# Risk During the Financial Crisis: The Role of the Insurance Industry

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**Abstract:** The risk of financial institutions has become one of the primary areas of focus in both regulation and research in the post-mortem of the recent financial crisis. We analyze the security risk of financial services firms, focusing on the different sub-industries of insurance companies. We find that the returns and risk associated with the different types of insurance companies respond differently to this major disruption, which has implications for the regulation of risk. We also find that the relationship between financial services industries has changed following the financial crisis. [Key words: interconnectedness; idiosyncratic risk; financial crisis]

## INTRODUCTION

The subprime crisis that ushered in the recession of 2008 and 2009 resulted from the convergence of many different forces. The *Financial Crisis Inquiry Report* conveyed that the causes included the housing bubble; specifically, the risky mortgages that helped inflate the bubble.[5] The U.S. housing market grew at unsustainable rates, sweeping in borrowers, mortgage originators, dealers, government sponsored entities, insurers, and investors. Another factor that may have contributed to the crisis is the

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[5] Financial Crisis Inquiry Commission (2011).



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passage of the Financial Services Modernization (FSM) Act, more commonly referred to as the Gramm-Leach-Bliley Act, which ushered in a new competitive landscape for the financial sector.[6] The FSM Act, signed into law in 1999, was the culmination of continual loosening of the Glass-Steagall Act of 1933. The purpose of the FSM Act was to deregulate the financial industry, allowing firms to enter into other industries within the financial sector. Many financial firms took advantage of the FSM Act, expanding into previously restricted financial services. During the period between the enactment of the FSM Act and the financial crisis, there were a number of mergers and acquisitions among firms in different financial industries, as well as mergers among banks that eliminated the less-efficient banks.[7]

Regardless of the causes and the degree of contribution by diverse participants, the outcome is clear; the rapid deterioration of the subprime mortgage market led to a severe financial crisis in the U.S. beginning in 2007. The primary regulatory concern going forward is to dampen or prevent financial industry contagion that could spread to the general economy. This led the regulators to focus on monitoring systemic risk, the risk that an event may result in adverse effects on the general economy through a loss of value and confidence as noted by Mayer, Pence and Sherlund (2009).[8] The financial sector's exposure to systemic risk is through asset correlation across financial firms leading to a "domino" or contagion effect, and exposure to a common shock that simultaneously and significantly affects many financial firms.[9]

The purpose of this paper is to examine the insurance industry's contribution to financial sector risk during the financial crisis. As you can see in Figure 1, the insurance component of the financial industry is significant. We posit that insurers have diverse underwriting and investment portfolios and interact differently with other financial firms, such as depository institutions. We also suggest that not all types of insurance companies are interconnected with other financial services providers. We confirm that insurers specializing in financial guarantee, property and casualty (P&C) insurance, and reinsurance have some degree of interconnectedness with the financial system, whereas accident and health (A&H)

[6] U. S. Public Law No. 106-102.

[7] See, for example, Strahan (2003).

[8] Cummins and Weiss (2014) note this definition of risk is very similar to that in the Geneva Association's Group of Ten (2001, p. 126) report, as well as others such as the Financial Stability Board (2009), S. L. Schwarcz (2008), Thomson (2009), and Helwege (2010).

[9] Helwege (2010) provides a summary of the financial crisis and its causes, but leaves the degree of contribution of systemic risk by these participants to future research.

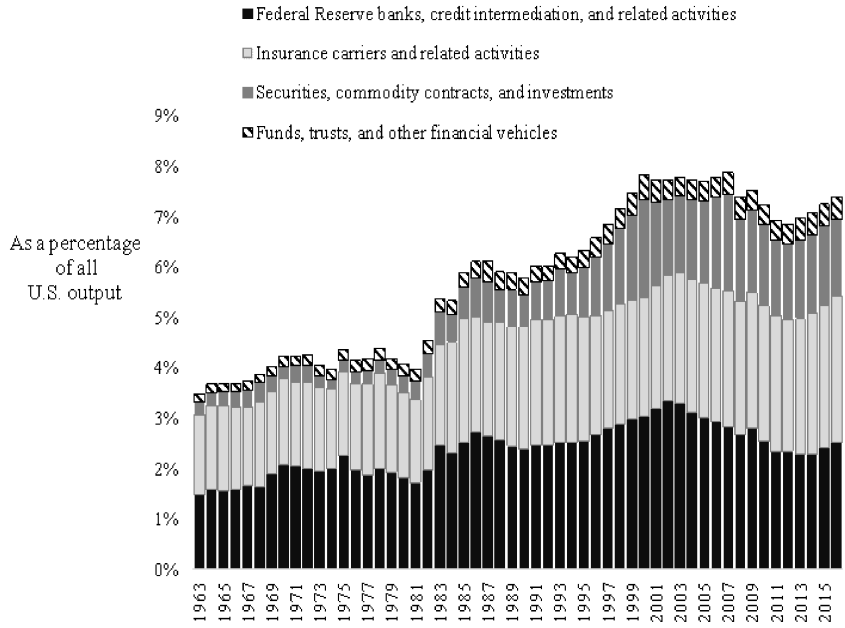



**Fig. 1.** Gross output in the financial sector, 1963–2016.
*Source of data:* Bureau of Economic Analysis, U.S. Department of Commerce

insurers do not. The influence of life insurers is limited to the time period before the crisis.

Our primary focus is on the equity risk of insurance companies. We examine whether insurance companies have risk similar to that of other financial institutions. For purposes of comparison, we analyze the risk of depository institutions, non-depository institutions, and insurance companies to complete the picture for the financial sector. Our analysis has implications for, and can inform the debate surrounding, the identification of systemically important insurance firms. We observe that, whereas there is significant correlation among returns of the different types of financial service firms, the dominant directional influences are from the banking institutions to insurance companies, and that the influence of life insurers, an insurance industry specifically identified by regulators, has waned since the financial crisis.

## SYSTEMICALLY IMPORTANT FINANCIAL INSTITUTIONS

Section 112(b)(2) of the Dodd-Frank Wall Street Reform and Consumer Protection Act created the Financial Stability Oversight Council (FSOC). The FSOC uses six factors to identify companies in need of FSOC supervision; three factors relate to the company's ability to affect the economy and three factors relate to the company's likelihood of financial distress. The FSOC laid out a three-stage process to manage this determination. In this process, the FSOC first filters the large number of nonbank companies on size and at least one quantitative factor, producing a smaller number of nonbank firms.[10] Then, using publicly available and supervisory data, the FSOC narrows this set of nonbank firms further using quantitative factors and risk profiles. In the third stage, the FSOC produces a much smaller number of nonbank entities that are subject to further scrutiny by the FSOC.

In its determination of whether a firm is a systemically important financial institution (SIFI), the FSOC uses one of two determination standards to analyze a company's threat to the stability of the national economy due to either (1) material financial distress, or (2) the "nature, scope, size, scale, concentration, interconnectedness, or mix of activities."[11] Once identified as systemically important, these companies must subsequently develop "recovery and resolution" plans. The FSOC used the material financial distress threshold in its 2014 designation of MetLife as a SIFI due to their interconnectedness with other firms arising from their products and activities including securities lending, guaranteed investment contracts, captive reinsurance, and variable annuities.

The Financial Stability Board (FSB), an international body similar to the U.S.'s FSOC, identifies institutions as Global Systemically Important entities. These institutions include banks (Global Systemically Important Banks, GSIBs) and, starting in 2013, insurance companies (Global Systemically Important Insurers, G-SIIs). In development of the G-SII list, the FSB works with the International Association of Insurance Supervisors (IAIS). In November 2014, the FSB identified thirty banking institutions and nine

[10]The size criterion is $50 billion in assets, which would capture half of the publicly traded life insurance companies in 2011 but few accident and health and property and casualty firms. These size criteria would have only identified one or two of the financial guarantee insurers, depending on the year.

[11]There are ten additional statutory factors the FSOC must consider by law. They are found on page 4 of the final determination of MetLife located at https://www.treasury.gov/initiatives/fsoc/designations/Documents/MetLife%20Public%20Basis.pdf.

insurers as systemically important; three of the G-SIIs are U.S. insurers: American International Group, MetLife, and Prudential Financial.

## The FSOC and Met Life

MetLife became the first nonbank company to challenge the SIFI designation, arguing that the FSOC's decision is "arbitrary and capricious."[12] The Court agreed with MetLife, ruling the SIFI designation should be rescinded. Specifically, the Court found the FSOC had "violated its own Guidance by failing to assess MetLife's vulnerability to financial distress." The Court found there was no basis to conclude that MetLife's distress would "materially impair" its counterparties as defined by the FSOC's Guidance because the FSOC did not actually estimate losses. The Court also took issue with the fact that the FSOC did not consider the costs of the SIFI designation. The FSOC admitted it did not consider the costs of the designation, but argued that it is not required by Dodd-Frank.

