns are calculated using the S&P 500 total returns index from Bloomberg for the same time period. The control variables in the sample are:

- One-month and three-month daily Treasury rates, U.S. Federal Reserve database
- One-month and three-month repo rates, Bloomberg
- Daily volatility index, U.S. VIX index from Chicago Board Options Exchange website
- 10-year Treasury bond rates and 10-year BAA corporate bonds, Bloomberg

### 3.1 Data Cleaning and Organization

- Daily share price data are converted into weekly return data using log returns. This is done for all firms in the sample as well as for S&P 500 share price data.

$$R_{it} = \log \left( \frac{price_t}{price_{t-5}} \right)$$

- Based on SIC classifications, the firms are classified into four sectors using the following mapping:(Note 3)
  - Banks: SIC 60 and SIC 61
  - Brokers: SIC 62, SIC 6719, SIC 6722, SIC 6794, and SIC 6799
  - Insurance: SIC 63 and SIC 64
  - Real estate: SIC 65 and SIC 6798

After data cleaning and accounting for missing values, the sample comprises 84 banks, 28 brokers, 66 insurance companies, and 74 real estate companies.

- Financial system returns (returns of all firms in our sample) and industry returns are calculated using the following:

$$R_t^{System} = \frac{\sum_{i=1}^N ((Mkt\ Cap_{i,t-1} * R_{it}))}{\sum_{i=1}^N Mkt\ Cap_{i,t-1}}$$

$$R_t^{Ind} = \frac{\sum_{i=1,ind}^N ((Mkt\ Cap_{i,t-1} * R_{it}))}{\sum_{i=1,ind}^N Mkt\ Cap_{i,t-1}}$$

Where,  $R_t^{System}$  and  $R_t^{Ind}$  are the weekly returns of the financial system and each industry, respectively.  $Mkt\ Cap_{i,t-1}$  is the one-week lag current market capitalization of each firm ( $i = 1, 2 \dots N$ ), within the financial system or within a particular sector.

- In order to capture time-varying  $VaR$  and  $CoVaR$ , the following quantile regression equations include one-week lagged control (state) variables. Following Brunnermeier, Dong, & Palia (2012), the control variables are liquidity risk, interest rate risk, term structure, and default risk.
  - Liquidity risk is measured as the spread between the three-month Treasury rate and three-month repo rate.
  - Volatility is captured through the VIX close price.
  - Interest rate risk is measured as the difference between the three-month Treasury rate and its lag value.
  - Term structure is the “yield spread between the 10-year Treasury bond rate and three-month Treasury bill rate.” Brunnermeier, Dong, & Palia (2012).
  - Default risk is defined as the “credit spread between the 10-year BAA corporate bond rate and the 10-year Treasury bond rate.” Brunnermeier, Dong, & Palia (2012).

### 3.2 Systemic Risk Using Delta CoVaR

Systemic risk is calculated using the  $\Delta CoVaR$  measure proposed by Adrian & Brunnermeier (2010). The measure builds on the traditional  $VaR$  measure of the risk imposed by a particular firm in distress on other firms, thus capturing the interdependencies and risk spillovers.

#### 3.2.1 Definitions

A.  $VaR_i^q$  is the worst expected loss incurred by firm  $i$  over a specific time period with a  $q\%$  confidence level. We use quantile regressions to calculate  $VaR_i^q$ —defined as the potential asset return/loss ( $R_i$ ) of firm  $i$  over a specific period of time at a given quantile level. We consider one five-day calendar week at a 1% confidence level.

$$Probability(R_i \leq VaR_i^q) = q$$

B.  $CoVaR_{ij}^q$  is the VaR of firm  $i$  given firm  $j$  is in distress at confidence level  $q$ . According to Brunnermeier, Dong, & Palia (2012), firm  $j$  being in distress means that its loss is at its  $VaR_j^q$  level. We first calculate  $CoVaR_{ij}^q$  at  $q = 1\%$  and then calculate  $CoVaR_{ij}^q$  at  $q = 50\%$ ; i.e., when firm  $j$  is operating at its median (normal) state. Firm  $j$ 's contribution to systemic risk is defined as the difference between the  $VaR$  of firm  $i$  when firm  $j$  is operating at its  $VaR$  loss levels and the  $VaR$  of firm  $i$  when firm  $j$  is operating at its median state.

$$\text{Systemic risk} = \Delta \text{CoVaR}_j^q = \text{CoVaR}_{i|j}^{q=1\%} - \text{CoVaR}_{i|j}^{q=\text{median}=50\%}$$

In order to reach this measure—the contribution of systemic risk of firm  $j$  to firm  $i$  – the following analysis is done:

- **Calculation of VaR.** Perform quantile regression of the weekly return variable of firm  $j$  on control variables at 1% quantile and at 50% quantile. Use the fitted values from these regressions to obtain VaR at 1% and at 50%.

$$R_{j,t}^q = \alpha_j^q + \beta_j^q C_{t-1} + \varepsilon_j^q \text{ – where } q = 1\% \text{ and } 50\%$$

Where  $R_{j,t}^q$  is the weekly return of firm  $j$  at time  $t$  at  $q\%$  quantile; and  $C_{t-1}$  is the vector of control variables, taken at a lag of one week.

Taking the fitted values from the above regression, VaR is estimated through:

$$\text{VaR}_{j,t}^q = \hat{\alpha}_j^q + \hat{\beta}_j^q C_{t-1} \text{ – where } q=1\% \text{ and } 50\%$$

- **Calculation of CoVaR.** Run 1% quantile regression of weekly return of firm  $i$  on lagged values of control variables and lag of weekly returns of firm  $j$ :

$$R_{i,t}^q = \alpha_{i|j,t}^q + \beta_{i|j}^q C_{t-1} + \delta_{i|j}^q R_{j,t-1} + \varepsilon_{i|j}^q \text{ – where } q = 1\%$$

Then plug the fitted values from this regression into the following regression to obtain the conditional VaR for both  $q=1\%$  and  $q=50\%$ :

$$\text{CoVaR}_{i|j,t}^q = \hat{\alpha}_{i|j}^q + \hat{\beta}_{i|j}^q C_{t-1} + \hat{\delta}_{i|j}^q \text{VaR}_{j,t}^q + \varepsilon_{i|j}^q \text{ – where } q = 1\% \text{ and } 50\%$$

- **Calculation of systemic risk.** Contribution of systemic risk of firm  $j$  to firm  $i$  is then calculated using:

$$\text{Systemic risk} = \Delta \text{CoVaR}_{j,t}^q = \text{CoVaR}_{i|j,t}^{q=1\%} - \text{CoVaR}_{i|j,t}^{q=\text{median}=50\%}$$

- **Size effects.** Divide the sample into three quantiles—small, medium, and large—by market capitalization as of December 2007 for all companies in the sample and companies within each sector. Then measure the contribution of systemic risk from individual firms to their respective industries, filtered by size.

#### 4. Empirical Analysis

The above methodology is used to calculate the contribution of systemic risk for the following:

- *Intra-industry interlinkages*—Individual companies on their respective industries, such as a bank’s imposition of systemic risk on the banking industry
- *Size effects*—Contribution of systemic risk of individual firms to their respective industries, filtered by size
- *Inter-industry interlinkages*—Contribution of risk from one industry to another industry, such as the banking industry’s contribution of systemic risk to the insurance industry

## 5. Results

### 5.1 Understanding the Sample

The sample consists of 252 firms in the financial sector: 84 banks, 66 insurance companies, 28 brokers, and 74 real estate firms. Among these firms, average (median) weekly returns for the analysis period (October 1, 2002 to April 30, 2011) were 0.19% for insurance and 0.12% for banks, falling to -0.17% and -0.48% during the crisis period. The Herfindahl index shows that this is a well-diversified sample, with brokers being the most concentrated at 10.4%, followed by insurance companies at 8.2%, banks at 6.3%, and real estate firms at 2.6%, indicating no disproportionate market power or an industry run by only a few.

Table 1. Firm-wise weekly share returns (%)

Firm-wise weekly share returns (%)	Time period	1 percentile	25 percentile	Median	75 percentile	99 percentile	Standard deviation
Banks	2002—2011	-19.73	-2.08	0.12	2.23	17.82	6.75
	2007—2009	-30.10	-4.66	-0.48	3.62	27.01	10.57
Insurance	2002—2011	-19.34	-1.84	0.19	2.17	16.18	6.26
	2007—2009	-33.07	-3.23	-0.17	2.85	27.30	9.71
Brokers	2002—2011	-18.56	-2.43	0.34	3.02	16.77	7.13
	2007—2009	-27.82	-4.39	-0.15	4.02	23.68	11.09
Real estate	2002—2011	-17.73	-1.93	0.38	2.46	15.35	5.90
	2007—2009	-29.62	-4.29	-0.20	3.79	26.02	9.51
All firms	2002—2011	-18.93	-2.01	0.23	2.36	16.61	6.43
	2007—2009	-30.39	-4.12	-0.27	3.49	26.34	10.11

Source: Author’s calculations using Bloomberg data.



