Dynamic Conditional Correlations between the Insurance Sectors and the Overall Market: Evidence from the 2008 Financial Crisis

Raja Bouzouita
University of Central Missouri

Mihaela Craioveanu
University of Central Missouri

ABSTRACT

The impact of the 2008 great recession on the dynamic conditional correlations of insurance stock returns with the stock market index is analyzed. A DCC GARCH model is applied to estimate the correlation of the industry returns with the market over time. Daily stock returns for insurance companies covering the period from 1990 to 2011 comprising four segments are used. The analysis reveals an increased linkage between the US stock market and the different insurance sectors. This result potentially reduces the effectiveness of portfolio diversification.

Keywords: Financial Crisis, Insurance Industry, DCC GARCH, Correlation, Volatility.

INTRODUCTION

During the 2007-2009 financial crisis, the volatility of stock prices, especially among financial institutions, spiked markedly, raising concerns about the viability of the U.S. financial system and the potential impact on the wider economy. Similarly, insurance companies' stock returns exhibited large swings affecting the performance of the industry. The volatility of stock returns is a concern to investors, analysts, brokers, and regulators. Understanding return volatility and market correlation is the cornerstone of asset allocation decisions, hedging, and systemic risk calculations. Several studies (Lee and Kim 1993, Chiang et al. 2007) show that during tumultuous periods, stock returns' correlation increases significantly. This pattern is referred to as financial contagion, defined as the spread of financial shock from one market to another. The contagion effect during a major financial crisis significantly reduces the benefits of holding a diversified portfolio.

This paper models the performance of the insurance industry correlation returns with the market and return volatility in the period surrounding the 2007-2009 financial crisis. The insurance industry is multi-dimensional. We conduct a segment analysis of the insurance industry, with substantial time series variations in volatility/correlation profiles, to identify the impact of the financial crisis across lines of business. We apply a DCC GARCH model (Engle 2002) to the insurance stock returns to estimate the volatility and correlation over the period of 1988-2010. The relatively long estimation period was marked by impactful events such as rising and falling interest rates, economic recessions, natural catastrophes, 9/11, and obviously the subprime mortgage crisis. These events may cause instability and shocks in the time series of the stock returns. The tests show that towards the end of 2008, there is a marked increase in the volatility for the segments with the surety and guarantee segment showing the steepest increase. The spike in volatility was temporary as by the end of 2009, the volatility returned to the pre-crisis levels. With respect to the correlation, the four segments experienced an increase making insurance stocks more sensitive to market movements with higher correlation values for life, accident & health, and property & casualty. In contrast, the surety and financial guaranty sector's correlation increased at a lower than the rest of the segments.

LITERATURE REVIEW

In the summer of 2008, the volatility of stock prices, especially in the banking sector, had spiked dramatically causing panic among policymakers and industry leaders worrying about the overall health of the financial system and the economy. Several insurance companies made headline news such as MetLife, Aetna, and AIG, in particular about their role in the financial crisis. Like the rest of the financial sector, the insurance industry stocks experienced large swings around the crisis period. In this study, we analyze the behavior of the insurance sector volatility during the financial crisis to test whether the response to the crisis was uniform across segments of the industry. The widely popular GARCH estimation is often used to model the behavior of asset returns. The basic GARCH model and its extensions have been applied to the insurance stock returns in several scholarly papers. Brewer et al. (2007) analyze the effect of interest risk on life insurance companies' returns. They find evidence that life insurance stocks are highly correlated with the market index (beta = 0.77) and stock return volatility is time-varying with a pattern of alternating high values and low values. Most importantly, their tests show that the volatility in the life insurance sector is slow to revert to pre-shock levels and would linger over

several periods. The authors test the impact of the change in the monetary policy on the volatility of life insurance returns in the period of 1979-82 and afterward. They find that the Federal Reserve's measures had significantly exasperated the interest rate risk for insurance companies.

Expanding on the work of Brewer et al. (2007), Carson et al. (2008) analyze market and interest risks for three different sectors of the insurance industry: life, accident & health (A&H), and property & casualty (P&C). The authors confirm the findings of Brewer et al. (2007) that the returns of the insurance segments are less risky than the market having betas less than one. In terms of volatility, the life insurance segment had the highest estimate. They also tested the impact of the passage of the Gramm-Leach-Bliley Act (GLBA) in 1999 on the different insurance returns and volatility. They found that the stock return volatility increased significantly for A&H and P&C following the passage of GLBA. The above studies predate the financial crisis and show that the volatility of insurance stock returns is impacted by changes in the economic and legal environment. Other events that directly impact the insurance industry such as natural disasters, and the 9/11 terrorist attack have been the focus of a study by Thomann (2013) who finds that natural catastrophes increase insurance stocks' volatility but reduce the market correlation.

