보험금융연구 제27권 제4호 (2016. 11) pp. 75-130

The Linkages among Insurance, Banking Credit and Stock Markets in G7 Countries* **

- Evidences from Long- and Short-run Perspectives -

G7국가의 보험, 은행, 주식시장 간의 장단기 연관성 분석

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This paper investigates the short-run and long-run linkages among insurance activity, banking development, and stock market for G-7 countries. To examine the short-run causal nexus, we adopt the Granger causality approach proposed by Toda and Yamamoto(1995). To explore the long-run relationships, we introduce an extended nonlinear econometric model with the Jumarie's fractional derivative based on the fractional financial model for economic system, and the multiple stepwise regression technique is employed to explore the optimal regression. Our empirical results show that there exist various patterns of dynamic relationships among the three financial sectors. Specifically, their short-run and long-run relationships are country-specific, and the long-run linkage is stronger than the short-run linkage. Furthermore, the short-run causal relationship between insurance activity and banking credit is the strongest, whereas the long-run relationship between stock market and banking credit is the strongest. These findings offer some useful insights not only for investors to diversify their risk away, but also for policy makers to realize the synergistic development of the financial system in the process of economic growth.

Key words: banking development, causal nexus, insurance activity, multiple stepwise regression, nonlinear relationships, stock market

한국연구재단 분류 연구분야 코드: B030600

* Korean title, abstract and keywords of this paper are translated by editors themselves(Any errors are their responsibility.).

** The authors are grateful to the editor and two anonymous referees for helpful comments and suggestions.

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논문 투고일: 2015. 12. 09, 논문 최종 수정일: 2016. 08. 26, 논문 게재 확정일: 2016. 11. 10

Ⅰ. Introduction

In the past few years, lots of researches particularly focus on the causal nexus between insurance activity and economic growth(Lee et al., 2013b ; Lee, 2013). According to previous theoretical and empirical studies, it is easy to find that the importance insurance markets have on economic performance is quite notable. During the period 1997－2007, the world's total written real insurance premiums increased with an annual growth rate of 55 percent, far exceeding the annual growth rate of the global economy. The rapid expansion of insurance's business volume strengthens its economic role remarkably. Meanwhile, the economic roles of risk transfer and capital allocation would have a great influence on the development of other financial markets. Therefore, there exist some interactions between the insurance industry and other financial sectors in the process of economic development(Webb et al., 2005 ; Tennant, 2010 ; Lee, 2013 ; Liu and Lee, 2014 ; Liu et al., 2014). These ideas prompt the initial motivation of this article, which will focus on the relationship among insurance activity, banking credit, and stock market. Note that, taking the different functions of life and nonlife insurance activities into consideration, we discuss them separately.

As an important component of the financial system, a large body of the theoretical literature(for example, Skipper, 1997 ; Skipper and Kwon, 2007 ; Haiss and Sümegi, 2008) has discussed the insurance industry's influence on the economy and society. Meanwhile, the life and nonlife insurance activities affect economic growth in diverse ways. Specifically, there are more likely to be different effects on economic growth from life and nonlife insurance markets, implying that these two types of insurance business protect households and corporations from risk prospective. And, life insurance companies facilitate long－term investments, rather than short－term investments, as the case of the nonlife insurance industry.

With respect to bank credit, it has the ability to amplify aggregate fluctuations through either their roles in monetary transmission mechanism(Hasin and Majid, 2011)[1] or their pro-cyclical nature, based on theories that build upon asymmetric information and capital market imperfections. In addition, stock market can encourage specialization as well as acquisition and dissemination of information(Greenwood and Jovanovic, 1990 ; Williamson, 1986), and it may reduce the cost of mobilizing savings and thereby facilitates investment(Greenwood and Smith, 1997). Well-developed stock market may enhance corporate control by mitigating the principal-agent problem through aligning the interests of managers and owners, in which case managers would strive to maximize firm value(Diamond and Verrecchia, 1982)[2].