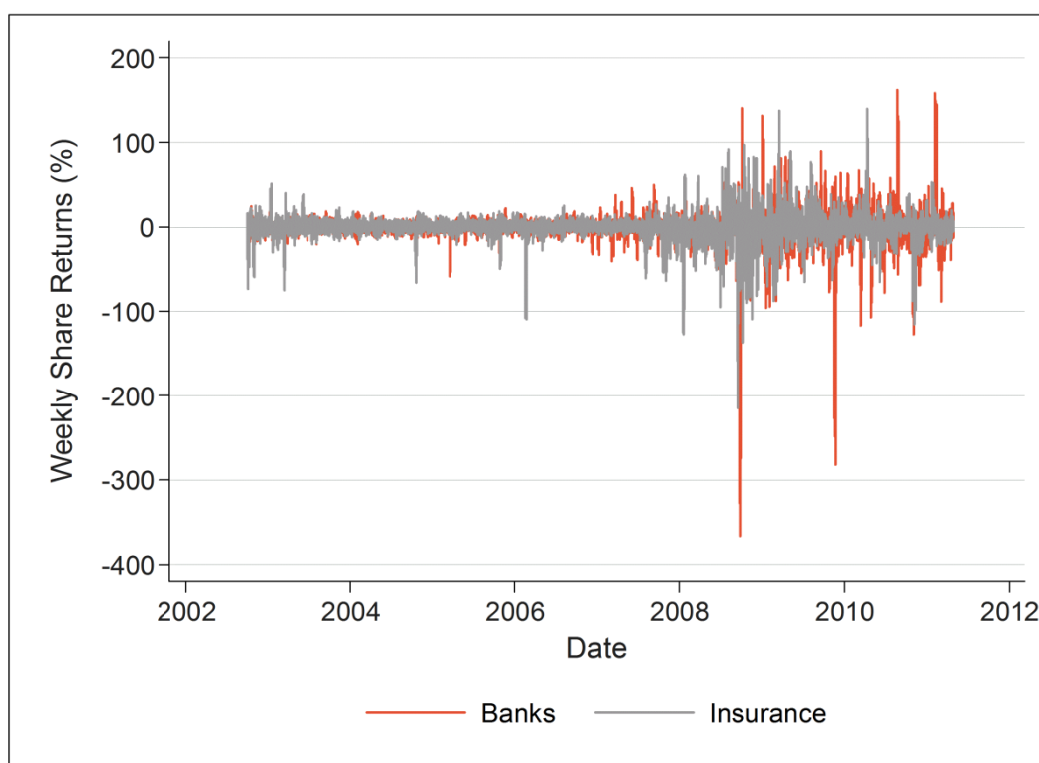


Figure 1. Firm-wise weekly share returns (%)

Source: Author’s calculations using Bloomberg data

Table 2. Firm-wise weekly value at risk (%)

Firm-wise weekly value at risk (%)	Time period	1 percentile	25 percentile	Median	75 percentile	99 percentile
Banks	2002–2011	-50.43	-16.71	-11.34	-7.95	-3.63
	2007–2009	-60.42	-27.70	-21.17	-16.63	-8.90
Insurance	2002–2011	-55.53	-17.47	-11.49	-8.11	-3.05
	2007–2009	-75.81	-31.00	-22.86	-16.25	-6.54
Brokers	2002–2011	-38.08	-14.47	-10.77	-7.54	-3.62
	2007–2009	-50.95	-22.52	-17.01	-13.01	-7.02
Real estate	2002–2011	-47.16	-14.84	-9.76	-6.86	-2.93
	2007–2009	-63.95	-22.69	-16.15	-11.15	-3.95
All firms	2002–2011	-49.35	-16.03	-10.83	-7.71	-3.56
	2007–2009	-64.68	-25.79	-19.36	-14.59	-6.24

Source: Author’s calculations using Bloomberg data

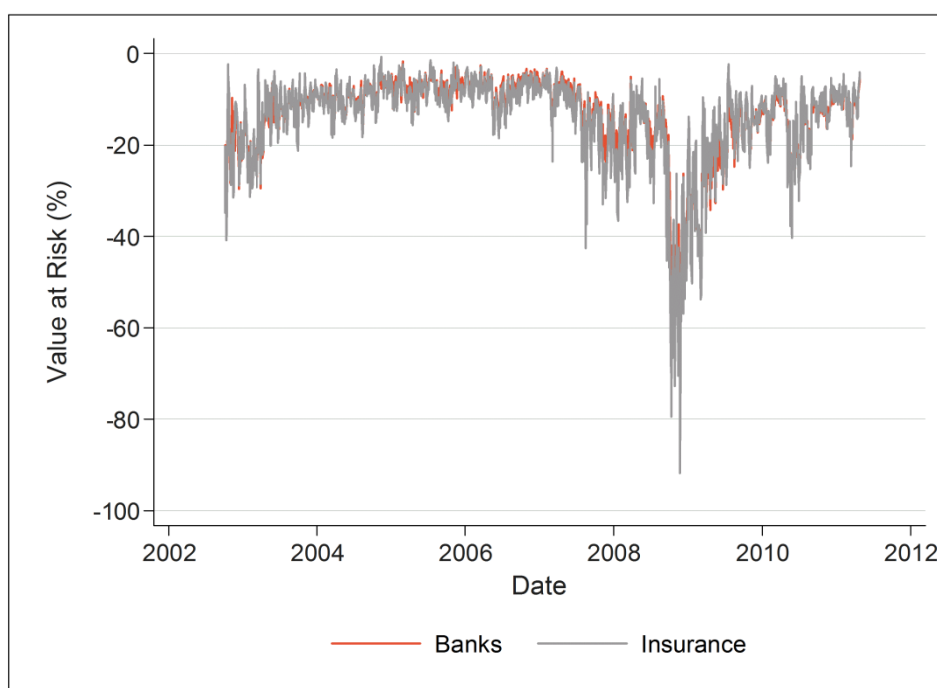


Figure 2. Firm-wise weekly value at risk (%)

Source: Author's calculations using Bloomberg data

Firm-wise weekly VaR results show that, on average (median levels), returns for banks and insurance firms would fall by around 11% in a week, and up to roughly 22% during the crisis period with a confidence level of 99%. As mentioned earlier, VaR measures probable loss levels and does not reflect interlinkages or major correlations, so we consider these results as indicative and move to a more robust measurement of systemic risk through conditional VaR analysis in the next section.

Table 3. Sector-wise weekly share returns (%)

Sector-wise weekly share returns (%)	Time period	1 percentile	25 percentile	Median	75 percentile	99 percentile	Standard deviation
Banks	2002–2011	-32.98	-4.80	0.35	5.26	27.84	10.66
	2007–2009	-47.18	-11.49	-1.40	7.77	36.81	16.33
Insurance	2002–2011	-19.87	-2.90	0.48	3.71	13.70	6.77
	2007–2009	-29.30	-6.46	-0.66	4.75	19.70	10.14
Brokers	2002–2011	-13.79	-1.78	0.45	2.35	8.83	4.23
	2007–2009	-21.59	-4.43	-0.22	3.68	10.77	6.32
Real estate	2002–2011	-34.42	-4.02	0.98	5.60	23.30	10.86
	2007–2009	-48.53	-11.39	-1.26	8.38	33.12	16.18

Source: Author's calculations using Bloomberg data

Sector-wise weekly share returns for all sectors fell the furthest during the financial crisis (July 2007 to December 2009). Real estate and banking were the hardest hit, with returns falling as low as -91.8% and -96.5%, respectively, and 1 percentile returns for banking falling to 47.2%. Insurance returns also took a hit, albeit a less severe one, with the lowest being -73.8%, and 1 percentile returns falling to -29.3% during the financial crisis (Table 3).

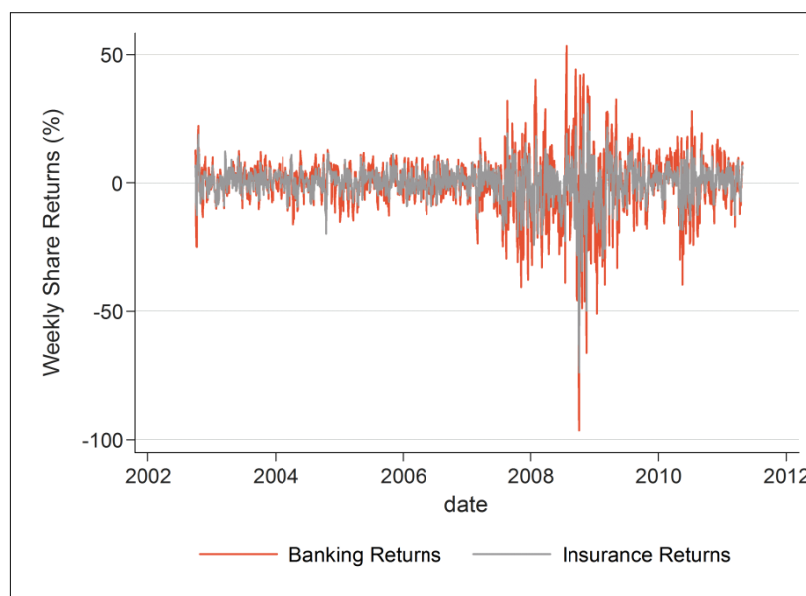


Figure 3. Sector-wise weekly share return (%)