The financial crisis was a major economic event and prompted a flurry of research about the causes, impact, and to some extent the role of the insurance sector in the crisis. While most studies focused mainly on the banking industry, others include the insurance sector as part of the wider financial services industry. Drake et al. (2017) analyze insurance companies' stock returns risks as a component of the whole financial system. The results show that few insurance business lines contributed to the financial systemic risk. The analysis provides evidence that only financial guarantee and surety insurers are interconnected to bank risks. Bouzouita and Craioveanu (2019) focus exclusively on the entire insurance industry. They use a DCC GARCH model to estimate the correlation and volatility of five insurance segments. The correlation estimates show higher codependence with market risk for the life and property-casualty sectors. This result could be due to the size of these companies as investors started to worry about outsized financial companies coined with the phrase "too big to fail" and whether these large insurance companies could be classified as SIFI (Systemically Important Financial Institutions) by regulators. The surety and guarantee line of business experienced the highest volatility compared to the other sectors whose volatility increased also.

In conclusion, the volatility and correlation of insurance stocks have been proven to be affected by major economic events, man-made disasters, and natural catastrophes. This study examines the behavior of the conditional correlation and volatility of insurance returns over three subperiods of the financial crisis. The analysis is conducted by insurance segments.

The remainder of the article is structured as follows. The next section offers an overview of the insurance industry. Section 3 discusses the dataset. Section 4 describes the estimation method. Section 5 provides a summary of the results, and the final section concludes the paper.

OVERVIEW OF THE INSURANCE INDUSTRY

The insurance industry plays a major role in the U.S. economy. According to the U.S. Bureau of Economic Analysis, insurance companies contributed over $500 billion, or 2.7 percent of the U.S. gross domestic product, and employed around 2.6 million individuals in 2016 (Insurance Information Institute, 2016). Insurance companies perform important economic functions such as risk transfer, financial intermediation, and loss payment. Even though the core

business of insurance companies is protection against unexpected losses, there are different sectors designed for specific risks. In fact, state laws prohibit insurance companies from combining personal and liability risks. For the purpose of this study, we consider the following segments of the insurance industry.

(1) Life insurance companies offer protection to millions of individuals who buy life insurance, income replacement, long-term care, and retirement products such as annuities. Policyholders buy life insurance to protect their loved ones in case of death and buy annuities to save for retirement. Investing in annuities has become more important as 401(k) plans have replaced private pensions in the workplace. A second reason for the popularity of annuities is the concerning financial outlook of the social security system. The data shows steady growth in the annuity considerations while sales of life insurance have been in decline. Also, businesses part of the compensation package to their employees, offer group life insurance, group disability, and group annuities. Life insurance policies and annuities are long-term contracts under which life insurance companies make commitments to pay claims in the distant future (in the case of life insurance) or could be paying benefits (annuities) for a lifetime. Therefore, life insurance companies invest the premiums and/or considerations in long-term assets to match their obligations towards their policyholders. As an industry, life insurance companies' assets are mainly comprised of bond investments. Heavy investments in fixed-income securities expose life insurance companies to interest rate risk. In the process of managing this risk, life insurance companies may become less focused on core activities (managing personal risks) but more focused on financial instruments carrying higher market risks.

(2) Property and casualty (P&C) insurance consists primarily of auto, home, and commercial insurance. P&C provides protection for assets against natural disasters and protection against lawsuits. To be approved for loans, businesses and individuals are required to buy insurance protection on vehicles and real estate; this prerequisite facilitates raising the funds needed. Many P&C companies are multiple-line insurers providing coverage for a multitude of risks, including financial guarantees. Property and casualty insurance companies invest heavily in bonds (62%); therefore, the performance of invested assets is closely related to movements in the interest rate.

(3) The health and medical insurance industry underwrites health and medical risks. For the most part, industry revenues come from premiums paid either by individuals and/or employers for fully funded insurance policies. Health insurers also generate income by providing beneficiaries with network-based health and well-being services in government-sponsored healthcare programs such as Medicare and Medicaid. In addition to premium revenues, health insurance companies generate fee income by acting as third-party administrators (TPAs) for self-funded plans under which the employer or plan sponsor is directly responsible for providing health benefits. According to Kaiser Family Foundation, the landscape of health plans has changed dramatically in the past three decades from predominantly fee-or-service plans to preferred provider organizations (PPO) plans covering about 48% in 2017.

(4) The surety and financial guaranty sector provides financial protection to borrowers such as financial institutions and local and state governments to facilitate their bond issues. It is a type of insurance that guarantees that interest and principal will be paid on time and in full in the event of default. Prior to the financial crisis, asset-backed securities (especially mortgage-backed securities) and municipal bonds were heavily insured.