In its appeal, the FSOC contended that its guidance does not require numerical assessment of the likelihood of failure or estimation of counterparty losses. It concluded that the estimation of the costs of the designation or resulting effects is not required because it does not consider those costs to be a risk-related factor. A panel of academic experts filed a brief in support of the FSOC stating that the quantification of risk and a subsequent analysis of the costs of SIFI designation is an "unachievable burden" and, if required, could end the FSOC's ability to designate any firm a SIFI.[13]

There is concern that if MetLife succeeds in the revocation of its SIFI status, which is currently under appeal by the FSOC, then AIG and Prudential will come under more pressure to dispute their designations. Both MetLife and AIG expressed concerns, noting that regulatory requirements for SIFIs have not yet been specified.[14] Both firms are concerned that the costs of the SIFI designation are unknown; AIG reports the costs of the designation could significantly affect business operations, including capital and liability management, and stakeholder perceptions regarding financial strength.[15] This uncertainty could also affect financing costs. In its Schedule 14A, filed on February 1, 2016 with the SEC, AIG notes it has

[12]MetLife, Inc. vs. Financial Stability Oversight Council, filed in the U.S. District Court of the District of Columbia, civil action no. 15-14, Introduction, paragraph 3.

[13]Brief of *Amici Curiae* scholars of insurance and financial regulation in support of appellant and reversal filed in the U.S. Court of Appeals for the District of Columbia Circuit, No. 16-5086.

[14]More detail is found in MetLife's 2015 10-K, in the Insurance Regulation section, pages 44–45.

[15]AIG's 2015 10-K, Item 1A—Risk Factors—Regulation, page 41.

come under pressure to separate AIG into "separate insurers focusing on life, property-casualty, and mortgage coverage." Although the SIFI designation is not specifically referenced as the reason to separate, it is reasonable to assume it has some influence on decision-making. MetLife has since decided to separate part of their business regardless of the outcome of their case.[16]

The outcome of this dispute has consequences for all stakeholders, systemic risk regulators, and the implementation of the systemic regulatory section of the Dodd-Frank law. It has consequences for all potentially SIFI nonbank firms, including life and property-casualty insurers. At the heart of the issue is the SIFI designation process, with an even more fundamental question of risk measurement. Should the FSOC be required to quantify systemic risk, and, if so, how? Regardless, both the FSOC and industry struggle with the identification and measurement of firms that may pose systemic risk to the financial industry. In this study, we provide additional information regarding not only the general interconnectedness of financial firms, but also the conditions under which each insurance segment is more likely to influence banking firms.

## Measures of Systemic Risk

Several researchers have developed firm-specific measures of systemic risk. One measure, based on value-at-risk, is proposed by Adrian and Brunnermeier (2014). These authors develop the CoVAR measure, which is based on market data of leverage and size as well as maturity mismatch. Another measure of systemic influence is the Systemic Risk Index (SRISK) measure. SRISK, developed by Brownlees and Engle (2016), is a measure of an individual company's influence on the economy. SRISK is an estimate of the marginal expected shortfall (MES) for an individual firm. Based on credit-scoring methods, SRISK is an estimate of the capital shortage in the event of severe economic distress. In both cases, CoVar and SRISK, an estimate that is large relative to other financial firms suggests that the financial institution is a potential source of systemic risk. As Kupiec and Güntay (2016) point out, however, neither CoVar nor SRISK measures are associated with statistical tests that allow the user to test whether a firm is systemically important.

We use the SRISK measures estimated by the V-Lab at New York University's Volatility Institute to provide some descriptive information on potential capital shortfall of the insurance firms identified by the FSOC as SIFI. We graph the SRISK measure in both dollars of shortfall and percent

[16]2015 Chairman's Letter. MetLife Annual Report.

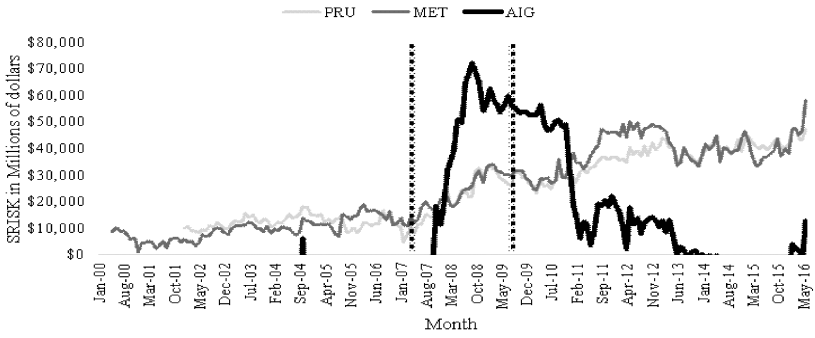



**Fig. 2.** SRISK measure for SIFI nonbank companies, in millions of dollars.

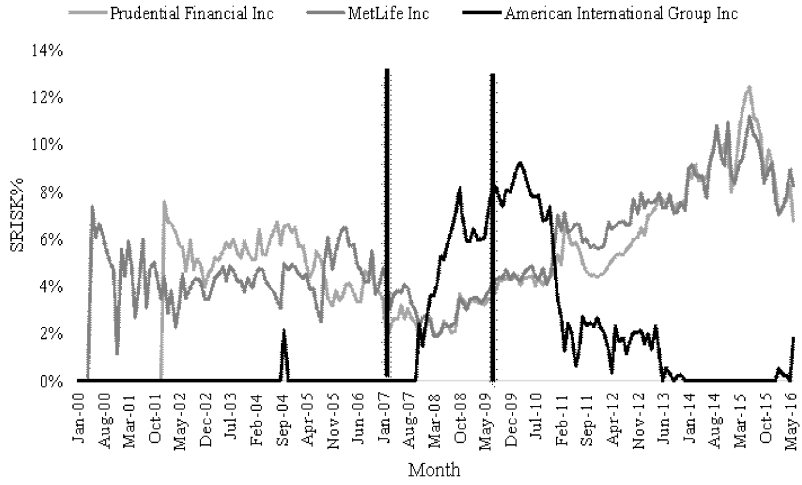



**Fig. 3.** SRISK measure for SIFI nonbank companies: percent of economic impact.

of the economy's shortfall in the U.S. for MetLife, AIG, and Prudential Financial, and present this in Figure 2 and Figure 3, respectively. In terms of potential capital shortfall, both MetLife and Prudential Financial are in the top ten contributors based on SRISK of financial institutions in the post-crisis period.

When we examine the SRISK by type of insurance, we see that life insurers, as a group, have SRISK of approximately $120 billion by mid-2016. Putting this in perspective, the top three depository institutions (Bank of America, JPMorgan Chase & Co., and Citigroup) together had SRISK of

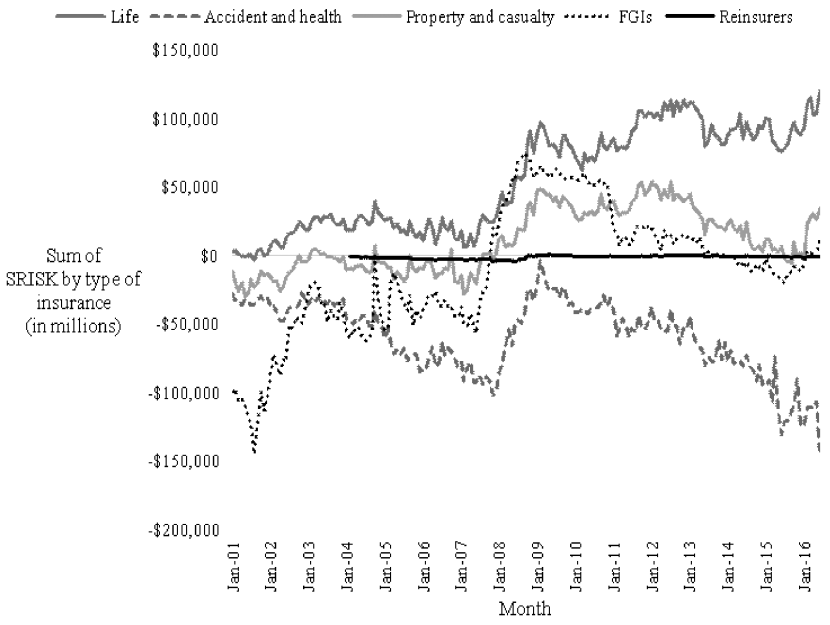



**Fig. 4.** SRISK for insurance companies, by type of insurance. Estimated dollar capital shortfall associated with a severe market decline, estimated by the New York University V-Lab.

$134 billion. We show in Figure 4 that, as of mid-2016, life insurers have the highest systemic risk, followed by property and casualty insurers. Financial guarantee firms, which experienced a high risk of capital shortfall during the crisis, have levels of SRISK by 2016 that suggest little capital shortfall risk.

## Primary Research Question

Given the recent financial crisis, current economic outlook, and resulting regulatory reform, it is important to ensure that reform efforts target the appropriate industries and firms. In this study, we provide additional insight into the interconnectedness of industries within the financial sector, and specifically within segments of the insurance industry and under what conditions each insurance segment exhibits interconnectedness. We do this by examining the interconnectedness of financial firms and insurance subindustries before, during, and after the financial crisis. Previous studies were published relatively soon after the crisis. Our post-crisis time period

is longer than earlier studies, therefore including more information regarding post-crisis performance.