Source: Author's calculations using Bloomberg data

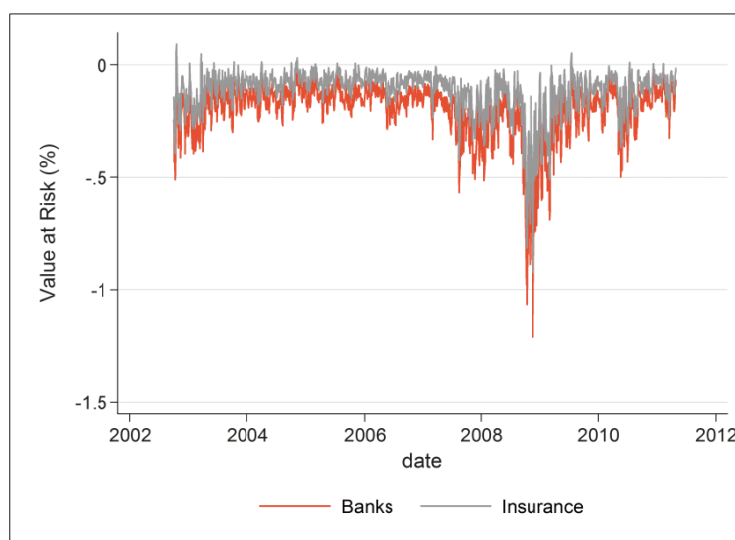


Figure 4. Sector-wise value at risk (%)

Source: Authors calculations using Bloomberg data

Looking at these results, one might conclude that the insurance industry was affected as severely as the banking industry during the recent financial crisis, which was triggered by the collapse of the real estate and banking sectors. However, most of the absolute returns were also affected by other macroeconomic risks, like liquidity risk, interest rate risk, term structure, and default risk. With most indicators going negative during the crisis, insurance industry returns were bound to take a hit. To assess the interlinkages between sectors and thus measure systemic risk contribution, we must isolate the impact of one on the other while controlling for other macroeconomic risks.

### 5.2 Systemic Risk from Individual Companies to Their Respective Industries

We now look at the systemic risk imposed by individual companies on their respective industries, which is the risk that a distressed or collapsing firm could harm its entire sector.

Table 4. Systemic risk from individual firm on own industry

Delta CoVaR, Individual firm on own industry	1 percentile	25 percentile	Median	75 percentile	99 percentile
Banks	-0.0914	-0.0331	-0.0225	-0.0160	-0.0090
Insurance	-0.0618	-0.0207	-0.0138	-0.0103	-0.0053
Brokers	-0.0149	-0.0063	-0.0049	-0.0042	-0.0032
Real estate	-0.2210	-0.0759	-0.0512	-0.0380	-0.0216

Source: Author’s calculations using Bloomberg data

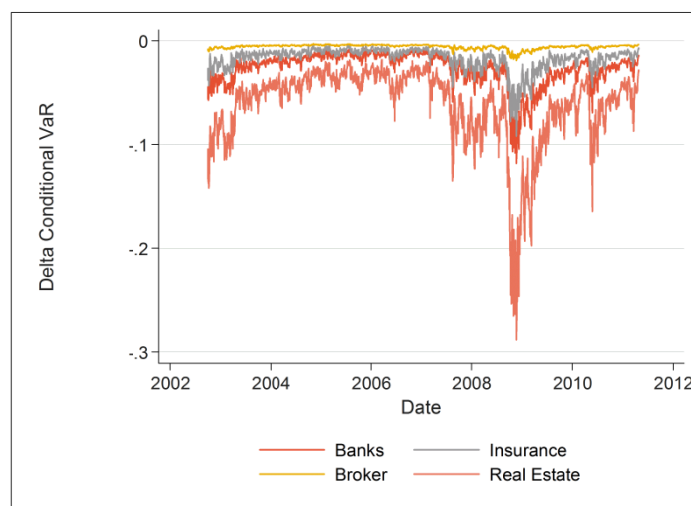


Figure 5. Systemic risk from individual firm on own industry

Source: Author’s calculations using Bloomberg data

As reflected in Table 4 and Figure 5, real estate companies are the most systemically risky. In a worst-case scenario, a collapsing real estate firm could impose as much as a -22.1% (1 percentile) loss. Banking firms, on the other hand, could impact the banking sector by up to

-9.1%, while insurance firms would impact the insurance sector by -6.2%. Brokerage firms would impact their sector by only -1.5%.

A collapsed insurance company would have less effect on its overall sector than would real estate and banking companies, but a greater effect than a collapsing brokerage firm, according to these results. Looking at absolute numbers, however, a -6.2% impact indicates turbulence, albeit at a lesser degree than in real estate or banking. This suggests that correlations and industry intralinkages within the insurance sector make it vulnerable to failure. The source of these vulnerabilities and their impact may be less pronounced than in real estate and banking, but they do exist.

### 5.2.1 Size Effect

This section aims to capture differences in systemic risk based on firm size. We divide the sample into three quantiles by market capitalization as of December 2007 for firms in each industry, and then measure the contribution of systemic risk from individual firms to their respective industries, filtered by size.

Table 5. Median market capitalization by size across industries

Median market cap. (USD bn)	Small	Medium	Large
Banks	1.22	2.69	22.10
Insurance	1.92	4.77	27.00
Brokers	2.09	6.54	29.70
Real estate	1.16	2.57	7.29
All firms	1.30	3.28	16.20

Source: Author's calculations using Bloomberg data

Table 6. Systemic risk on own industry by firm size

Median Delta CoVaR by size of firm (individual firm on own industry)	Small	Medium	Large	All
Banks	-0.0069	-0.0083	-0.0085	-0.0225
Insurance	-0.0046	-0.0061	-0.0063	-0.0138
Brokers	-0.0065	-0.0044	-0.0020	-0.0049
Real estate	-0.0159	-0.0182	-0.0171	-0.0512

Source: Author's calculations using Bloomberg data

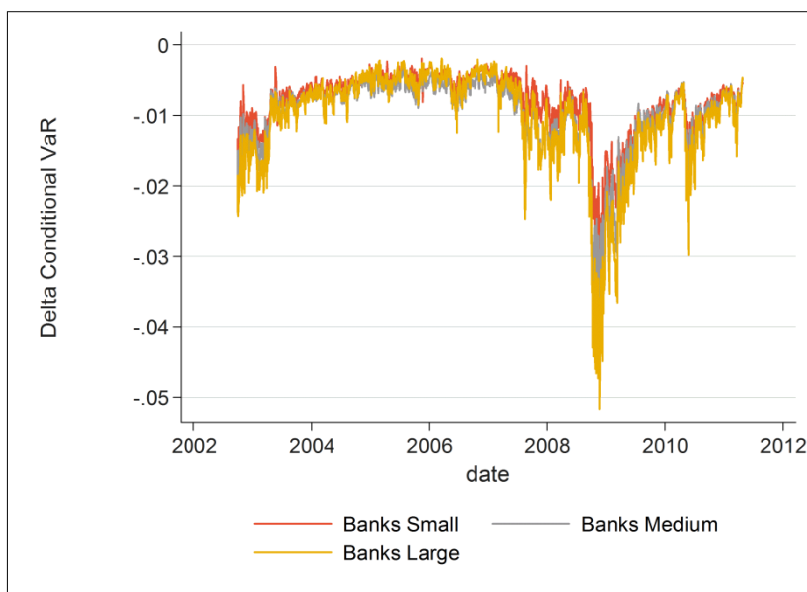


Figure 6. Systemic risk by firm size for banks

Source: Author's calculations using Bloomberg data

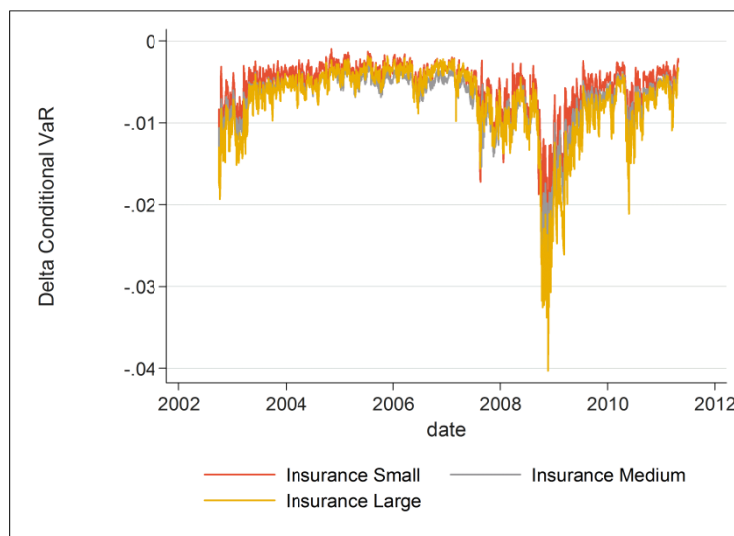


Figure 7. Systemic risk by firm size for insurance

Source: Author's calculations using Bloomberg data

As shown in Table 6, and Figures 6 and 7, systemic risk *increases by size* for both banks and insurance companies, implying that the larger a company's market capitalization, the higher the systemic risk to its own industry. The systemic risk contribution averages 0.85% for a large bank compared with 0.69% for a small bank, and 0.63% for a large insurance firm versus 0.46% for a small insurer. These results confirm the assumption that the larger the firm, the greater its risk contribution in the event of distress.