DATA

Daily stock returns data were collected from the CRSP data set from January 2, 1990, through December 30, 2011. Insurance companies with the following SIC codes: 6311, 6321, 6324,

6331, and 6351 were included. Thus, the sample covers the following insurance segments: life insurers (Life), accident and health insurers (A&H) with hospital and medical service plans, property and casualty insurers (P&C), and surety insurance companies (Surety), respectively. As a measure of the market return, the CRSP value-weighted return with dividends was used. Following this screening process, a total of 208 U.S. insurance companies made up the sample.

Summary statistics for the data are presented in Table 1 (Appendix). On average, insurance daily stock returns are 0.06% which is slightly higher than the corresponding market return, measured by the CRSP value-weighted benchmark (0.041%) over the sample period. Among the four sectors, the property and casualty segment has the highest daily return, and hospital and medical service plans have the lowest daily average return. During the crisis period, as expected, all average returns were negative, except for the life insurance sector. Looking at the standard deviation of daily returns, insurance stock returns have a higher risk than the overall market with the surety business lines having the highest risk. Post-crisis period, the average daily returns are positive again, and levels of standard deviation are comparable to the full sample levels.

Table 2 (Appendix) reports the pairwise correlations of the four insurance sectors and their correlation with the market index. There are strong correlations between the individual insurance lines returns with the market benchmark measured by the value-weighted CRSP index. The market correlations are above 0.7 except for the surety line showing a 0.577 correlation. The cross-correlations between the insurance returns are the strongest between life and property and casualty. There is a substantial correlation among individual sectors. This strong correlation could be attributed to commonalities among insurance companies due to their products, investment strategies, and risk management policies.

METHODOLOGY

A Multivariate GARCH framework is used in order to analyze the insurance industry and the market simultaneously. In particular, the DCC GARCH model is used. This model simultaneously accounts for time-varying volatility and correlations among assets. In particular, the dynamic conditional correlation is analyzed by insurance segments during and after the financial crisis.

Volatility is an important component in any asset pricing model. One of the stylized facts of financial volatility is the phenomenon of volatility clustering, characterized by persistent periods of high and low volatility. Engle (1982) proposed the ARCH model to account for this main feature of the data. This model was further modified by Bollerslev (1986) in the form of the GARCH model.

The co-movement between financial assets is another important element in asset pricing models. Most models do not allow for a time-varying correlation, which is not consistent with what is observed in the data. One exception is the DCC GARCH Model of Engle (2002) which estimates asset volatility returns based on their historical volatility and their intercorrelations. The DCC GARCH model is an extension of the CCC GARCH model of Bollerslev (1990) which uses constant conditional correlations.

In this paper, the multivariate DCC GARCH model (Engle, 2002) is applied. The model includes the correlation between the insurance sector and the market. The insurance stock returns and the market returns, r_t, follow a conditionally Normal distribution with a mean of zero and a conditional variance given by H_t. The market returns are measured as the CRSP value-weighted

returns with the dividends index. The variance-covariance matrix can be decomposed as the product of the conditional standard deviations D_t and the correlation matrix R_t:

$$H_t=D_tR_tD_t. \quad (1)$$

D_t is a diagonal matrix containing the time-varying standard deviations from the univariate GARCH specification.

The novelty of the DCC GARCH model lies in the time-varying correlation matrix R_t. The conditional correlations have the following specification

$$R_t = diag\{Q_t\}^{-1} Q_t diag\{Q_t\}^{-1} \quad (2)$$

Where Q_t is a symmetric positive definite matrix of correlations that follows the following specification:

$$Q_t = (1 - \lambda_1 - \lambda_2)\bar{Q} + \lambda_1(e_{t-1}\, e'_{t-1}) + \lambda_2\, Q_{t-1} \quad (3)$$

With λ_1, λ_2 being non-negative scalars such that $\lambda_1 + \lambda_2 < 1$. The matrix $\bar{Q}$ represents the unconditional variance of the standardized residuals as given by $e_t = \frac{r_{it}}{\sqrt{h_{i,t}}}$.

The model is estimated in two steps. In the first step, a univariate GARCH model is specified for each insurance sector and the market. In the second step, the standardized residuals are obtained and used to estimate the correlations.

ESTIMATION RESULTS

The correlation and volatility insurance segments' estimates reveal that each sector was impacted differently by the financial crisis in terms of correlation and volatility. In the aftermath of the financial crisis, it was determined that only large financial institutions dubbed "too big to fail" were the main contributors to the crisis. Few insurance companies are considered to be large, not as sizable as mega banks, especially in the life and property and casualty sectors.

Figure 1 (Appendix) panel (a) shows the correlations between the four segments considered. The property and casualty sector moves closely together with the life insurance sector. There is higher volatility for the accident and health sector and the surety sector compared to the other two sectors, especially during the crisis period. Drake and Neale (2011) explain that during the financial crisis, surety insurance companies shifted to non-insurance activities such as selling guaranteed investment contracts, investing in municipal bonds, and participating in credit default swaps. Some of the credit swaps were on residential and commercial real estate mortgages that were the cause of the financial crisis. Therefore, these insurers were more affected by the crisis than the other insurance sectors.