## PREVIOUS EVIDENCE

The empirical evidence regarding insurance companies' systemic risk is mixed. Several studies posit that systemic risk of insurers increased when they expanded into investment management, derivatives trading, writing credit default swaps, and/or insuring financial products. In general, studies conclude that the risk for traditional insurance companies engaged in core insurance activities is relatively low when compared to other financial institutions, but that this risk increased with expansion into product or services noted above; see, for example, Harrington (2009), Baluch, Mutenga, and Parsons (2011), Billio, Getmansky, Lo, and Pelizzon (2012), Cummins and Weiss (2014), D. Schwarcz (2009).

Harrington (2009) points out, however, that some life insurers may have excessive risk, and even systemic risk, due to leveraging, risky investments, and the possibility of cash withdrawals, but that life insurers, in general, are not risky. On the other hand, Cummins and Weiss (2014) conclude life insurers are more exposed to systemic effects than P&C insurers, but the core activities are not systemically risky. In our study, we find that life insurance companies' portfolio composition changed significantly from pre-crisis to the crisis, in which period the SRISK and idiosyncratic risk of life insurers increased drastically; however, post-crisis, the composition returned to pre-crisis allocations and the risk again decreased, supporting the findings above. Of interest, Berry-Stölzle, Nini, and Wende (2014) find earnings and capitalizations of life insurers returned to pre-crisis levels relatively quickly.

Kessler (2014) examines past failures and finds insurers and reinsurers are not systemically important if they stay within the "traditional business model." Park and Xie (2014) find a relationship between reinsurer rating default risk and P&C insurer downgrade risk, but their examination of publicly traded reinsurers finds the spillover effects are not enough to conclude reinsurers pose a significant systemic risk to P&C insurers. Cummins and Weiss (2014) conclude P&C and life insurers are exposed to reinsurance counterparty credit risk, but find little evidence that risk will significantly disperse to financial markets. Empirical studies of systemic risk in the insurance industry include interconnectedness of the different types of financial firms as one of the primary factors of systemic risk. Of the 18 indicators proposed by the IAIS to identify systemically important insurers, interconnectedness is assigned a weight of 30–40% (Baranoff, 2012).

Baluch et al. (2011) examine global insurance sector returns and find, in general, that insurers have lower systemic risk than banks, but that risk increased in later years due to the strategic expansion previously discussed.[17] Bernal, Grabo, and Guilman (2014) examine three industries within the financial services sector and find that other financial services firms contribute the most systemic risk in the Eurozone, while the insurance sector is the riskiest in the United States. They conclude that banking poses the least systemic risk of the three U.S. industries analyzed.

Billio et al. (2012) focus on the connectedness of the different industries within the U.S. financial sector and find that banks and insurers are more important to the interconnectedness of the financial sector and have an asymmetric effect on the monthly returns of brokers and hedge funds. Chen, Cummins, Viswanathan, and Weiss (2014) use credit default swap spreads and linear and nonlinear Granger-causality tests to examine interconnectedness of insurers and banks. They conclude that the dominating influence is that of banks affecting insurance companies.[18] Similarly, Elyasiani, Staikouras, and Dontis-Charitos (2016) find evidence of contagion when banks acquire insurers but no significant effects when insurers acquire banks. Lastly, Billio et al. (2012) and Acharya, Pedersen, Philippon, and Richardson (2010) find firms in the financial industry interconnected with insurers being one possible origin of systemic risk. Schwarcz and Schwarcz (2014) strongly argue that insurer operations, in general, pose systemic risk.

The bottom line of this evidence is that there appears to be some degree of interconnectedness among financial firms, and that some insurance companies may be systemically important. However, the interconnectedness by the type of insurer has not been fully examined, which is what we explore in more detail. We expand the analysis of interconnectedness by segmenting insurance companies by product focus and segmenting and expanding the sample period to account for relationship heterogeneity before, during, and after the financial crisis.

[17]Baluch et al. (2011) find that United Kingdom, Asia-Pacific, and United States property-casualty insurers were the least affected by the crisis. Life insurers, global composite insurers, global reinsurers, and other European insurers were the most affected and had the worst performance during the crisis. They also find that the crisis affected certain lines of insurance more, including financial guarantee, credit, and liability insurers as well as those that deviated from their core insurance business, such as AIG and Swiss Re.

[18]Notably, liquidity and leverage played a significant role in the crisis beginning in 2007; see the Republican Commissioners on the Financial Crisis Inquiry Commission in the *Financial Crisis Primer: Questions and Answers on the Causes of the Financial Crisis*, December 15, 2010.

# INSURANCE, RISK, AND INTERCONNECTIONS

Understanding the equity risks associated with insurance companies and the interconnectedness with others in the financial sector requires understanding the nature of each type of business. The bulk of insurance operations fall in three main industries: life, property-casualty (P&C), and accident-health (A&H). We can also break out some firms typically classified as P&C insurers into their own groupings: financial guarantee insurers (FGIs) and reinsurers. Financial guarantee insurers are technically within the property-casualty industry, and these firms were some of the first financial firms affected significantly by the unfolding crisis.[19] In the SIC system, reinsurers are classified as property and casualty insurers; however, these firms are distinct in terms of their risks.[20] A further group to consider is the surety insurance industry, which has characteristics of banking and insurance. We consider the insurance industry as a whole and the characteristics of each insurer group, including their underwriting and investment operations, to evaluate interaction between insurance and financial services. Based on previous research, we expect to find that insurance industry equity returns, in general, are interconnected with and influence other financial industries; see, e.g. Baluch et al. (2011), Billio et al. (2012), Cummins and Weiss (2014), Schwarcz and Schwarcz (2014). Specifically, insurers' expansion into non-insurance financial products either precipitated or enhanced any pre-existing interconnection.

## Insurance Segments

### *Life Insurers*

The premiums received for mortality and longevity protection provided by life insureres result in large reserves invested and held over many years. As a result, life insurers are exposed to runs similar to those of banks that typically occur during periods of financial distress, when policyholders decide to cancel their policies or otherwise access any existing cash

[19]On January 18, 2008, AMBAC became the first FGI downgraded from AAA because of the subprime mortgage market decline, followed by Moody's downgrade of both AMBAC and MBIA in June 2008. The Federal Reserve Bank of New York agreed to lend AIG, a property-casualty insurer, $85 billion on September 16, 2008. On November 17, 2008, three life insurance companies requested TARP funding; these insurers were Genworth Financial, Hartford Financial Services Group, and Lincoln National.

[20]In the SIC system, reinsurers were classified within property and casualty insurers, within the 633 3-digit SIC code grouping. Under the NAICS system, reinsurers are separate from P&C insurance (NAICS of 524130 for reinsurers compared with 524126 for property and casualty insurers.

value (Russell, Fier, Carson, and Dumm, 2013). Life insurers also produce deposit-type contracts, including annuities and guaranteed investment contracts (GICs).[21] In addition to the sheer volume of life insurer assets exposed to capital market fluctuations, other areas of sensitivity include securities lending and Funding Agreement Backed Securities (FABS) and Notes (FASN).[22,23] While insurers of other lines of business participate in these transactions, life insurers dominate the securities lending participation; hence, life insurers are significantly exposed to market or interest rate risk (Klein, Ma, Ulm, Wang, Wei, and Zanjani, 2009).[24]

Using data from the NAIC's Center for Insurance Policy and Research (2011, 2016) we compare allocations in invested assets by insurer type in Figure 5. In the years preceding the financial crisis, life insurers shifted their investments towards fixed income securities, including securitized assets of mortgage-backed securities, while decreasing allocation in government-sponsored entities and U.S. Government risk-free investments.[25] Life insurers also invest in assets such as bonds that are insured by financial guarantee insurers. FGIs were some of the first and hardest hit firms impacted by the recession, incurring significant credit downgrades as a result. Thus, life insurers experienced deterioration in asset values from the general decline in the market and from the reduction in credit rating of FGIs. Baluch et al. (2011) observe that life insurers experienced a greater loss of valuation of assets during the financial crisis than non-life insurers, and that the

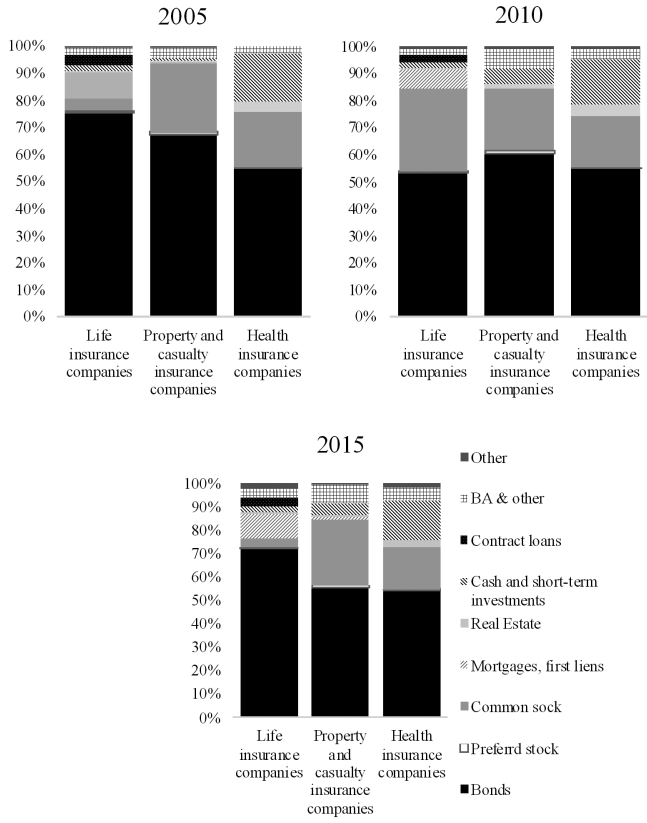
[21]Deposit-type services offered by life insurers also include dividend and coupon accumulations, lottery payouts, structured settlements, and premium funds (Graham and Xie, 2007).