### 5.3 Systemic Risk-Industry Interlinkages

Having looked at the risk posed by individual firms on their respective sectors, we now look at how the collapse of an entire industry would impact other industries in the financial system.

#### 5.3.1 Banks as a Source of Distress

The recent crisis exposed the systemic importance of the banking sector. The interlinkages to the financial system were apparent, with the collapse of Lehman Brothers triggering the collapse of the banking industry, and the ramifications rippling through the U.S. economy and spiraling into a global crisis.

Our analysis shows that, if banking were to collapse, it would have the most severe impact on the banking sector, followed by real estate, insurance, and brokerage. On average (median), the banking sector's systemic risk contribution is -12.5% on banking, -9.8% on real estate, -2.4% on insurance, and -1.0% on the brokerage sector.

Of the four sectors in the sample, the insurance sector would suffer less than banking or real estate and only slightly more than brokerage, suggesting some degree of resiliency to a banking sector collapse. Nevertheless, -2.4% is not a marginal impact, suggesting interconnectedness between the banking and insurance industries, which could be due to the greater role played by insurance companies in global financial markets, as investors and through financial intermediation. Insurance companies are using capital markets to offload their own risks through financial instruments such as derivatives, credit default swaps, and other risky and complex financial innovations. To some extent, this has blurred the distinction between banks and insurance companies and increased interdependencies (Krennand Oschischnig, 2003).

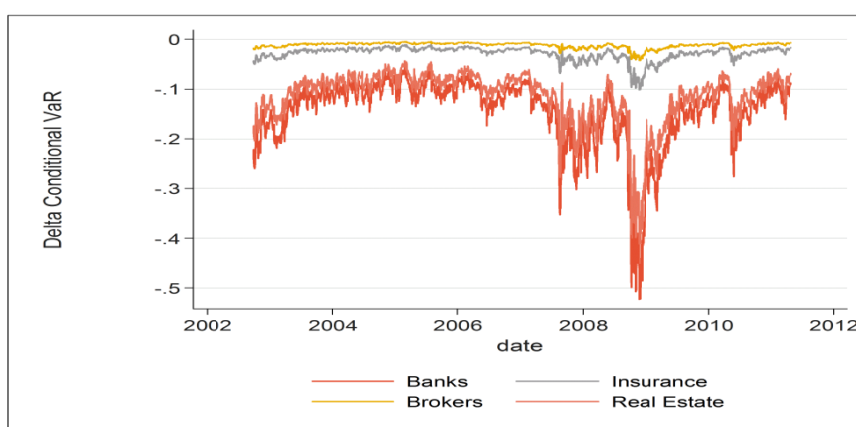


Figure 8. Systemic risk contribution from banking sector

Source: Author's calculations using Bloomberg data

### 5.3.2 Real Estate and Brokers as a Source of Distress

We next look at the systemic risk contribution of the real estate and brokerage sectors, and estimate the impact on all four sectors—banking, real estate, insurance, and brokerage—if the sector were in distress.

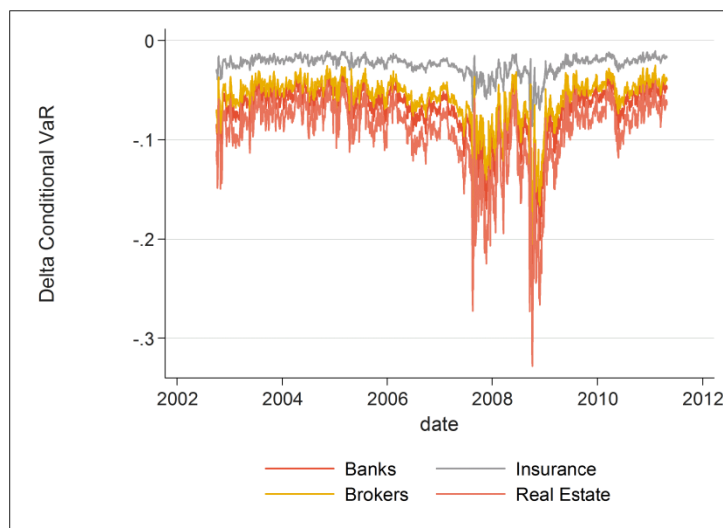


Figure 9. Systemic risk contribution from brokerage sector

Source: Author's calculations using Bloomberg data

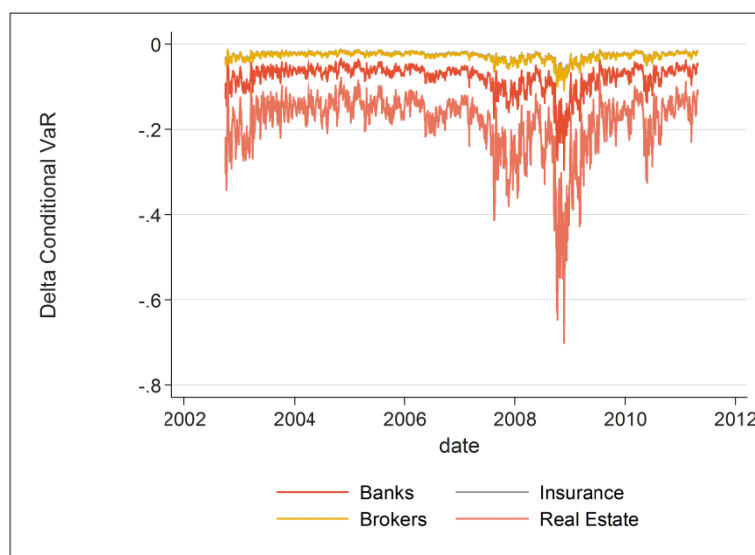


Figure 10. Systemic risk contribution from real estate sector

Source: Author's calculations using Bloomberg data

As shown in Figures 9 and 10, the insurance sector is the least affected by both the brokerage and real estate sectors, with the average systemic risk contributions being -2.2% and -2.3%, respectively. The real estate and banking sectors are again affected most strongly, with the systemic risk contribution from the brokerage sector averaging -8.3% for real estate and -6.3%



for banking. The systemic risk contribution from real estate averages -16.4% to real estate and -6.9% to banking.

Collapses of other sectors would have a smaller impact on the insurance sector than they would have on other industries. In terms of absolute numbers, however, this impact is not insignificant. On the one hand, this result highlights the relative robustness of the insurance regulatory environment, the nature of the insurance business and its risks, and current best practices that help keep the industry resilient. On the other hand, the results also show interlinkages of the insurance sector and risk exposures it shares with other sectors, due to the use of special purpose vehicles (SPVs) and other complex instruments to transfer risk.

The analysis now looks at the outcome of an insurance sector collapse or a crisis arising from the insurance sector.

### 5.3.3 Insurance as a Source of Distress

Table 7. Delta CoVaR-Insurance sector on all sectors

Delta CoVaR—Insurance on different industries	1 percentile	25 percentile	Median	75 percentile	99 percentile
Banks	-0.4412	-0.1494	-0.1044	-0.0815	-0.0466
Insurance	-0.3694	-0.1250	-0.0874	-0.0682	-0.0390
Brokers	-0.1383	-0.0468	-0.0327	-0.0255	-0.0146
Real estate	-0.2459	-0.0832	-0.0582	-0.0454	-0.0259

Source: Author’s calculations using Bloomberg data

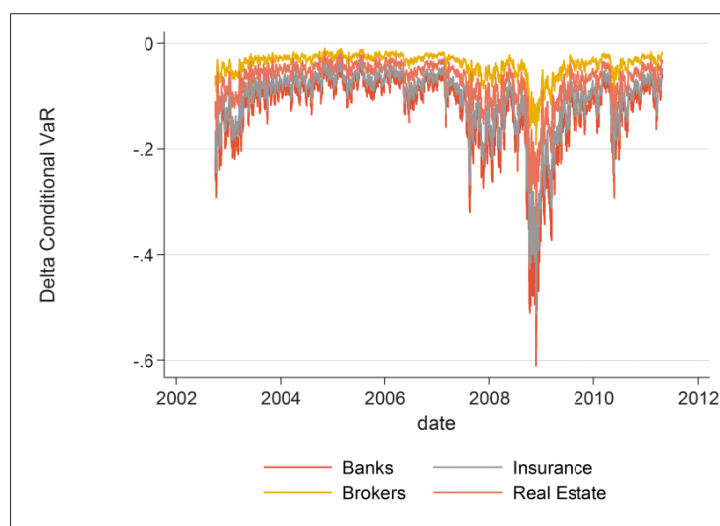


Figure 11. Systemic risk contribution from insurance sector

Source: Author’s calculations using Bloomberg data

Looking at the systemic importance of the insurance industry, Table 7 paints an entirely different picture. If the insurance industry were to collapse, its average systemic risk contribution would be -10.4%, -8.7%, -5.8%, and -3.3% on banking, insurance, real estate, and brokerage, respectively. *This indicates that the collapse of the insurance industry would pose an inherent risk to the financial economy.* Some share of these risks could be attributed to the massive and complex interconnections that continue to evolve within the financial system (Schwarcz & Schwarcz, 2014).