Figure 1 (Appendix) panel (b) displays the conditional volatility of the four insurance sectors. A surge in volatility is noticeable for all insurance segments in particular the surety and financial guarantee companies that experienced the highest increase.

All four sectors show an increase during the crisis period, with the surety insurance sector showing the most dramatic increase. These insurers traditionally insured municipal bonds but during the period leading up to the financial crisis, the industry expanded its business by offering guarantees tied to the performance of the housing market, such as mortgage-backed securities and collateralized debt obligation. According to Drake and Neale (2011), the insurance industry had provided coverage for over $800 billion of structured finance instruments, and $1.3 trillion of municipal securities as of 2006. As the mortgage and its related structured finance securities collapsed, the potential liability of financial guarantors raised concerns among investors and regulators. Providing financial guarantees is not limited to specialty insurers. Multiple line

property and casualty insurers, to some extent, offer such guarantees, which explains the increase in the conditional dynamic correlation of these companies. The high volatility of the surety and guarantee sector was persistent for months after the onset of the financial crisis. As the conditions of the financial guarantee sector continued to deteriorate, rating agencies downgraded these companies (Drake and Neale (2011)) as the extent of the potential liability became apparent to investors. The life insurance segment also experienced a pronounced increase in volatility. This can be explained by the fact that these companies have steadily shifted toward non-insurance activities such as trading in derivatives, and offered guarantees on some of its insurance products.

To focus on the crisis period, Figure 2 (Appendix) shows both the estimated conditional correlation and the conditional volatility during the crisis period starting January 2007 through June 2009. There is no consensus in the literature about the onset of the crisis, January 2007 was picked. Figure 2 shows that during the crisis period, there was an increase in the return correlation with the market index while noticing that the surety line experienced much higher volatility, as shown in panel (b), than the other insurance sectors due to its direct ties to the turmoil in the mortgage market. It is observed that the life insurance and property casualty sectors experienced almost the same pattern in correlation and volatility.

Figure 3 (Appendix) panel (a) shows that the conditional correlation for the life segment and the property and casualty segment move closely together. This could be due to the possibility that some life insurance companies especially the largest firms own stocks in the property & casualty companies. These two segments tend to dominate the insurance industry in terms of size. Among the four segments, the surety line has experienced the largest increase in the conditional correlation with the market. These companies are specialty insurers and tend to be less diversified than their life and property& casualty counterparts.

Figure 4 (Appendix) shows the correlation during the post-financial crisis period. We notice that, again the surety sector's correlation remains very volatile along with accident and health. The life insurance and property and casualty sectors have a market correlation of around 0.9 and seem to follow the same pattern. Panel (b) of Figure 4 (Appendix) shows a steady decrease in the correlation volatility of life insurance, property and casualty, and accident and health. The surety line volatility remained high and then eventually decreased to levels close to the volatility of the other insurance sectors.

In the second stage of the analysis, we use the estimated correlations from the DCC GARCH model to investigate any changes in the conditional dynamic correlations of the different insurance segments and the wider market measured by the CRSP index. The sample was divided into two periods: the crisis period and the post-crisis period. The choice of dates is somewhat arbitrary as the exact starting and ending points of the financial crisis is still subject to discussion in the literature. The crisis period covers the period from February 27, 2007, to June 30, 2009, while the post-crisis covers the period from July 1, 2009, to December 31, 2010. The following model was estimated:

$$Q_{ij,t} = \alpha_{ij} + \lambda_1 Q_{ij,t-1} + \delta_1 D_{1,t} + \delta_2 D_{2,t} + e_{ij,t} \quad (4)$$

Where $Q_{ij,t}$ is the pairwise conditional correlation coefficient between the stock market return (i) and the stock returns insurance segments j= life, accident and health, property and casualty, and surety. The dummy variable ($D_{1,t}$) is set to a value of one for the period from February 27, 2007, through June 30, 2009, and zero otherwise. The dummy variable $D_{2,t}$ takes the value of one for

the post-crisis period from July 1, 2009, through December 31, 2010, and zero otherwise. The number of observations in each period varies by segment, as the number of companies is not the same. The AIC and SIC criteria is used to determine the number of lags to include in equation (7). This method indicates that an autoregressive specification with one lag is the best model for all sectors.