[22]Securities lending is, effectively, a loan for investors' short sale activity. The insurer benefits from a fee charged to the investor as well as any return on the lent investments in the form of dividends, interest, and capital appreciation. Securities lending loans are generally short-term, less than twelve months in duration.

[23]A contributing factor is life insurers' use of structured securities, first introduced in 2003; life insurance companies buy low-quality securities and then issue notes profiting on the spread between these securities. Essentially, insurers would borrow using their investment-grade rating and then lend at A or BBB rates, with a spread of 75 to 100 basis points. The practice of issuing these notes diminished significantly in 2009, as investors lost their appetite for structured securities.

[24]If it is a product where the assets are part of the general fund, the insurer guarantees a minimum interest rate and assumes all risk from fluctuations; as a result, the cash surrender value varies. If the product places the assets in a separate account, the policy owner assumes interest rate risk, yet the assets are not available to general creditors in the event of insolvency.

[25]In addition, according to the NAIC, the predominant type of bond is the corporate bond. Some of the shrinkage of the bond category in 2010 may be attributed to the loss of value of some bonds during the period of economic stress, and this stress also resulted in some insurance companies holding downgraded, below-investment-grade bonds.




Source of data: NAIC

**Fig. 5.** Distribution of invested assets of US insurance companies, by type of insurance.

decrease in value was similar to that experienced by banks. Of the three types of insurance company, life insurers had the largest exposure to common stock and non-agency residential mortgage-backed securities.

Based on this analysis, we expect to find interconnectedness in our analysis of the equity returns of the life insurance industry and other industries within the financial sector.

### *Accident and Health Insurers*

Accident and health insurance protects against unexpected morbidity losses such as illness, incapacity, or injury by indemnifying costs of the loss and/or wages. This includes insurance for medical and hospital expenses,

long-term care, and disability. In contrast to life insurance, most policyholders renew health insurance annually, except for long-term care insurance. Generally, claimants file very close to the time of services; therefore, there is a relatively short time between premiums and claims payouts. Therefore, accident and health insurance is primarily a short-tail line of insurance, a relatively small part of the insurance market and not likely to have interconnectedness with other financial services providers. Our study is the first to examine A&H insurers as a segment. Based on these characteristics of A&H firms, we do not expect to find interconnectedness among the equity returns of A&H insurers and other industries within the financial sector.

*Property and Casualty Insurance*

We find no support in the literature that P&C insurers are interconnected with other financial services firms, though Cummins and Weiss (2014) and Park and Xie (2014) find some effects of reinsurers' risk on P&C insurers. Harrington (2009) notes that large loss events, such as catastrophes, may affect P&C insurers and reinsurers, possibly disrupting that market; but based on past evidence, there is little chance of significant contagion to other markets. In summary, P&C insurance is a diverse set of insurance products. The property side of the business consists of first-party, short-tail property coverage, while liability claims for significant injuries to a third party resulting from an insured's negligence usually take longer, sometimes several years, to resolve.

In addition to traditional insurance, large commercial and financial services firms have a diverse set of insurance risks that may be geographically dispersed, requiring a customized policy, specialized underwriting, and layered limits. Noninsurance financial firms of interest to systemic risk regulators obtain much of their coverage from the global insurance markets. Typical lines of insurance purchased by these financial institutions are coverage for property, network security and cyber risks, Directors and Officers (D&O) liability, political risk, political violence and terrorism, and comprehensive nonpayment insurance to cover against insolvency or "protracted insolvency" of customers and other counterparties. Apart from the investment portfolio, P&C insurers have exposure to the general economy, as claims in some lines, such as Directors and Officers insurance, may correlate to general economic conditions.

Similar to life insurers, P&C insurers' investment portfolios are sensitive to general market conditions. However, the relatively shorter tail nature of P&C products mitigates some of the interest rate risk, so we do not expect to find interconnectedness among the equity returns of the P&C industry and those of other financial sector industries.

### *Financial Guarantee Insurers*

Financial guarantee insurers (FGIs) provide credit enhancement for a variety of financial products. These credit enhancements are in the form of insurance on public finance, guaranteed investment contracts, structured finance, and credit default swaps; however, after the 2008–2009 financial crisis, FGIs are no longer permitted to participate in the credit default swap market. Many investments in securitized assets were "wrapped" by financial guarantor firms, thus effectively transferring the FGIs' investment-grade rating to these assets. When rating agencies downgraded the FGIs, the downgrading of associated "wrapped" assets led to a weakening in insurers' capital positions. For example, many municipal bonds are "wrapped" by FGIs, which increases the credit rating of the bond and reduces the cost of capital to the municipal.

FGIs operate over a long horizon. For example, they may receive a one-time premium payment to insure a municipal bond with duration of 20, 30, or even 40 years. FGIs may also manage the proceeds from the bond sale for the municipality, providing a guarantee of a set amount of interest (that is, a guaranteed investment contract). The majority of FGIs also insured structured finance, primarily the higher-rated tranches of collateralized debt obligations (CDOs), and some financial guarantee insurers issued credit default swaps (CDS).[26]

An FGI derives its value from its investment-grade rating. The business model of FGIs leverages this rating by "lending" this rating to the structurer or owner of an insured financial product in exchange for a protection payment or premium. The FGI promises to make payments in the event of default of the underlying assets of the protected financial product, and FGIs employ no-loss or remote-loss underwriting guidelines to preserve the investment-grade rating required for their business model.[27] Prior to the crisis these guidelines resulted in extremely low losses and very high surplus amounts relative to other insurers. The crisis caused FGIs to enter financial distress, with negative effects spreading to entities and markets that relied on this insurance. As stated previously, larger insurers invested significantly in bonds and other structured assets insured by FGIs that lost value when FGIs' credit ratings were downgraded. Hence, FGIs are interconnected with other financial services entities.[28]

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[26]For a comprehensive analysis of FGIs, see Drake and Neale (2011).

[27]The *no-loss* or *remote loss* underwriting assumes that there will be zero loss on a transaction.

[28]Researchers often exclude monoline insurers such as FGIs from their sample due to their unique exposures (for example, Cummins and Weiss, 2014).

*Surety Insurers*

Surety insurance is a guarantee that the insured (the principal) will fulfill its obligations to the beneficiary (the obligee); if the insured fails to fulfill its obligation, the surety insurer takes the place of the insured. As with any insurance, there is an underwriting process required before the surety grants the insurance. Surety insurance shares some features of banking; for example, surety insurers require customers to qualify for credit. Companies and individuals use surety insurance for a variety of obligations, including court-ordered bonds for lawsuits, developers' bonds with local townships, construction for state and federal governments, bonds covering lease payments, and security for licenses and permits.[29]

In contrast to traditional insurance and similar to FGIs, the surety employs no-loss or remote-loss underwriting with the expectation the insured will fulfill obligations. Unlike FGIs, under the surety agreement surety insurers have the right to recover from the insured money paid out for claims. Hence, we believe surety insurers are interconnected to other financial services, but potentially less so than FGIs.

*Reinsurers*

Reinsurers provide insurance, referred to as reinsurance, for insurance companies to off-load risk and free up underwriting capacity. Reinsurers develop a diversified insurance pool by combining risks from different insurers from around the world. One concern is that the reinsurance market is heavily concentrated. Park and Xie (2014) note that a few internationally domiciled firms dominate the market, with uneven regulation.[30]

The Group of Thirty (2006) performed a "stress test" and found no widespread insolvencies of P&C insurers in the event 20 percent of global reinsurers failed. In addition, in the event of a reinsurer failure, P&C insurers remain fully liable to policyholders. Therefore, this study suggests reinsurers are not significantly interconnected with noninsurance financial segments.

On the other hand, there is evidence that reinsurance companies' failures can lead to instability in the P&C insurance sector, with possible

[29]Like other forms of insurance, there are underwriting risks, especially in terms of modeling or predicting risks. Trade credit and surety insurers' profits are sensitive to the economy, as business insolvencies result in losses for the insurers. Surety insurers are also tied to other financial service industries through their competition with banks in the guarantee business outside the U.S. Further, because many businesses view surety bonds as an alternative to a bank letter of credit, surety firms compete directly with domestic banks.