It is essential to investigate the linkages among insurance activity, banking development, and stock market. On one hand, investors can diversify their investment risks away based on the findings of empirical studies. In general, the short-run relationships among the three financial sectors differ from their long-run relationships so that short-term and long-term investors should adopt different portfolios strategies. On the other hand, according to the empirical results, policy makers can implement macro policies to achieve the co-evolution of the three financial sectors, and then the stability of financial system is strengthened. More importantly, economic policies can be implemented to realize their interactive effects on economic growth. In addition, the financial linkage within the banking sector and the connection between banks and other financial markets are important while analyzing and forecasting their fragility (Bernoth and Pick, 2011 ; Billio et al., 2012 ; Liu et al., 2014). The strong financial linkage within and between the banking and other financial sectors have important implications for financial stability. In particular, when forecasting systemic risk linkages within the financial sectors, it is inevitable to consider whether they are caused by financial linkages or by common shocks to the financial system.

1) Hasin and Majid(2011) conclude monetary transmission mechanism by several channels in terms of interest rate, bank lending, asset price, and exchange rate.
2) Asset liquidity and price volatility are both of important characteristics in stock markets.

To the best of our knowledge, there still have no theoretical and empirical researches modeling the linkages among insurance activity, banking credit, and stock markets in a unified framework. Furthermore, the existing researches employ a conventional linear model to investigate the relationships among different financial markets. Nevertheless, in the process of economic growth, the financial system exhibits complex dynamics that attract much attention recently with differential equations(for example, Lifschitz, 1999 ; Chen, 2008 ; Danca et al., 2013). Most economic justifications for nonlinearity are the coexistent heterogeneity between investor's expectations(De Grauwe and Grimaldi, 2005), the presence of different transaction costs(Anderson, 1997 ; Dumas, 1992), mimetic behaviors, and the existence of stock market frictions, which may imply some smoothness, persistence, discontinuities, structural breaks, inertia effects, and asymmetry in the adjustment dynamics. Such stylized facts also characterize an insurance market. In practice, Outreville(1990) proves that there is a nonlinear relationship between insurance activity and financial development, although the quality of the statistical adjustment is not as good as a linear measure. Jawadi et al.(2009) show that the switching transition error correction model performs better than a linear error correction model while investigating the long-term relationship between nonlife insurance activity and other financial markets. Liu and Lee(2014) and Liu et al.(2014) find that the relationship between insurance activity and banking credit in different countries is dynamic and nonlinear. Those ideas convince us that there may be a nonlinear relationship between insurance activity and other financial markets.

To accomplish these analyses, we focus on a time-series econometric framework[3] for individual G-7 countries(i.e., Canada, France, Germany, Italy, Japan, the United

3) The reason is that, from econometric viewpoint, panel data analysis is not able to explore the dynamic linkages among the different financial markets in one single country, or not able to perform multi-country comparisons to study its economic policies. Hence, we use time-series together with multi-country analysis to examine our perspective.

Kingdom, and the United States). Note that, our work includes two parts. First, the Toda and Yamamoto(1995 ; TY-VAR hereafter) approach is employed to examine the causal nexus among insurance activity, banking credit, and stock markets in the short run. The TY-VAR method has several advantages. It can be performed safely for whether the variables are integrated or not, and it does not depend on sample sizes (Yamada and Toda, 1998). Second, to investigate the nonlinear relationships that potentially related to growth of insurance premiums, banking credit, and stock returns in the long run, we extend the fractional order model for the economic system proposed by Chen(2008) with the interaction terms and quadratic terms into the differential equations. In fact, the value of current state in the financial system depends on both recent values and historical values of objective function, which is the unique property of fractional derivative and previous works neglect the issue. Moreover, to eliminate the possible multicollinearity problem, we adopt the stepwise regression technique to get the optimal models.

The reminder of this paper is organized as follows. Section 2 details the interactions among insurance activity, banking credit, and stock markets, and provides the theoretical structure and the main hypothesis. Section 3 presents the methodology used for the empirical research. Section 4 analyzes the empirical results and gives further discussions and implications. Conclusions are given in the Section 5.

II. Theoretical Structure and Main Hypotheses

1. The interaction between insurance activity and banking development

The development of insurance activity covers banks and their customers against a range of risks, “underpinning bank lending by protecting customers against risks that might otherwise leave them unable to repay their debts”(Rule, 2001). The risk protection offered by insurance companies encourages bank borrowing by reducing companies’ market cost of capital(Grace and Rebello, 1993). These economic roles are critical because this protection could determine whether firms could develop their activities while having a direct impact on bank credit risk. In this context, for example, property insurance may facilitate bank intermediation activity by collateralizing credit, which would reduce a bank’s credit risk exposures, promoting higher levels of lending (Zou and Adams, 2006). A potential competitive relationship between insurance activity, particularly life insurance, and banks may be due to the “saving substitution effect”(Haiss and Sumegi, 2008) because in the market for intermediated saving, insurance companies compete to one another and could reduce banks’ market share(Allen and Santomero, 2001). Insurers, however, may invest(part of) that savings in bank capital investments(for example, equities) and subordinated debt, so that the magnitude of the final effect has to be evaluated empirically.