A test for heteroscedasticity in the conditional correlations is performed using Engle's ARCH LM statistic. The results find evidence of significant heteroscedasticity for all insurance segments. Therefore, a GARCH (1,1) model for the conditional variance is selected. The following variance equation of the correlation is estimated using the dummy variables corresponding to the same periods as the mean equation of the correlations.

$$h_{ij,t} = \omega + \phi\epsilon^2_{ij,t-1} + \beta_1 h_{ij,t-1} + \theta_1 D_{1,t} + \theta_2 D_{2,t} + \tau_{ij,t} \quad (5)$$

Table 3 (Appendix) reports the estimation results of the GARCH (1,1) model from equations (4) and (5). In the mean equation, the coefficient for the crisis dummy variable, δ_1, is positive and significant for property and casualty and surety, indicating that the correlation during the first phase of the crisis is significantly different compared to the correlation in the pre-crisis period for these two segments. The paths of the correlations for the four sectors in the first part of the crisis can be seen in Figure 2 (Appendix) panel (a). Compared to the pre-crisis period, the first phase crisis correlation increases by 0.0012 for property and casualty and 0.0054 for surety. This corresponds roughly to a 14% increase for property and casualty and a 19% increase for surety. The δ_1 coefficient is not statistically significant for life and accident and health, indicating that the correlation in the pre-crisis period is not significantly different when compared to the correlation for the crisis period for these two segments.

In the post-crisis period, the coefficient of the second dummy variable δ_2 is positive and significant in the life and accident and health sectors and not significant in the property and casualty and surety business lines. Figure 4 (Appendix) panel (a) shows the correlations for the four sectors for the second phase of the crisis. Compared to the pre-crisis period, the post-crisis correlation with the market is 16% higher for life insurance companies and 19% higher for accident and health companies. The increase in the correlation compared to the pre-crisis period for the two insurance segments during the post-crisis period is an indication of no contagion effect from the broader market to the life and accident & health insurance industry segments. There has been an adjustment period for investors to realize the extent of the impact of the financial crisis on these two sectors. The rise of correlation may be explained by industry fundamentals rather than by herding behavior. For the remaining insurance business lines, there was no significant increase in the mean volatility during the financial crisis. This result may have been good news to investors in the other insurance segments as they did not experience higher volatility like the rest of the market and may have had the chance to rebalance their portfolio into safer assets and avoid market turbulences.

Estimates from the variance equation (5) show that the coefficient attached to the lagged squared errors and the coefficient attached to the lagged variance are highly significant for all sectors indicating the presence of volatility clustering. The results also show a significant increase in the variability of the conditional correlation for the life insurance and the accident and health sectors and a significant decrease in variability for property and casualty and surety lines of business during the post-crisis compared to the pre-crisis period. In the post-crisis period, the volatility of the dynamic conditional correlation between the different insurance segments and the

overall stock market decreased significantly except for the surety sector for which θ_2 is negative but not statistically significant. Investors remain concerned about the surety sector, the one that is more directly affected by the financial crisis than other insurance lines. This sector has provided large guarantees to mortgage issuers, and the extent of the liability of these companies remains uncertain several months after the crisis. These results provide evidence that the insurance sector stock prices stabilized, except for the surety, during the post-financial crisis period providing investors with the diversification benefits of investing in the insurance sector.

CONCLUSION

This paper examines the volatility of insurance companies' stock returns and their interdependence with the overall stock market during the 2007-2009 great recession. A DCC GARCH model which is best suited for estimating asset returns volatility as a function of their past volatility and cross-correlations is used. Given the structure of the insurance industry which is characterized by independent sectors such as P&C on one hand and life and A&H on the other, the dynamic volatility and correlation are estimated for the different insurance segments. The analysis shows that the financial crisis had a varying effect on the insurance industry across segments and across the three subperiods considered. The time-varying correlation is significantly higher during the crisis period than in the pre-crisis and post-crisis periods for life insurers. For surety and financial guarantee providers, the volatility correlation with the market returns remained high in the sub-period following the financial crisis. The results are in line with previous research that modeled the correlation and volatility of insurance stocks. Carson et al. (2008) find that the passage of GLBA in 1999 increased the volatility of returns of both P&C and A&H insurance segments. From a policy and regulatory perspective, it is important to see that insurance segments were affected differently so that the policy changes would be tailored to segments that potentially will be marred in a financial crisis to the point of becoming insolvent with a far-reaching impact on the financial system and the wider economy. From an investor perspective, the correlation results will help in the asset allocation decisions. The long-established state regulation may not be adequate because of its limited jurisdiction and does not have oversight over financial nontraditional insurance activities.

REFERENCES

Acharya, V., Engle, R., and Richardson, M. (2012) Capital Shortfall: A New Approach to Ranking and Regulation Systemic Risk, *American Economic Review: Papers & Proceedings*, 102(3):59-64.

Brewer, E., Carson J.M., Elyasiani, E. I. Mansur I. and Scott. W.L. (2007) Interest Rate Risk and Equity Values of Life Insurance Companies: A GARCH-M Model, The Journal of Risk and Insurance, Vol. 74, No.2, 401-423.