The vulnerability and source of systemic risk for the insurance sector could be through higher liabilities due to increasing longevity and interest rate decline in the longer term, or natural disasters, technology-related disasters, or terrorism in the shorter term.

## 6. Characteristics and Key Risks Faced by the Insurance Sector

The insurance sector faces several risks from the exogenous environment, such as macroeconomic downturns, inflation, low interest rates, unfavorable legislation, terrorist attacks, and natural disasters. It is also vulnerable to long-term risks like global aging, rising health care costs, and climate change. These risks are intrinsically different from those faced by the banking sector, which tend to be shorter term. Insurers have long-term liabilities, which they match with long-term assets (securities). Banks, on the other hand, have short-term liabilities, which they typically match to mostly long-term illiquid assets (loans), thus resulting in liability mismatches and incentives to take credit risks to generate returns.

Insurance companies face both non-financial liabilities—relating to losses in the real economy—and financial liabilities—relating to savings and credit protection products provided by life insurers. The latter are mostly linked to the financial markets and constitute the primary source of vulnerability. However, insurance companies invest mostly in high-quality assets that are marked-to-market (reflecting immediately in the income sheet), while banks hold mostly trading assets. Moreover, reinsurers play an enormous role in insurers' balance sheets. Reinsurance is generally recognized as a reduction in liabilities and is recoverable as an asset. Though reinsurance has been dominated by the non-life market, there has been an increase by the life segment as well (Impavido & Tower, 2009).

### 6.1 Risks Faced by Insurance Companies

**Underwriting risks.** These risks arise from the very nature of the insurance industry and are confined to this industry. The underwriting risks faced by the non-life business are more uncertain than those in the life business, since death rates remain relatively stable and predictable. However, natural and man-made disasters could significantly affect death rates, introducing greater uncertainty. Moreover, financial guarantee insurers may exacerbate a financial crisis if the guarantees are backed by risky and complex financial instruments, such as mortgage-backed securities, due to higher counterparty risk. In addition to these risks, operational processes, including calculating premiums, designing products, and selling insurance, could be subject to risks. Several of these risks are transferred through the issuance of bonds, such as catastrophe (CAT) bonds and the creation of SPVs.

**Market risk/investment risk.** This risk is associated with the asset side of the balance sheet. Insurance companies invest in bonds, shares, property, loans, and similar vehicles. These investments are affected by changes in interest and exchange rates, political upheaval, and other factors, and thus are subject to market risk. Insurance companies try to mitigate these risks through various regulations, as well as by applying asset liability, VaR, and other models.

**Credit risk.** This is the risk of a counterparty's defaulting or being unable to meet its obligations. Even where a counterparty can meet its obligations, risks can arise from a downgrade in credit quality due to the economic environment. This impacts the creditworthiness of insurance company investments. Insurance companies should diversify their risks as much as possible.

Reinsurance companies probably face maximum credit risk since most of the risks they insure relate to disasters and other large-scale upheavals. Reinsurers tend to diversify their risks by providing their services to different insurance segments and in different geographical regions.

**Liquidity risk.** This is the risk of a firm's being unable to meet its liabilities. This might be due to unfavorable market conditions or downgraded credit quality, or be specific to the company. Companies can mitigate liquidity risk through hedging strategies along with asset liability management (ALM).

Given these risks, the primary source of vulnerability is the larger role insurance companies play in global financial markets as investors and through financial intermediation. Moreover, varying insurance regulations across countries along with the insurance sector's limited experience with these new investment tools suggests that the market has little information about the potential impact of these tools on insurance companies, and whether existing market and credit risk management tools are adequate (Krenn & Oschischnig, 2003).

Off-balance sheet transactions and the use of SPVs and other complex instruments to transfer risk are generally procyclical and subject to economic and macro environment factors. Thus, insurance companies are exposed to external factors as well as to accounting and financial frauds. Moreover, increased reliance on credit rating agencies seemed to backfire in the recent crisis. Another threat to financial sustainability while using alternative instruments to transfer risks could arise from the credit risk associated with most of these financial instruments (Krenn & Oschischnig, 2003).

In addition to these factors, overlapping roles between banks and insurance companies through financial conglomerates and bancassurance (bank insurance model) channels of distributing insurance increase risks (Krenn and Oschischnig, 2003).

## *6.2 Management of These Risks*

The key question is how insurance companies manage these risks. While non-life insurance companies bear all the risk (with shareholders bearing both underwriting and investment losses), life insurance companies might be able to share risks. For the latter, the emergence of

the savings and investment business has created products that are similar to those provided by mutual and other funds, but with a tax advantage. Most of the investment risk associated with these products (e.g., unit linked, market linked) falls on policyholders (Impavido & Tower 2009).

The Geneva Association recommends focusing on activities rather than entire institutions to understand systemic risk. None of the activities of insurance companies—investment management, liability origination, or capital management—pose direct systemic risk. However, non-core activities—“derivatives trading on non-insurance balance sheets and mismanagement of short term funding from commercial paper or securities lending”—pose systemic risk (The Geneva Association, 2010).

## **7. Conclusion**

Using the  $\Delta CoVaR$  measure of systemic risk by Adrian & Brunnermeier (2010), this analysis measures the systemic risk of individual firms on their respective sectors and captures industry interlinkages by estimating the impact of one industry’s collapse on the other sectors. Our analysis shows that, while these linkages are considerably more limited in insurance than in banking, they are not negligible. This indicates that, despite protection provided by its regulatory environment, the nature of the risks, and current best practices, insurance firms are vulnerable to increasing interconnectedness through complex financial tools and processes. An insurance sector collapse would harm other sectors in the financial economy, and regulations should be designed to recognize and try to minimize such risks. The probability of an event that could trigger a crisis in the insurance sector is relatively low but, given the nature of the risks and the core practices of an insurer, must be considered a possibility.

This paper looks at insurance companies as a whole rather than at specific business activities. We recognize that, in the shorter term, traditional insurance activities are not systemically risky and vulnerabilities are due to exogenous risks, like natural catastrophes, cyber-attack, and terrorism (Eling & Pankoke, 2014). Moreover, the risks faced by insurance firms are longer term in nature, such as climate change and global aging, and are mostly triggered by the external environment or activities that are considered non-core to the insurance sector.

Given the different risk profiles confronting banking and insurers, subjecting insurance to the same regulations designed for banking could leave the insurance industry unprotected from other risks of significant macroeconomic impact.

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## Appendix

Appendix 1. Company list, industry mapping, and market capitalization (data from Bloomberg)

Company	BB ticker	Market cap (as of Dec. 2007) USD billion	SIC code	Industry
FNB CORP	FNB US Equity	0.89	6021	Banks
PARK NATL CORP	PRK US Equity	0.90	6021	Banks
UMPQUA HOLDINGS	UMPQ US Equity	0.92	6035	Banks
PAC CAP BANCORP	PCBC US Equity	0.93	6022	Banks
PRIVATEBANCORP	PVTB US Equity	0.93	6022	Banks
OLD NATL BANCORP	ONB US Equity	0.99	6021	Banks
GLACIER BANCORP	GBCI US Equity	1.00	6022	Banks
BOSTON PRIV FINL	BPFH US Equity	1.00	6022	Banks
MB FINANCIAL	MBFI US Equity	1.10	6035	Banks
LAURENTIAN BANK	LB CN Equity	1.10	6029	Banks
CITIZENS REPUBLI	CRBC US Equity	1.10	6021	Banks
PACWEST BANCORP	PACW US Equity	1.20	6021	Banks
HANCOCK HLDG CO	HBHC US Equity	1.20	6022	Banks
UNITED BANKSHS	UBSI US Equity	1.20	6022	Banks
FIRST NIAGARA FI	FNFG US Equity	1.20	6036	Banks
NORTHWEST BANCSH	NWBI US Equity	1.30	6021	Banks
WESTAMERICA BANC	WABC US Equity	1.30	6021	Banks