[30]In the 1980s, there were a number of small reinsurers, but there were also a large number of failures among these small reinsurers.

ramifications for the general economy (Baluch et al., 2011, and Park and Xie, 2014), though Harrington (2009) concludes that the chance of significant contagion is small. According to the Group of Thirty (2006), about 50 percent of reinsurance premiums generated annually are from North America. The 2014 Federal Insurance Office (FIO) report discusses the importance of the global reinsurance market to U.S. insurers, noting that seven of the ten costliest catastrophes in the world, as measured by insured losses, occurred in the U.S. In 2005, non-U.S. reinsurers paid over 60 percent of insured losses from Hurricanes Katrina, Rita, and Wilma. Similarly, reinsurers paid around 40 percent of total insured losses from Superstorm Sandy in 2012.[31] Even though U.S. primary insurers spread their risks across several reinsurers, failures of the largest global reinsurers can affect the reinsurance market's capacity to underwrite insurance by tightening underwriting guidelines and charging higher premiums. Scordis and Steinorth (2012) find that reinsurance increases the value of smaller insurers, allowing them to write more insurance and increasing overall market capacity. Therefore, we expect the equity returns of reinsurers to exhibit interconnectedness with those of other financial service industries.

*Summary*

Previous research documents some systemic risk originating from the insurance sector but the evidence is not clear on the origin within the sector. Based on our analysis of the characteristics of the different types of insurance firms as well as prior evidence, we expect to find that life insurers, FGIs, surety insurers, and reinsurers exhibit interconnectedness with other industries within the financial sector. We also expect no interconnectedness of A&H and P&C insurers with other industries within this sector.

## DATA

Our analysis has two layers. First, we examine the interconnectedness of insurance companies with other financial industries. Second, we exam-

[31]Using 2011 data, the IAIS reports that the property sector purchases 44 percent of global reinsurance premiums, the largest amount of all sectors. Life reinsurance makes up 31 percent of global premiums, while premiums for liability lines account for 22 percent of purchases. Three percent of global reinsurance premiums are for financial lines. European reinsurers assumed most of the risk, $47 billion more than they ceded out to other reinsurers. North American insurers ceded out $16 billion more than they assumed. Asia and Australia ceded $23 billion while assuming only $2 billion (IAIS *Global Insurance Market Report*, 2012 Edition, pp. 20–21).

ine whether interconnectedness is specific to certain lines or firms within the insurance sector.

We draw daily returns from the Center for Research in Security Prices (CRSP) Daily Stock File for the entire financial sector from January 1, 2001, through December 2015.[32] We classify the sample based on SIC codes into the following financial services industry portfolios:

1 Depository institutions
2 Non-depository credit institutions
3 Insurance carriers

We perform this classification based on the SIC code corresponding to the daily return; hence, a firm may shift from one portfolio to another over time if their lines of business change significantly.

We also break down the insurance firms by type of insurance. However, we specifically identify financial guarantee insurers (XL Capital Assurance, MBIA, Radian, and Assured Guaranty) and separate these firms and AIG from the P&C category. We also break out the reinsurers from the property and casualty firms. We use the following insurance portfolios:

3.1 Life insurers
3.2 Accident and health insurance and medical insurers (A&H)
3.3 Property and casualty insurers (P&C)
3.4 Surety insurers
3.5 Financial guarantee insurers (FGI)
3.6 Reinsurers

We construct portfolios using market capitalization weighted averages of the individual components for the portfolios, and use the CRSP value-weighted market return with dividends to represent the market return. We allow firms to enter and leave a portfolio based on SIC code changes, entrance to the financial industry, exit from the financial industry, or delisting.

[32]We begin our analysis after passage of the Financial Services Modernization Act. The only insurance companies excluded from the insurance carriers' industry were title insurance companies and "other" insurance companies, which, based on SIC codes, we could not otherwise classify. We ran all analyses with and without the few title insurance companies and did not find different results; the returns to the stocks of title insurers tend to be driven by factors outside the scope of this analysis.

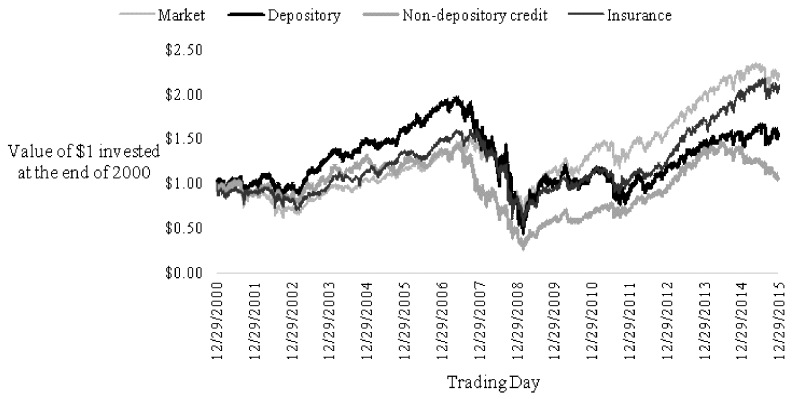



**Fig. 6.** Compounded monthly returns for financial services portfolios.

We divide the entire period into three intervals relative to the financial crisis. We base the financial crisis period on key events, with February 27, 2007, representing when Freddie Mac announced that it stopped purchasing sub-prime mortgages for securitization, and June 30, 2009, representing the end of the recession that began December 2007. Therefore, our three intervals are:

| Interval | Beginning date | Ending date | Description |
|---|---|---|---|
| 1 | January 1, 2001 | February 26, 2007 | Pre-crisis |
| 2 | February 27, 2007 | June 30, 2009 | Crisis |
| 3 | July 1, 2009 | December 31, 2015 | Post-crisis |

We provide a graphical representation of the monthly returns for each portfolio in Figures 6 and 7, providing the value of $1 invested in each portfolio at the beginning of 2001. In Figure 6, we graph the value of $1 for the three primary industries and the overall market; in Figure 7, we graph the portfolios based on the insurance sub-industries.

We observe that the compounded returns of these portfolios in Figure 6 diverge around 2004, leading up to the financial crisis, converge during the peak of the crisis, and then diverge following the crisis. Prior to the financial crisis, depository institutions outperformed the other components of the financial services sector, but both depository and non-depository institutions underperformed both the market and insurers following the financial crisis.

The insurance industry returns, shown in Figure 7, are like those of the general market. Within the insurance industry, the A&H insurers are most volatile, outperforming the other lines of insurance. Financial guarantee

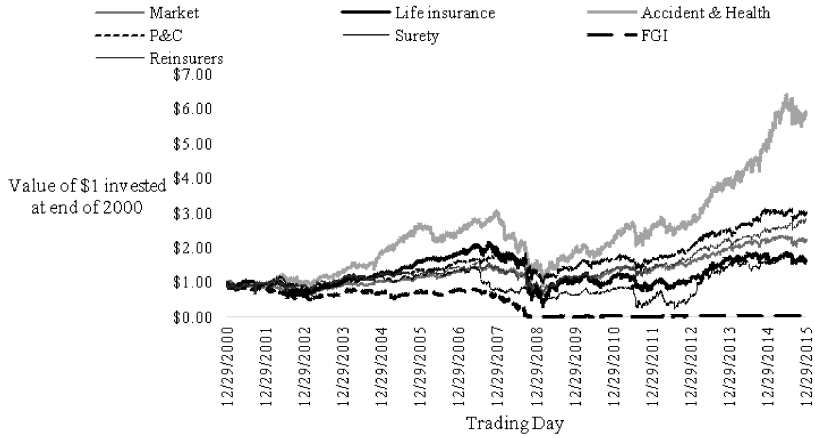



**Fig. 7.** Compounded returns based on type of insurance.

insurers perform worse than the other insurers and the market, underperforming all other forms of insurance at that time. Note, however, that only two publicly traded firms represent this industry following the financial crisis. Interestingly, surety insurers are the second-worst performers beginning around the time of the financial crisis.

As further description of the stock return performance of the different types of financial services companies, we calculate idiosyncratic volatility for each portfolio using 250-day moving average windows to control for the market movements.[33] This allows systematic risk to change and permits us to isolate the idiosyncratic components of the returns. We provide graphs of the idiosyncratic risk in Figure 8 (by major financial service groupings) and Figure 9 (by type of insurance). In Figure 8, we see that non-depository institutions appear to have the greatest idiosyncratic risk during the financial crisis, with depository institutions and insurance portfolios exhibiting similar, elevated idiosyncratic risk during the crisis. In Figure 9, we can attribute some of insurers' increased idiosyncratic risk to the FGIs. Surety insurers also appear to contribute to insurer

[33]We use a method similar to Semaan and Drake (2011). We define the idiosyncratic volatility as the difference between the total variance of stock returns in a moving 250-day window and the systematic risk over the same window. We define systematic risk as the ratio of the product of the correlation of the portfolio's returns and the portfolio's standard deviation to the variance of the market, each calculated using a moving 150-trading day window, and using the CRSP value weighted index with dividends as the market proxy. The general results are not sensitive to the choice of market index or the span of time used in the calculation.