Bouzouita R. and Craioveanu M. (2019) Insurance Systematic Risk during the Financial Crisis, *Academy of Accounting and Financial Studies Journal*, Volume 23, Issue 1.

Bouzouita R., Craioveanu M., and Young A. (2012) Insurance Stock Returns Sensitivity to Changes in the Default Spread, *The Journal of Finance Issues*, Vol 10 issue 2, pages 132-139.

Baluch, Mutenga, and Parsons (2011) Insurance, Systemic Risk and the Financial Crisis, *The Geneva Papers on Risk and Insurance-Issues and Practice*, 36(1):126-163.

Bollerslev, T. (1986) Generalized Autoregressive Conditional Heteroskedasticity, *Journal of Econometrics*, 31(3): 307327.

Bollerslev, Tim (1990), "Modeling the Coherence in Short-run Nominal Exchange Rates: A Multivariate Generalized ARCH Model," Review of Economics and Statistics, 72:498-505.

Carson, James, Elyas Elyasiani, and I. Mansur (2008) Market Risk, Interest Rate Sensitivity, and Interdependency in Insurer Stock Returns, *Journal of Risk and Insurance*, Vol. 75, No.4, 873-891.

Chen, Hua, J. David Cummins, Krupa S. Viswanathan, and Mary A. Weiss (2014) Systemic Risk and the Interconnectedness Between Banks and Insurance: An Econometric Analysis, *Journal of Risk and Insurance*, Vol. 81, No 3. 623-652.

Chiang, T.C.; Jeon, B.N.; Li, H. (2007) Dynamic Correlation Analysis of Financial Contagion: Evidence from Asian Markets. *Journal of International Money and Finance*, 26, 1206-1228.

Chow, Fung, and Yeh (2018) CDS Spreads, Systemic Risk and Global Systemically Important Insurers Designations, *Journal of Insurance Regulation*, 37: 1-33.

Cummins, J. D. and Mary A. Weiss, (2014) Systemic Risk and the Insurance Sector, *Journal of Risk and Insurance*, Vol. 81, No 3. 489-527

Drake P., F. R. Neale Faith, P. J. Schorno, and E. Semaan, (2017) Risk during the Financial Crisis: The Role of the Insurance Industry, *Journal of Insurance Issues*, 40(2): 181-214.

Drake P., F. R. Neale, (2011), Financial Guarantee Insurance and the Failures of Risk Management, *Journal of Insurance Regulation*, 30:29-76.

Engle, R. (1982) Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation, *Econometrica*, 50, 987-1007.

Engle, R. (2002) Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroscedasticity Models, *Journal of Business and Economic Statistics*, 20(3), 339-350.

Grace, Martin F. (2010) The Insurance Industry and Systemic Risk: Evidence and Discussion, Working paper, Georgia State University, Atlanta, GA

Hillebrand, E. (2005). Neglecting Parameter Changes in GARCH Models, *Journal of Econometrics*, 129, 121-138.

Insurance Information Institute, Inc. (2016), New York, New York.

Lee, S. B., and Kim, K. J. (1993). Does the October 1987 Crash Strengthen the Co-Movements Among National Stock Markets? *Review of Financial Economics*, *3*(1), 89-102.

Mighri, Z., Mansouri, F. (2013) Dynamic Conditional Correlation Analysis of Stock Market Contagion: Evidence from the 2007-2010 Financial Crises, *International Journal of Economics and Financial Issues*, Vol.3, No 3, pp.637661.

APPENDIX

Table 1 Sample Statistics

Full Sample			Pre-Crisis		Crisis		Post-Crisis	
1/1 /1988-12/31/2011			1/1/ 1988-2/26/2007		2/ 27/2007-6/ 30/2009		7/1/2009-12/31/2011	
Mean		Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Insurance Segments								
Life Insurance	0.00075	0.03145	0.00078	0.0276	0.00018	0.05907	0.00169	0.03145
Accident&Health	0.00634	0.02642	0.00071	0.02454	-0.0002	0.03806	0.00123	0.02134
Property&Casualty	0.00084	0.02787	0.00057	0.02253	-0.00022	0.03824	0.00107	0.02543
Surety	0.00064	0.04519	0.00070	0.01862	-0.0007	0.08695	0.0032	0.05378
All	0.00060	0.02875	0.00068	0.02492	-0.00015	0.04628	0.00132	0.02790
Market Index (CRSP)	0.00041	0.01172	0.00051	0.00931	-0.00044	0.02049	0.00105	0.01147

The Table reports descriptive statistics for the whole sample period, pre-crisis, during the crisis, and after the crisis. The sample includes a total of 208 insurance companies representing the different segments as follows:75 life, 33 accident & health and medical service plans, 96 property & casualty, and 4 surety insurers.