PROSPERITY BNCSH	PRSP US Equity	1.30	6022	Banks
CATHAY GENERAL B	CATY US Equity	1.30	6022	Banks
INTL BANCSHARES	IBOC US Equity	1.40	6022	Banks
TRUSTMARK CORP	TRMK US Equity	1.50	6021	Banks
UCBH HOLDINGS	UCBHQ US Equity	1.50	6022	Banks
FIRST MIDWEST/IL	FMBI US Equity	1.50	6021	Banks
FIRST CITIZENS-A	FCNCA US Equity	1.50	6022	Banks
EAST WEST BNCRP	EWBC US Equity	1.50	6022	Banks
SUSQUEHAN BNCSHS	SUSQ US Equity	1.60	6021	Banks
UMB FINANCIAL	UMBF US Equity	1.60	6021	Banks
FIRSTMERIT CORP	FMER US Equity	1.60	6021	Banks
SVB FINANCIAL GR	SIVB US Equity	1.60	6022	Banks
WEBSTER FINL	WBS US Equity	1.70	6021	Banks
WHITNEY HLDG	WTNY US Equity	1.70	6021	Banks
DORAL FINL CORP	DRL US Equity	1.80	6029	Banks
BANCORPSOUTH INC	BXS US Equity	1.90	6022	Banks
FULTON FINANCIAL	FULT US Equity	1.90	6021	Banks
CAN WESTERN BANK	CWB CN Equity	2.00	6021	Banks
ASTORIA FINL	AF US Equity	2.20	6035	Banks
TCF FINL CORP	TCB US Equity	2.30	6021	Banks
VALLEY NATL BANC	VLV US Equity	2.30	6021	Banks
FIRST HORIZON NA	FHN US Equity	2.30	6021	Banks
WASH FED	WFSL US Equity	2.30	6035	Banks
WILMINGTON TRUST	WL US Equity	2.40	6022	Banks
CAPITOL FEDERAL	CFFN US Equity	2.50	6035	Banks
CITY NATL CORP	CYN US Equity	2.90	6021	Banks
BANK OF HAWAII	BOH US Equity	2.90	6022	Banks
POPULAR INC	BPOP US Equity	3.00	6022	Banks
CULLEN/FROST	CFR US Equity	3.00	6021	Banks
COMMERCE BCSHS	CBSH US Equity	3.20	6022	Banks
ASSOC BANC-CORP	ASBC US Equity	3.40	6022	Banks
BOK FINL CORP	BOKF US Equity	3.60	6022	Banks
ZIONS BANCORP	ZION US Equity	5.00	6021	Banks
PEOPLE'S UNITED	PBCT US Equity	5.40	6035	Banks
HUNTINGTON BANC	HBAN US Equity	5.40	6021	Banks
NY COMM BANCORP	NYB US Equity	5.70	6036	Banks
CREDICORP LTD	BAP US Equity	6.10	6029	Banks
AMERICAN CAPITAL	ACAS US Equity	6.50	6159	Banks
COMERICA INC	CMA US Equity	6.50	6021	Banks
MARSHALL & ILSLEY	MI US Equity	7.00	6022	Banks
HUDSON CITY BNCP	HCBK US Equity	7.30	6036	Banks
SYNOVUS FINL	SNV US Equity	7.90	6021	Banks

M&T BANK CORP	MTB US Equity	9.00	6022	Banks
NATL BK CANADA	NA CN Equity	9.10	6029	Banks
KEYCORP	KEY US Equity	9.10	6021	Banks
SLM CORP	SLM US Equity	9.40	6141	Banks
WAMU INC	WAMUQ US Equity	12.00	6035	Banks
FIFTH THIRD BANC	FITB US Equity	13.00	6022	Banks
REGIONS FINAN CIA	RF US Equity	16.00	6021	Banks
BB&T CORP	BBT US Equity	17.00	6021	Banks
NORTHERN TRUST	NTRS US Equity	17.00	6022	Banks
CAPITAL ONE FINA	COF US Equity	18.00	6022	Banks
SUNTRUST BANKS	STI US Equity	22.00	6021	Banks
PNC FINANCIAL SE	PNC US Equity	22.00	6021	Banks
STATE ST CORP	STT US Equity	31.00	6022	Banks
BANK OF MONTREAL	BMO CN Equity	33.00	6021	Banks
CAN IMPL BK COMM	CM CN Equity	36.00	6021	Banks
TORONTO-DOM BANK	TD CN Equity	54.00	6021	Banks
US BANCORP	USB US Equity	55.00	6021	Banks
BANK OF NOVA SCO	BNS CN Equity	55.00	6029	Banks
BANK NY MELLON	BK US Equity	56.00	6022	Banks
AMERICAN EXPRESS	AXP US Equity	60.00	6141	Banks
ROYAL BANK OF CA	RY CN Equity	75.00	6021	Banks
WELLS FARGO & CO	WFC US Equity	100.00	6021	Banks
JPMORGAN CHASE	JPM US Equity	150.00	6021	Banks
CITIGROUP INC	C US Equity	150.00	6021	Banks
BANK OF AMERICA	BAC US Equity	180.00	6021	Banks
INTERDIGITAL INC	IDCC US Equity	1.10	6794	Brokers
KNIGHT CAPITAL-A	KCG US Equity	1.30	6211	Brokers
DUNDEE CORP-A	DC/A CN Equity	1.40	6282	Brokers
GAMCO INVESTORS	GBL US Equity	2.00	6211	Brokers
INVESTMENT TECH	ITG US Equity	2.10	6211	Brokers
BAM INVESTMENTS	BNB CN Equity	2.10	6719	Brokers
JEFFERIES GROUP	JEF US Equity	2.90	6211	Brokers
WADDELL & REED-A	WDR US Equity	3.10	6211	Brokers
RAYMOND JAMES	RJF US Equity	3.90	6211	Brokers
FEDERATED INV-B	FII US Equity	4.20	6282	Brokers
AFFIL MANAGERS	AMG US Equity	4.60	6282	Brokers
JANUS CAPITAL GR	JNS US Equity	5.50	6282	Brokers
EATON VANCE CORP	EV US Equity	5.90	6282	Brokers
SEI INVESTMENTS	SEIC US Equity	6.30	6211	Brokers
ALLIANCEBERNSTEIN	AB US Equity	6.50	6282	Brokers
CI FINANCIAL COR	CIX CN Equity	8.00	6722	Brokers



ICAHN ENTERPRISE	IEP US Equity	9.10	6719	Brokers
TD AMERITRADE HO	AMTD US Equity	11.00	6211	Brokers
LEGG MASON INC	LM US Equity	12.00	6282	Brokers
IGM FINANCIAL IN	IGM CN Equity	13.00	6282	Brokers
T ROWE PRICE GRP	TROW US Equity	16.00	6282	Brokers
BROOKFIELD ASS-A	BAM/A CN Equity	20.00	6719	Brokers
BLACKROCK INC	BLK US Equity	25.00	6282	Brokers
SCHWAB (CHARLES)	SCHW US Equity	30.00	6211	Brokers
FRANKLIN RES INC	BEN US Equity	31.00	6282	Brokers
LEHMAN BROS HLDG	LEHMQ US Equity	33.00	6211	Brokers
MORGAN STANLEY	MS US Equity	56.00	6211	Brokers
GOLDMAN SACHS GP	GS US Equity	99.00	6211	Brokers
RADIAN GROUP INC	RDN US Equity	0.94	6351	Insurance
STATE AUTO FINL	STFC US Equity	1.10	6331	Insurance
HARLEYSVILLE GRP	HGIC US Equity	1.10	6331	Insurance
PMI GROUP INC	PMI US Equity	1.10	6351	Insurance
NAVIGATORS GROUP	NAVG US Equity	1.10	6331	Insurance
SELECT INS GRP	SIGI US Equity	1.20	6331	Insurance
RLI CORP	RLI US Equity	1.30	6331	Insurance
ARGO GROUP INTER	AGII US Equity	1.30	6331	Insurance
PROASSURANCE COR	PRA US Equity	1.80	6331	Insurance
MGIC INVT CORP	MTG US Equity	1.80	6351	Insurance
UNIVERSAL AMERIC	UAM US Equity	1.90	6324	Insurance
DELPHI FINL GRP	DFG US Equity	1.90	6311	Insurance
ARTHUR J GALLAGH	AJG US Equity	2.20	6411	Insurance
MBIA INC	MBI US Equity	2.30	6351	Insurance
HANOVER INSURANC	THG US Equity	2.40	6331	Insurance
STANCORP FINL	SFG US Equity	2.50	6321	Insurance
AMBAC FINL GROUP	ABKFQ US Equity	2.60	6351	Insurance
MERCURY GEN CORP	MCY US Equity	2.70	6331	Insurance
PROTECTIVE LIFE	PL US Equity	2.90	6311	Insurance
WESCO FINANCIAL	WSC US Equity	2.90	6331	Insurance
UNITRIN INC	UTR US Equity	3.10	6331	Insurance
ERIE INDEMNITY-A	ERIE US Equity	3.10	6331	Insurance
AMER NATL INSUR	ANAT US Equity	3.30	6311	Insurance
REINSURANCE GROU	RGA US Equity	3.30	6321	Insurance
AMER FINL GROUP	AFG US Equity	3.30	6331	Insurance
HCC INSURANCE	HCC US Equity	3.30	6331	Insurance
BROWN & BROWN	BRO US Equity	3.30	6411	Insurance
ALLEGHANY CORP	Y US Equity	3.30	6331	Insurance
IND ALLIANCE INS	IAG CN Equity	3.40	6311	Insurance
OLD REPUB INTL	ORI US Equity	3.60	6351	Insurance