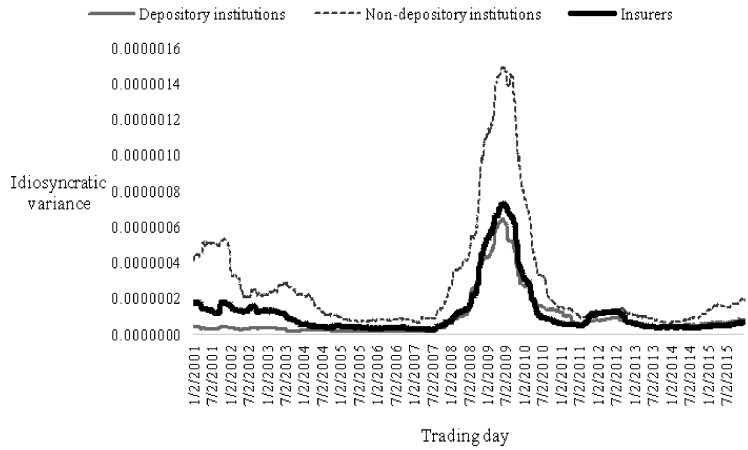



**Fig. 8.** Idiosyncratic risk of financial service firms.

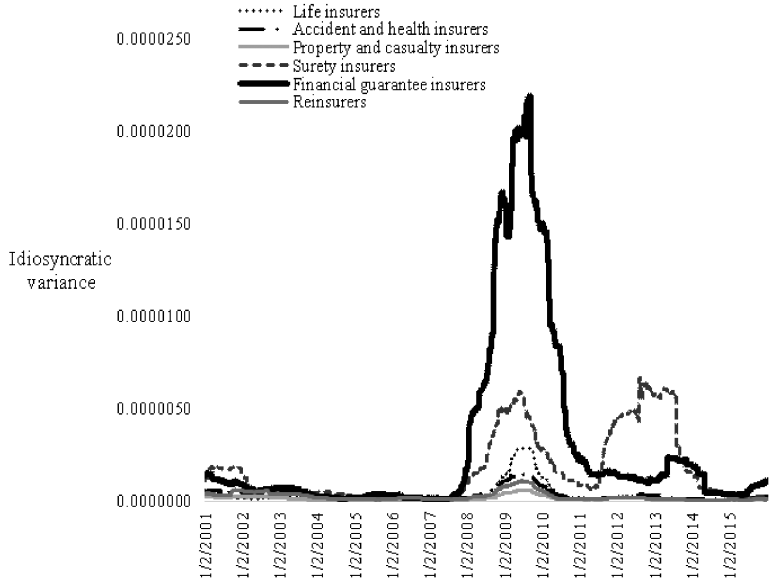
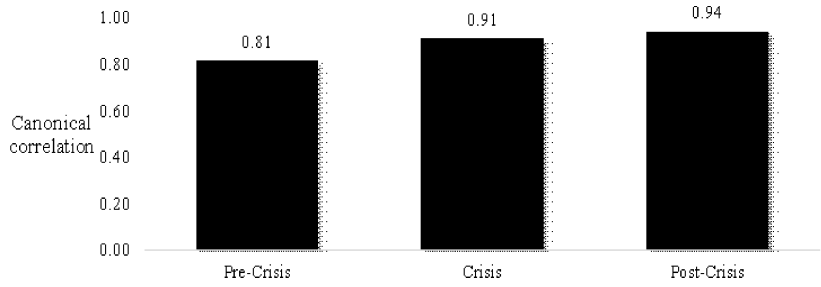



**Fig. 9.** Idiosyncratic risk by type of insurance.

idiosyncratic risk exhibiting two distinct periods of high volatility, with the second period beginning in 2011 and continuing through 2013.

In addressing the systemic nature of the insurance industry, we focus on the interconnections among financial service industries using principal

**Panel A—Canonical correlation for the three intervals.**




**Panel B—Canonical correlation for each year, 2001–2015.**

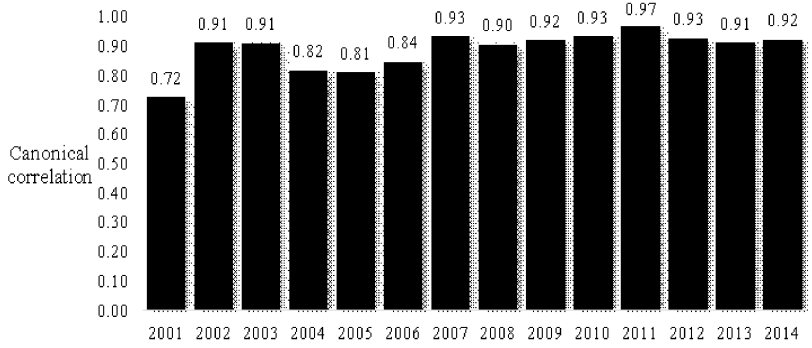



**Fig. 10.** Canonical correlation among financial service portfolios.

components analysis and Granger causality. From previous evidence, we know that there is interconnectedness among financial service firms, and we summarize this interconnectedness using canonical correlation of the portfolio returns, estimating the multiple correlation coefficient of portfolio returns for the non-insurance portfolios and the insurance portfolios. As we show in Figure 10, Panel A, the canonical correlation, relating the two non-insurance portfolios to the six insurance portfolios over time, increases from 0.81 before the crisis to over 0.93 after the financial crisis.[34] This supports the consensus that interconnectedness increased during the financial crisis. We show the correlation year by year in Panel B of this

[34]The canonical correlation analysis does provide information on which of the portfolios is most highly correlated with each of the canonical factors; we will discuss this later in the context of principal components analysis.

figure. It is evident that the correlation among the portfolio returns has increased from before to after the financial crisis, with a peak in 2011.

As we noted, many researchers have identified characteristics of different types of insurance companies that may lead to interconnectedness; the challenge in identifying this risk is to first identify the types of financial service firms with the highest degree of interconnectedness, which is an empirical issue.

## METHODOLOGY

We address interconnectedness empirically, investigating the connectedness of different types of insurers to other financial service industries using security returns. Using the daily returns of value-weighted portfolios, we use different approaches to address the potential for interconnectedness of insurance companies with other financial service companies, and as to whether the interconnectedness differs among the different types of insurance companies. The latter analysis is key in identifying industries and firms with systemic risk characteristics.

We use two approaches to address the risk characteristics of financial firms. The first is principal components analysis, where we identify whether there are common influences among the industries. The second is Granger-Causality tests to examine the directional relation in correlations among the different types of financial firms.

### Principal Components Analysis

We use principal components analysis to determine the commonality of factors that influence the returns of the different portfolios. The results of this analysis provide information on whether the same factor or factors explain the returns of these portfolios. In general, principal components analysis (PCA) is a nonparametric, linear transformation of a data matrix to a new coordinate system. Using PCA, we extract a structure from a dataset that is otherwise not noticeable or obvious. PCA does this by restating the dataset, filtering out noise, and identifying an orthogonal set of components that explain the variation in the data. The assumption of linearity forms a basis for the resulting components—the principal components.

We decompose the covariance matrix of monthly portfolio returns using principal components analysis. For example, if the first $K$ principal components, the $F_{it}$, i = 1 to $K$, explain most of the variability in returns, the model is:

$$R_{jt} = \alpha_j + \delta_1 F_{1t} + \ldots + \delta_K F_{Kt} + \varepsilon_{jt} \quad (1)$$

where $E[\varepsilon_{jt}\varepsilon_{j't}] = 0$ for any $j \neq j'$. Using matrices, the covariance matrix $\Sigma$ of the vector of returns is:

$$Var[R_t] \equiv \Sigma = Q\Theta Q', \ \Theta = \begin{bmatrix} \theta_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \theta_N \end{bmatrix} \quad (2)$$

where the diagonal elements of $\Theta$, $\Theta_1$ through $\Theta_N$, are the eigenvalues, and $Q$ is the matrix of eigenvectors.[35] An eigenvector is a vector that satisfies equation (2), and there may be any number of eigenvectors, though each will explain a different proportion of the variation in returns.

The first principal component (PCA1) is the direction in which the greatest variance lies. The second component (PCA2) is the direction in which the next largest variance lies, and so on. The number of components depends on the data, but, theoretically, there are as many components as there are input variables. However, there are stopping rules that we may apply based on the percentage of total variation explained by components.

From the principal components analysis, we determine:

(1) How the returns of each type of financial service firm relate to the unspecified, yet orthogonal, principal components; and
(2) The proportion of the variation in returns explained by each successively important principal component.

## Granger-Causality Tests

We apply linear and non-linear Granger causality tests to investigate the possibility of a lead-lag relationship interpreted as contributing to systemic risk. We test for causality using six lags.[36] Representing the series of daily portfolio returns as $X$ and $Y$, the linear inter-relationships are:

$$X_t = \Sigma_{j=1}^{m} a_j X_{t-j} + \Sigma_{j=1}^{n} b_j Y_{t-j} + \varepsilon_t \quad (3)$$

$$Y_t = \Sigma_{j=1}^{m} c_j X_{t-j} + \Sigma_{j=1}^{n} d Y_{t-j} + \eta_t \quad (4)$$

where $\varepsilon_t$ and $\eta_t$ are uncorrelated white noise processes, $a_j$,$b_j$,$c_j$,$d_j$ are coefficients in the model, and m and n are the number of lags which

[35]If the return equation holds, it can be shown that as the size of the cross section, N, increases without bound, exactly $K$ normalized eigenvalues of the covariance matrix approach positive finite values in the limit (it is the case that the remaining eigenvalues approach 0).

[36]The results are not sensitive to the number of lags beyond two.

minimize the Bayesian Information Criterion (BIC). If $Y$ does not cause $X$, then $b_1 = b_2 = \ldots = b_n = 0$; if $X$ does not Granger-cause $Y$, the $c_j$ will be zero.