Table 2 Correlation Matrix

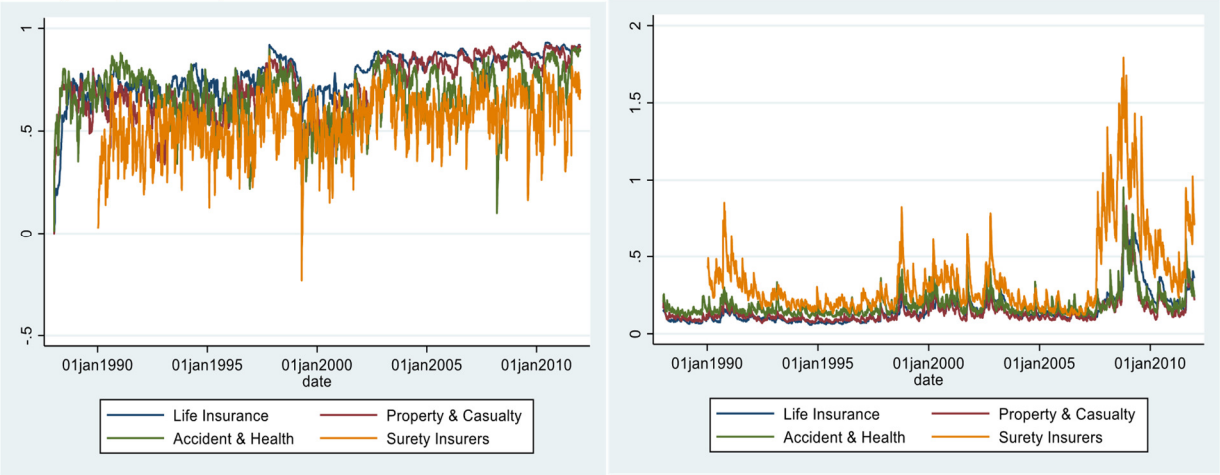
	Life	A&H	P&C	Surety	Market
Life	1.0000				
A&H	0.7496	1.0000			
P&C	0.8434	0.7608	1.0000		
Surety	0.6274	0.5255	0.6240	1.0000	
Market	0.7912	0.7342	0.7960	0.5771	1.0000

Table 3 Tests of Changes in Dynamic Conditional Correlation between Stock Market and Insurance Segments' Returns during and after the Financial Crisis.

	Life	A&H	P&C	Surety
Mean Equation				
α_{ij}	0.0158***	0.0121***	0.0084***	0.0278***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
λ_1	0.9792***	0.9828***	0.9893***	0.9485***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
δ_1	0.0034	0.0015	0.0012***	0.0054***
	(0.1603)	(0.7599)	(0.0001)	(0.0003)
δ_2	0.0026**	0.0021**	0.0006	0.0028
	(0.0063)	(0.0115)	(0.1008)	(0.2646)
Variance Equation				
ω	0.0001***	0.0002***	1.04-06***	0.0005***
	(0.000)	(0.0000)	(0.0000)	(0.0000)
ϕ	0.1084***	0.0620***	0.036***	0.0152***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
β	0.2483***	0.8126***	0.9627***	0.6546***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
θ_1	1.54E-05***	0.0002***	-9.50E-07***	-0.000187***
	(0.0063)	(0.0000)	(0.0000)	(0.0000)
θ_2	-0.0001***	-3.50E-05***	-6.27E-07***	-0.966E-06
	(-18.566)	(0.0000)	(0.0000)	(0.5027)
Q(40)	50099.72***	1.25E+08***	1.93E+05***	60543.07***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ARCH(10)	2214.62***	5493.57***	5802.22***	4350.82***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)

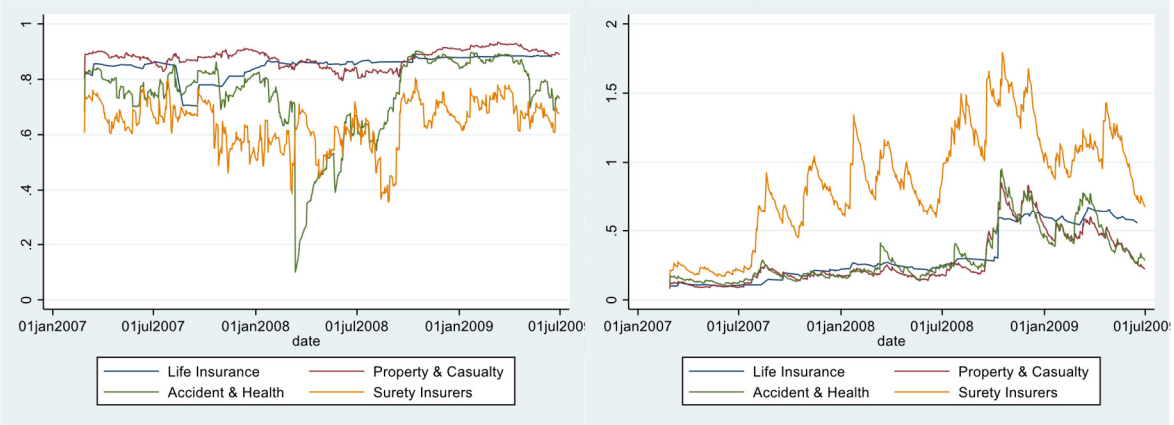
The table reports the mean and variance equations results, the corresponding parameter estimate of financial volatility. Q(40) reports the Ljung-Box test statistic for autocorrelation for the residuals up to 40 lags. ARCH(10) reports the LM test statistic for autoregressive conditional heteroskedasticity (ARCH) in the residuals. The p-values are in parentheses with *10% significant, **5% significant, ***1% significant.