RENAISSANCERE	RNR US Equity	4.20	6331	Insurance
PARTNERRE LTD	PRE US Equity	4.50	6331	Insurance
ARCH CAPITAL GRP	ACGL US Equity	4.70	6331	Insurance
TRANSATLANTIC HL	TRH US Equity	4.80	6331	Insurance
MARKEL CORP	MKL US Equity	4.90	6331	Insurance
FAIRFAX FINL HLD	FFH CN Equity	5.10	6331	Insurance
HEALTH NET INC	HNT US Equity	5.30	6324	Insurance
WR BERKLEY CORP	WRB US Equity	5.40	6331	Insurance
WHITE MOUNTAINS	WTM US Equity	5.40	6331	Insurance
TORCHMARK CORP	TMK US Equity	5.60	6311	Insurance
EVEREST RE GROUP	RE US Equity	6.30	6331	Insurance
CINCINNATI FIN	CINF US Equity	6.60	6331	Insurance
UNUM GROUP	UNM US Equity	8.60	6321	Insurance
XL GROUP PLC	XL US Equity	9.00	6351	Insurance
CNA FINL CORP	CNA US Equity	9.20	6331	Insurance
COVENTRY HEALTH	CVH US Equity	9.20	6324	Insurance
HUMANA INC	HUM US Equity	13.00	6324	Insurance
PROGRESSIVE CORP	PGR US Equity	13.00	6331	Insurance
MARSH & MCLENNAN	MMC US Equity	14.00	6411	Insurance
AON CORP	AON US Equity	15.00	6411	Insurance
CIGNA CORP	CI US Equity	15.00	6324	Insurance
LINCOLN NATL CRP	LNC US Equity	15.00	6311	Insurance
ACE LTD	ACE US Equity	20.00	6331	Insurance
CHUBB CORP	CB US Equity	20.00	6331	Insurance
LOEWS CORP	L US Equity	27.00	6331	Insurance
HARTFORD FINL SV	HIG US Equity	27.00	6331	Insurance
ALLSTATE CORP	ALL US Equity	29.00	6331	Insurance
AFLAC INC	AFL US Equity	30.00	6321	Insurance
SUN LIFE FINANCI	SLF CN Equity	32.00	6321	Insurance
GREAT-WEST LIFEC	GWO CN Equity	32.00	6311	Insurance
TRAVELERS COS IN	TRV US Equity	34.00	6331	Insurance
METLIFE INC	MET US Equity	45.00	6311	Insurance
MANULIFE FIN	MFC CN Equity	61.00	6321	Insurance
UNITEDHEALTH GRP	UNH US Equity	73.00	6324	Insurance
AMERICAN INTERNA	AIG US Equity	150.00	6331	Insurance
BERKSHIRE HATH-A	BRK/A US Equity	220.00	6331	Insurance
LEXINGTON REALTY	LXP US Equity	0.89	6798	Real Estate
STEWART ENTERP-A	STEI US Equity	0.89	6553	Real Estate
COMINAR REA-TR U	CUF-U CN Equity	0.93	6798	Real Estate
EASTGROUP PROP	EGP US Equity	1.00	6798	Real Estate
COLONIAL PROPS	CLP US Equity	1.10	6798	Real Estate

CAN APARTMENT	CAR-U CN Equity	1.10	6798	Real Estate
FELCOR LODGING	FCH US Equity	1.10	6798	Real Estate
PS BUSINESS PARK	PSB US Equity	1.10	6798	Real Estate
OMEGA HEALTHCARE	OHI US Equity	1.10	6798	Real Estate
MID-AMERICA APAR	MAA US Equity	1.10	6798	Real Estate
COUSINS PROP	CUZ US Equity	1.10	6798	Real Estate
MFA FINANCIAL	MFA US Equity	1.10	6798	Real Estate
PENN REIT	PEI US Equity	1.20	6798	Real Estate
TANGER FACTORY	SKT US Equity	1.20	6798	Real Estate
LASALLE HOTEL PR	LHO US Equity	1.30	6798	Real Estate
HEALTHCARE RLTY	HR US Equity	1.30	6798	Real Estate
WP CAREY & CO	WPC US Equity	1.30	6500	Real Estate
ENTERTAINMENT PR	EPR US Equity	1.40	6798	Real Estate
HOME PROPERTIES	HME US Equity	1.50	6798	Real Estate
WASHINGTON REIT	WRE US Equity	1.50	6798	Real Estate
CORP OFFICE PROP	OFC US Equity	1.50	6798	Real Estate
FIRST IND REALTY	FR US Equity	1.50	6798	Real Estate
POST PROPERTIES	PPS US Equity	1.50	6798	Real Estate
BRANDYWINE RLTY	BDN US Equity	1.60	6798	Real Estate
CBL & ASSOC PROP	CBL US Equity	1.60	6798	Real Estate
HIGHWOODS PROP	HIW US Equity	1.70	6798	Real Estate
EQUITY ONE INC	EQY US Equity	1.70	6798	Real Estate
NATIONAL RETAIL	NNN US Equity	1.70	6798	Real Estate
COMMONWEALTH REI	CWH US Equity	1.70	6798	Real Estate
CAN REAL ESTATE	REF-U CN Equity	1.80	6798	Real Estate
ALEXANDER'S INC	ALX US Equity	1.80	6798	Real Estate
KILROY REALTY	KRC US Equity	1.80	6798	Real Estate
FIRST CAP REALTY	FCR CN Equity	1.90	6512	Real Estate
SENIOR HOUSING	SNH US Equity	2.00	6798	Real Estate
BRE PROPERTIES	BRE US Equity	2.10	6798	Real Estate
MACK-CALI REALTY	CLI US Equity	2.20	6798	Real Estate
ESSEX PROPERTY	ESS US Equity	2.40	6798	Real Estate
H&R REAL-REIT UT	HR-U CN Equity	2.60	6798	Real Estate
LIBERTY PROP	LRY US Equity	2.60	6798	Real Estate
ST JOE CO	JOE US Equity	2.60	6552	Real Estate
WEINGARTEN RLTY	WRI US Equity	2.70	6798	Real Estate
REALTY INCOME	O US Equity	2.70	6798	Real Estate
UDR INC	UDR US Equity	2.90	6798	Real Estate
NATIONWIDE HLTH	NHP US Equity	3.00	6798	Real Estate
HOSPITALITY PROP	HPT US Equity	3.00	6798	Real Estate

ALEXANDRIA REAL	ARE US Equity	3.20	6798	Real Estate
CAMDEN PROP TR	CPT US Equity	3.30	6798	Real Estate
APARTMENT INVEST	AIV US Equity	3.30	6798	Real Estate
ISTAR FINANCIAL	SFI US Equity	3.50	6798	Real Estate
RAYONIER INC	RYN US Equity	3.70	6798	Real Estate
DUKE REALTY CORP	DRE US Equity	3.80	6798	Real Estate
HEALTH CARE REIT	HCN US Equity	3.80	6798	Real Estate
REGENCY CENTERS	REG US Equity	4.50	6798	Real Estate
DEVELOPERS DIVER	DDR US Equity	4.60	6798	Real Estate
RIOCAN REIT	REI-U CN Equity	4.60	6798	Real Estate
FED REALTY INVS	FRT US Equity	4.80	6798	Real Estate
MACERICH CO	MAC US Equity	5.10	6798	Real Estate
SL GREEN REALTY	SLG US Equity	5.50	6798	Real Estate
AMB PROPERTY	AMB US Equity	5.70	6798	Real Estate
FOREST CITY -A	FCE/A US Equity	6.20	6512	Real Estate
PLUM CREEK TIMBR	PCL US Equity	7.30	6798	Real Estate
AVALONBAY COMMUN	AVB US Equity	7.30	6798	Real Estate
ANNALY CAPITAL M	NLY US Equity	7.30	6798	Real Estate
HCP INC	HCP US Equity	7.50	6798	Real Estate
BROOKFIELD OFFIC	BPO CN Equity	7.60	6510	Real Estate
HOST HOTELS & RE	HST US Equity	8.90	6798	Real Estate
KIMCO REALTY	KIM US Equity	9.20	6798	Real Estate
EQUITY RESIDENTI	EQR US Equity	9.80	6798	Real Estate
GENERAL GROWTH P	GGP US Equity	10.00	6798	Real Estate
BOSTON PROPERTIE	BXP US Equity	11.00	6798	Real Estate
PUBLIC STORAGE	PSA US Equity	12.00	6798	Real Estate
VORNADO RLTY TST	VNO US Equity	13.00	6798	Real Estate
PROLOGIS	PLD US Equity	16.00	6798	Real Estate
SIMON PROPERTY	SPG US Equity	19.00	6798	Real Estate

Appendix 2. Additional Graphs

All graphs (author's calculations based on data from Bloomberg)