The test of causality is based on the Chi-square test of the null hypothesis that the coefficients $b_j$ or $c_j$ are equal to zero. We estimate equations (3) and (4) and calculate the Chi-square test statistic with $X$ as the set of financial institution portfolios and $Y$ for the set of insurance portfolios, and then repeat this using only a specific insurance type portfolio for $Y$. If we reject the null hypothesis of the $b_j = 0$, we are concluding that X is better predicted by both $Y$ and $X$ than by $X$ alone. For example, when testing banks' returns as the Y and insurance companies' returns as the $X$, a rejection of the null hypothesis indicates that banks' returns are better predicted with both bank and insurance companies' returns, compared to banks' returns alone. On the other hand, if we fail to reject the null hypothesis, we are concluding that the returns of the type of institution that we designate as $X$ do not explain the returns of the institution that we designate as $Y$.

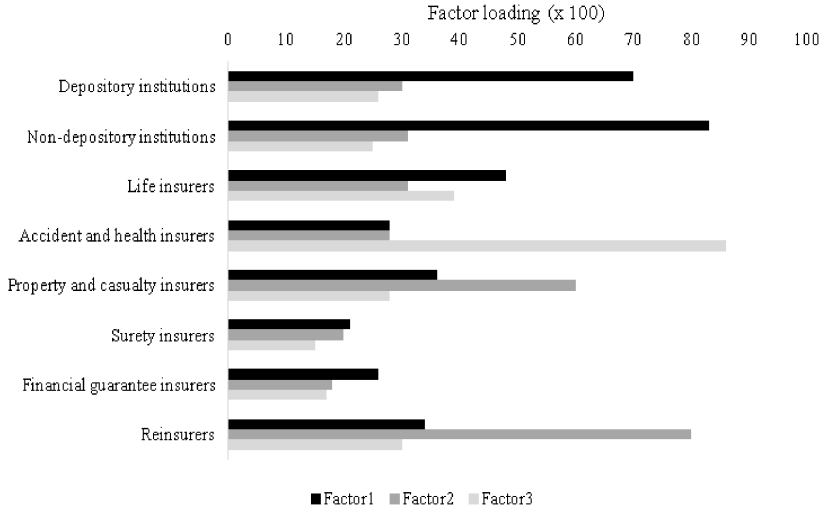
# RESULTS

## Principal Component Analysis

We estimate principal component analysis using the eight value-weighted portfolios for the financial services industries; we estimate the principal components for the entire period, and for the three intervals, as we show in Figure 11. The factor loadings indicate the importance of the principal component in explaining the portfolio's returns: the higher the loading, the more important the component. In Panel A, we provide the factor loadings on the first three factors, which account for over 90 percent of the variation in the portfolios' daily returns over the entire sample period. As we show in Table 1 Panel A and Figure 11 Panel A, depository institutions, non-depository credit institutions, and life insurers load significantly on the first factor, whereas P&C and reinsurers load significantly on the second factor. The third factor is significant for A&H insurers only. From these findings, we conclude that the only type of insurer whose returns are related to a similar factor as banking institutions (that is, depository and non-depository financial institutions), are life insurers.

These results are also consistent with those of Kritzman, Li, Page, and Rigobon (2011), who refer to the variation explained by a specific number of factors as the absorption ratio. The absorption ratio, they contend, indicates the degree of unification of risk sources and, thus, is a measure of the fragility of a system, and hence systemic risk.[37] The absorption ratio, as the sum of the variation explained by the first two factors, for the entire

**Panel A**—Factor loadings for the financial services industries for first three principal components: entire period




**Panel B**—Factor loadings for the financial services by industry for first principal component: by interval

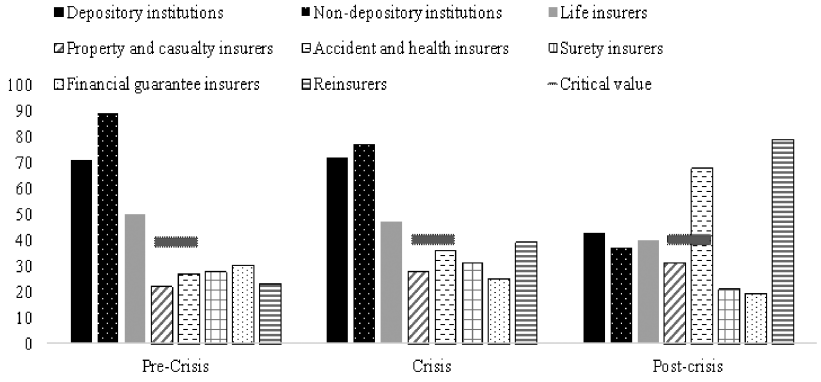



**Fig. 11.** Factor loadings for the financial services sector.

[37]Specifically, Kritzman et al. (2011) define the absorption ratio as "the fraction of the total variance of a set of assets explained or absorbed by a finite set of eigenvectors." They explain that a high absorption ratio indicates more unified risks and, therefore, a higher degree of systemic risk because shocks can quickly spread.

**Table 1.** Factor Loadings for Financial Services Portfolios

**PANEL A**—FACTOR LOADINGS BY PORTFOLIO AND FACTOR: ENTIRE PERIOD
Rotated factor loadings for the first three factors estimated using the daily returns of the eight portfolios

| | Factor loadings (x 100) | | |
|---|---|---|---|
| Financial service industry | Factor 1 | Factor 2 | Factor 3 |
| Depository institutions | 70* | 30 | 26 |
| Non-depository institutions | 83* | 31 | 25 |
| Life insurers | 48* | 31 | 39 |
| Accident and health insurers | 28 | 28 | 86* |
| Property and casualty insurers | 36 | 60* | 28 |
| Surety insurers | 21 | 20 | 15 |
| Financial guarantee insurers | 26 | 18 | 17 |
| Reinsurers | 34 | 80* | 30 |

*Indicates statistically significant at the 5 percent level.

**PANEL B**—ABSORPTION RATIOS BY PERIOD
The one-factor and two-factor absorption ratios for the principal components analysis using the daily returns of eight portfolios.

| Time frame | Absorption ratio: First component | Absorption ratio: First two components |
|---|---|---|
| Entire period | 71% | 79% |
| Pre-crisis | 67% | 74% |
| Crisis | 77% | 84% |
| Post-crisis | 72% | 80% |

*Note:* We decompose the covariance martrix of monthly portfolio returns using principal components analysis and estimate the factor loadings on each of the financial service industries. We show the factor loadings over the entire period of study, and then focus on the explanatory power of the components by time frame. The absorption ratio is the percentage of the total variance of the returns explained by the component or components.

sample period for the financial services industries for our study is 79 percent, but as we show in Table 1, Panel B, this ranges from 74 percent Pre-crisis to 84 percent during the crisis. Similarly Billio et al. (2012) observe correlations among returns of securities increase in periods of market stress.

We show the factor loadings for the first factor broken down by period in Panel B of Figure 11. The significant loading on the first factor that is apparent in the pre-crisis and crisis periods is not significant during the

post-crisis period. Over the entire period of study, the returns of depository and non-depository institutions and life insurers are driven by the same factor; however, with closer inspection, this single-factor driver is not apparent post-crisis. We conclude that viewing the entire time period provides a different picture of interconnectedness than for periods within that span. Similarly, examining the insurance industry as a whole, not accounting for differences in risk exposures arising from diverse underwriting portfolios by insurance industry, also provides incomplete information.

## Granger-Causality

We test for the explanation of portfolio returns using other portfolio returns and six lagged returns for each set of portfolios. We estimate the relations for each of the three intervals. We test the following two sets of variables, labeled Set 1 (banking) and Set 2 (insurance):

| **Banking portfolios** | **Insurer portfolios** |
|---|---|
| Depository institution | Life insurers |
| Non-depository credit institutions | Accident and health insurers |
| | Property and casualty insurers |
| | Surety insurers |
| | Financial guarantee insurers |
| | Reinsurers |

In the first round of tests, we examine if banking portfolios explain or Granger-cause insurer portfolio returns, and if insurer portfolio returns explain bank portfolio returns. In the second round of tests, we study specific insurer portfolio returns' effect on the variation of banking portfolio returns. For example, we test whether the returns of the life insurance portfolio Granger-cause or explain the returns of the banking portfolio. We repeat this second round for each insurance portfolio individually. Our goal is to examine and test whether the returns on specific types of insurance companies influence banking returns.

In the third round of tests, we look at whether banking portfolio returns explain the individual insurer portfolio returns. For example, we test whether the returns on the portfolios of financial institutions, depository institutions, and non-depository institutions affect returns on the portfolio of life insurance companies, and vice versa. Our goal is to examine and test whether the returns on banking securities explain the returns on individual insurance portfolios.

We present the results of our tests in Table 2. In the first round of tests, the returns on insurer and banking portfolios appear interconnected, with significant interconnectedness in both directions before and during the crisis. Post-crisis, however, the directionality is significant only in the case of insurance returns influencing banking returns. These results provide support for Billio et al. (2012) and Acharya et al. (2010), who find firms in the financial industry are interconnected with insurers being one possible origin of systemic risk.