Figure 1 Conditional Correlations and Volatilities for the four Segments for the Entire Sample (January 1988-December 2011)



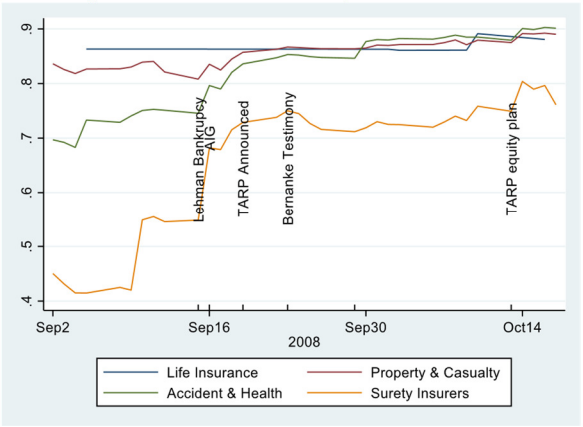
(a) Correlations (b) Volatilities

Figure 2 Conditional Correlations and Volatilities for the four Segments for the Crisis Subsample (January 2007-June 2009)

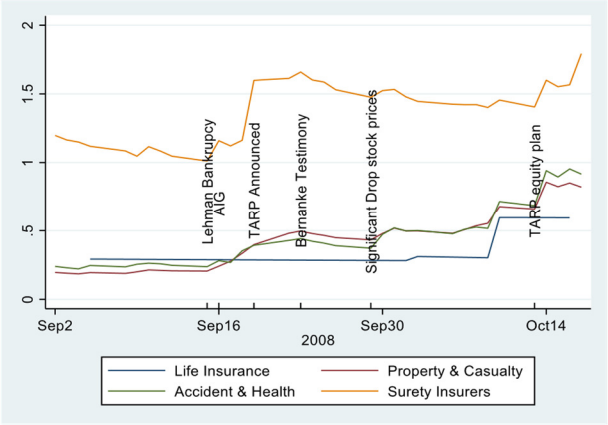


(a) Correlations (b) Volatilities

Figure 3 Conditional Correlations and Volatilities for the four Segments for the Crisis Subsample - Detailed Analysis

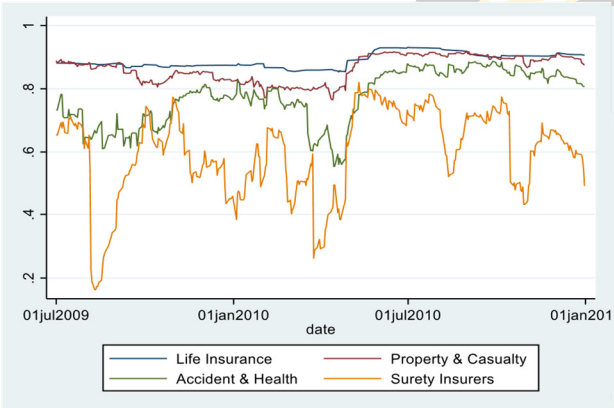


(a) Correlations

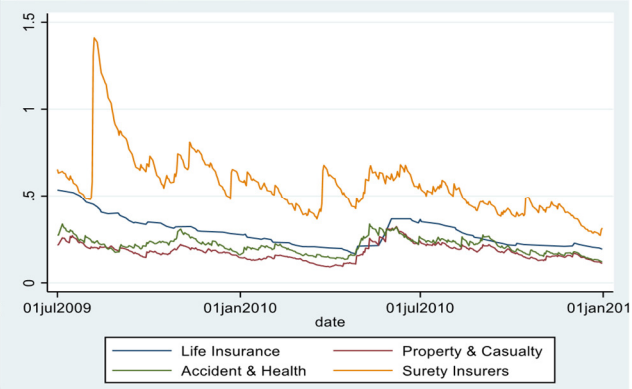


(b) Volatilities

Figure 4 Conditional Correlations and Volatilities for the four Segments for the Post-Crisis Subsample (July 2009-December 2010)



(a) Correlations



(b) Volatilities