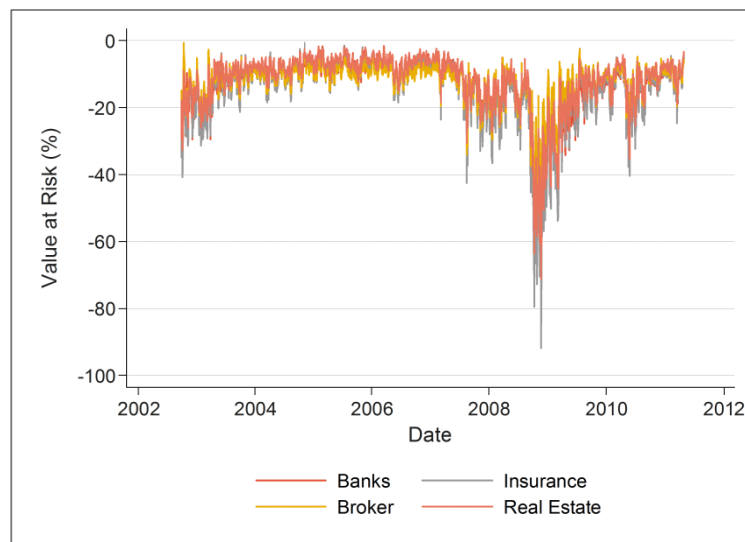
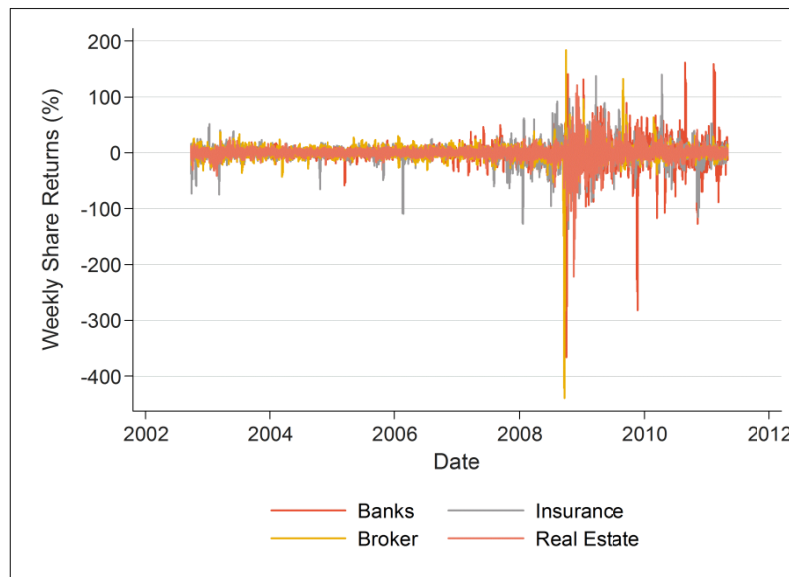


Figure 1. Firm-wise weekly share return and value at risk (1%)



Figure 2. CoVaR of individual firms on respective industries

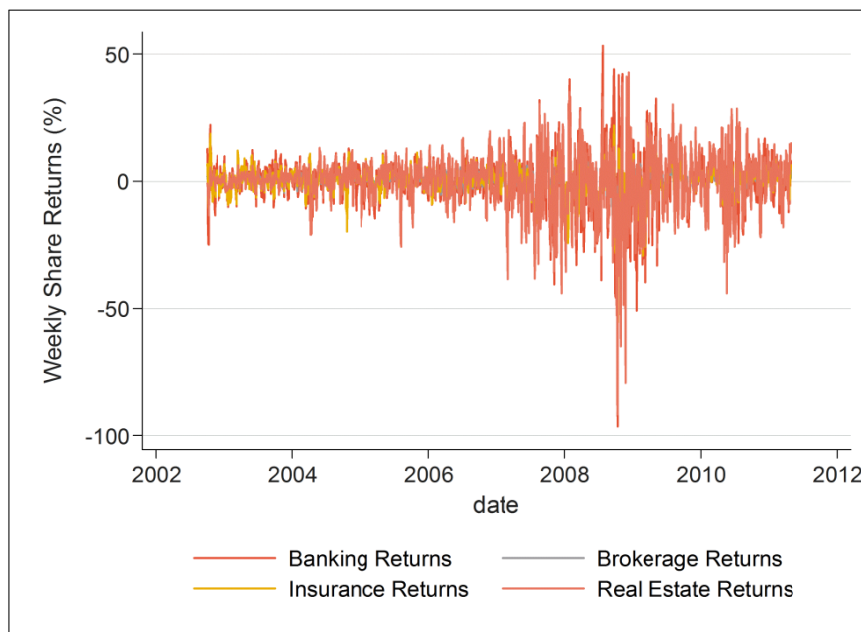
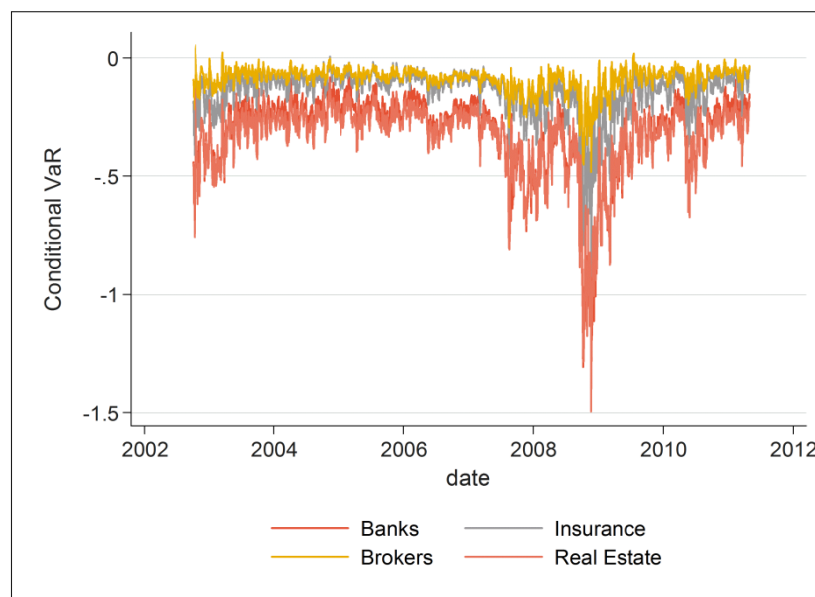




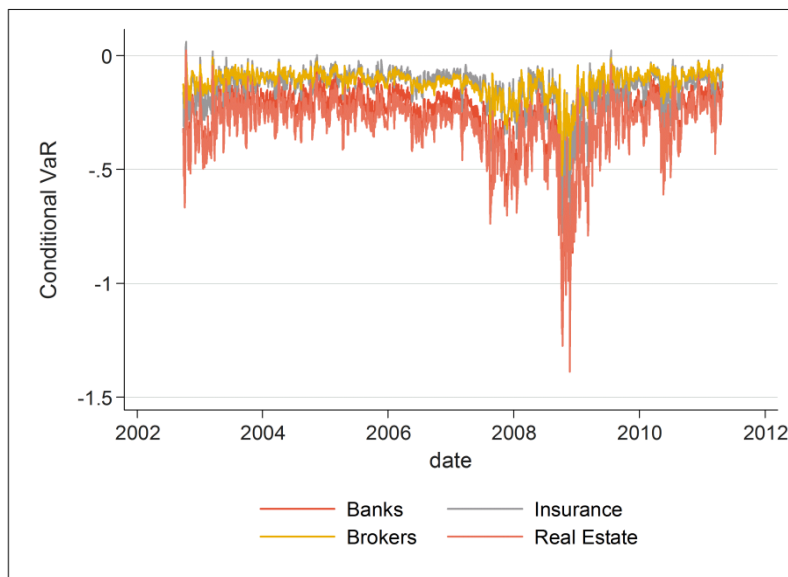
Figure 3. Industry interlinkages: sector-wise weekly share return and value at risk (1%)



Source of distress—Banking sector

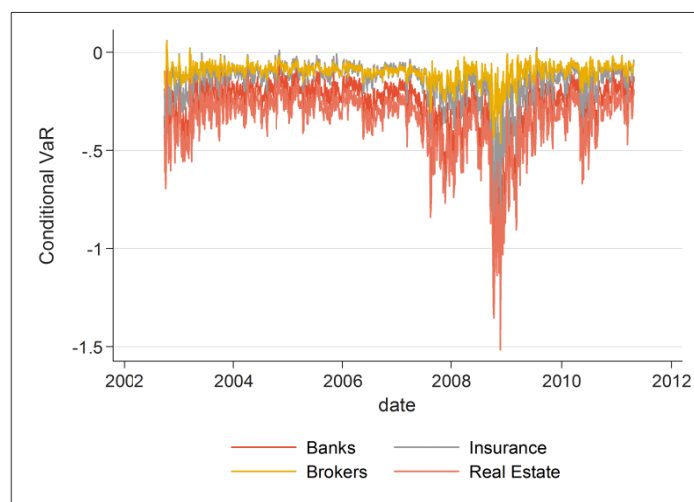


Source of distress—Insurance sector



Source of distress—Brokerage sector





Source of distress—Real estate sector

Figure 4. Industry interlinkages: conditional VaR

## Notes

Note 1. Explained below.

Note 2. See Appendix 1 for sector mapping and companies under each sample.

Note 3. See detailed description of all codes and companies within each sector in Appendix 1.

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