When we analyze the relationships in the second and third rounds, we see a different picture. Regarding insurer returns influencing banking returns, we see significant influence before the crisis, except for A&H insurers. During the crisis, no evidence is found of insurer returns influencing banking returns, and post-crisis this influence is limited to P&C insurers, surety insurers, and FGIs. The findings with respect to the P&C insurers may be due to feedback influence from their connection to reinsurers. The factors behind FGIs' influence over banking returns remains the same. FGIs write long-term products and assets "wrapped" years ago that are still maturing. The remaining FGIs continue to underwrite business. Banks and surety insurers are highly correlated. Banks will not make loans for certain projects unless the project provided is bonded by a surety insurer; therefore, it is reasonable that surety insurers influence banking returns in times other than a recession. Both banks and surety insurers are significantly correlated with the economy. If the economy does well, lending and building projects requiring surety bonds increase. P&C insurers also depend on a healthy economy. The better the economy, the more insurance is needed. For example, in personal lines such as automobile and homeowners', coverage is mandated by the states or banks when making loans.

Examining the results of the influence of banking returns on insurer returns, we see some influence before, during, and after the crisis. Before, during, and after the crisis, we see that banking returns influence FGI returns. This finding is in line with intuition, given the minimal number of companies that drove the returns of the entire FGI industry and their interrelation with the financial services industry. In addition, we find that banking returns influence surety insurers pre-crisis and life insurers during the crisis. The influence on surety insurers pre-crisis aligns with the increase in idiosyncratic risk for these insurers during the technology bubble of the early 2000s. The influence on life insurers during the crisis may be due to the increased market risk and interest rate risk in the economic downturn. Post-crisis, we see that the returns for A&H, P&C, FGI insurers, and reinsurers are affected by banking returns, but there is no longer an influence on life insurers. The bottom line of this analysis is that

**Table 2.** Granger-Causality Tests

Granger causality tests using different directionality applied to the daily retuns of the eight portfolios.

| Explained Y | Explaining X | Pre-crisis Chi-square | Pre-crisis p-value | Crisis Chi-square | Crisis p-value | Post-crisis Chi-square | Post-crisis p-value |
|---|---|---|---|---|---|---|---|
| Depository and non-depository | Insurance | 104.47 | 0.0003* | 77.09 | 0.0678* | 102.78 | 0.0005* |
| Insurance | Depository and non-depository | 107.16 | 0.0002* | 132.03 | <0.0001* | 73.76 | 0.1092 |
| Depository and non-depository | Life insurers | 21.13 | 0.0202* | 7.40 | 0.6871 | 4.88 | 0.8991 |
| Depository and non-depository | Accident and health insurers | 14.80 | 0.1393 | 16.43 | 0.0880 | 13.95 | 0.1754 |
| Depository and non-depository | Property and casualty insurers | 21.19 | 0.0198* | 12.72 | 0.2398 | 19.41 | 0.0354* |
| Depository and non-depository | Surety insurers | 26.43 | 0.0032* | 5.22 | 0.8759 | 36.04 | <0.0001* |
| Depository and non-depository | Financial guarantee insurers | 21.91 | 0.0156* | 16.21 | 0.0937 | 27.50 | 0.0022* |
| Depository and non-depository | Reinsurers | 29.32 | 0.0011* | 18.03 | 0.0544 | 10.01 | 0.4395 |
| Life insurers | Depository and non-depository | 10.41 | 0.4049 | 23.82 | 0.0081* | 10.41 | 0.4053 |
| Accident and health insurers | Depository and non-depository | 12.43 | 0.2575 | 6.03 | 0.8126 | 20.11 | 0.0283* |
| Property and casualty insurers | Depository and non-depository | 15.89 | 0.1920 | 12.22 | 0.2703 | 24.85 | 0.0056* |
| Surety insurers | Depository and non-depository | 18.61 | 0.0455* | 14.27 | 0.1609 | 17.58 | 0.0624 |
| Financial guarantee insurers | Depository and non-depository | 21.04 | 0.0208* | 45.51 | <0.0001* | 51.35 | <0.0001* |
| Reinsurers | Depository and non-depository | 6.21 | 0.7971 | 17.88 | 0.0571 | 24.07 | 0.0074* |

*Note:* We estimate linear and non-linear Granger causality tests to investigate the possibility of a lead-lag relationship between financial service industry returns that would indicate systemic risk contributions. We test for causality using six lags. Representing the series of daily portfolio returns as $X$ and $Y$, the linear interrelationships are: $X_t = \Sigma_{j=1}^{m} a_j X_{t-j} + \Sigma_{j=1}^{n} b_j Y_{t-j} + \varepsilon_t$ (equation 4), and $Y_t = \Sigma_{j=1}^{m} c_j X_{t-j} + \Sigma_{j=1}^{n} d Y_{t-j} + \eta_t$ (equation 5), where $\varepsilon_t$ and $\eta_t$ are uncorrelated white noise processes, $a_j$, $b_j$, $c_j$, $d_j$ are coefficients in the model, and m and n are the number of lags which minimize the Bayesian Information Criterion (BIC). If $Y$ does not cause $X$, then $b_1 = b_2 = \ldots = b_n = 0$; if $X$ does not cause $Y$, the $c_j$ will be zero. We report the Chi-square and corresponding p-values for these tests. A statistically significant Chi-square value implies that $X$ Granger-causes $Y$; that is, $Y$ is better predicted by both $X$ and $Y$ than by $Y$ alone.

while insurer returns influence bank returns, the type of insurer influencing bank returns has changed over time.

## CONCLUDING REMARKS

Consistent with other studies, we find that there is connectedness of equity returns between and among industries within the financial sector. We support the idea that there is substantial feedback from banking firms to insurance firms, and substantial feedback from insurance firms to banking. The results for life insurers are mixed with life insurers explaining bank returns only in the pre-crisis time period. We do find consistent support across all time periods that A&H insurers are not significantly interconnected with other financial segments.

However, we find that the primary drivers of the feedback between insurance firms to banking post-crisis appear to be from property and casualty, financial guarantee, and surety insurers. Using SRISK we find financial guarantee firms, which experienced a high risk of capital shortfall during the crisis, have levels of SRISK suggesting little capital shortfall risk by 2016.

It is important to note that the primary insurance industries affecting banking appear to change over time. The finding that P&C insurers Granger-cause bank returns before and after the crisis, but not during the crisis, is unexpected. However, this result is understandable considering that P&C insurers provide coverage for catastrophic events—several of the worst catastrophic losses in the U.S. occurred during the study period—and the related wealth effects of these events.[38] It is likely these results are driven, at least in part, by these unpredictable, catastrophic events unique to the P&C industry. On the other hand, we show life insurers' underwriting portfolios consist of highly predictable exposures of long duration, resulting in investment portfolios and allocations similar to commercial banks. We conclude that life insurers are exposed to similar risks as banks through investments and some of their securities products, such as securities lending, as well as asset management services. P&C insurers and

[38]The period of November 1999 to late February 2007 included five of the top-ten costliest catastrophes (CAT) in the U.S.: the 9/11 terrorist attack and Hurricanes Charley, Ivan, Katrina, and Wilma. Hurricane Rita also occurred during the same time as Katrina and Wilma, aggravating conditions. The subsequent relatively short crisis period included Hurricane Ike, the 6th mostly costly CAT. The post-crisis period includes two of the ten costliest CATs: Hurricane Sandy and the storms of April 2011 that included flooding, hail, wind, and tornadoes that devastated Tuscaloosa, AL. Statistics obtained from URL: www.iii.org/fact-statistic/hurricanes.

reinsurers' underwriting profiles and investment allocations are different from those of life insurers and commercial banks.

Our results provide insight into the conditions under which each insurance segment may affect commercial banks. Interestingly, the relatively new measure, SRISK, does appear to adequately reflect most of our findings during our study period. For example, the FGIs' increased risk and influence on capital markets during the crisis is illuminated, while A&H insurers are never a concern. Similarly, AIG's operations are significantly different post-crisis and that structural change is reflected as well.[39] SRISK may be a useful tool when identifying firms to evaluate or re-evaluate the SIFI designation.

A primary contribution of this study is that we show that interconnectedness varies by type of insurance company, with one type, A&H insurers, showing no interconnectedness and others showing substantial interconnectedness at times. Another contribution is our finding that time periods with different market conditions have a significant impact, providing important implications for regulators. Specifically, three industries—P&C, Surety, and FGI—Granger-caused bank returns pre- and post-crisis. Our expanded time period adds important information on interconnectedness post-crisis not available from earlier studies published relatively soon after the financial crisis. Using principal components and Granger-causality tests we show that insurers specializing in different types of risks experience diverse reactions to risk and return in each market period, while non-insurance, risk-bearing financial firms' reactions are similar to each other. Further, we find that post-crisis, P&C and FGI stock returns have bi-directional feedback with banks' returns post-crisis, whereas the returns of life insurers and banks no longer Granger-cause each other. However, SRISK indicates that, as of mid-2016, life insurers have the highest systemic risk, followed by property and casualty insurers.

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[39]We recognize that in the case of AIG, SRISK would not have raised concern prior to the financial crisis with the exception of the spike in 2004.

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