At the same time, the development of the banking sector may reinforce the development of insurance activity through a much more effective payment system that allows an improved financial intermediation of serves(Beck and Webb, 2003 ; Webb et al., 2005). In addition, the development of the banking sector provides liquidity facilities to insurance companies that enable them to pay their claims(Rule, 2001). Finally, in the last two decades, the interdependence between banking and insurance activities has increased strongly because of risk transfer. Given that banks and insurers have mutual exposures in many areas, banks have unbundled their credit risks to insurance providers mainly through both the securitization of credit portfolios(asset-backed securities and collateralized debt obligations) and derivatives(credit default swaps). On the insurance side, insurers have transferred credit risk to banks through liquidity facilities and letters and credit(Rule, 2001).

In practice, few attentions have been paid to the linkage between insurance activity and banking credit in the literature. Based on the cross-sectional data of different developing countries, Outreville(1990) explores the determinants of insurance markets. He finds that nonlife insurance demand is associated positively with a measure of financial development(M2/GDP) but life insurance demand is not. Using panel data aggregated at different frequencies for 68 countries from 1961 to 2000, Beck and Webb(2003) find that development of the banking sector is one of the most predictors of life insurance consumption. Furthermore, some researches focus on the interactions between insurance activity and banking credit in the process of economic growth. Webb et al.(2005) examine the effects of financial sectors(bank, life and nonlife insurance) on economic growth. By employing a cross term constituted of bank credit and insurance activity(life and nonlife insurance), they investigate the interaction between bank credit and insurance market. Empirical results indicate that there exists a cooperated relationship between banking credit and insurance(life and nonlife insurance) activities. Following Webb et al.(2005), Arena(2008) applies the generalized methods of moments(GMM) to dynamic models of panel data for 55 countries between 1976 and 2004. He finds that complementary relationships exist between insurance activities and banking credit. Tennant et al.(2010) develop proxies for each of Levine's(1997) five functions of the financial sector, and model the relationship between these functions and economic growth using error correction models that more accurately conform to theory. Their results show that there exists a competitive relationship between banking credit and insurance(life and nonlife insurance) markets, which is opposite to the results of Webb et al.(2005) and Arena (2008). Employing an advanced bootstrap VAR model with a fixed rolling window, Liu and Lee(2014) investigate the causal nexus between insurance activities and banking credit in China, and the results suggest that there is a time-varying causality between them in various samples.

Based on the above views, we demonstrate the hypothesis related to insurance activity and banking credit as follows:

H1: There is a significant relationship between insurance activity and banking credit.

H1.1: A complimentary relationship exists between life insurance activity and banking credit.

H1.2: A substitutionary relationship exists between life insurance activity and banking credit.

H1.3: A complimentary relationship exists between nonlife insurance activity and banking credit.

H1.4: A substitutionary relationship exists between nonlife insurance activity and banking credit.

H2: There is no significant relationship between insurance activity and banking credit.

2. The interaction between insurance activity and stock market

The development of insurance activity could promote stock and bond markets development by investing funds raised through contractual saving products in stock markets and equities(Catalan et al., 2000 ; Impavido et al., 2003), which is called capital markets deepening. At the same time, stock markets may also reinforce the growth of insurance industry because liquid capital markets help insurance companies invest their resources captured through premium payments. This is especially important for life insurance companies that want to match long-term liabilities with long-term assets. Finally, there are inter-linkages between insurance activities and stock markets for risk transfer. According to Rule(2001), insurance companies transfer market risk to capital markets not only by hedging of embedded options in life insurance portfolios but also by its involved natural catastrophes. In contrast, capital markets may transfer market risk to insurance companies when the latter write options and buy bonds with embedded options. Moreover, the saving functions of insurance companies would develop the stock market and foster a more efficient capital allocation because the insurance companies would gather significant information to perform their evaluation of projects and firms, in order to allocate the financial capital and interesting risk bearing capacity(Skipper, 1997). In addition, it is worth noting that insurance company is appealing to potential investors because it is uncorrelated with other types of business activities(Arena, 2008). Hence, a substitutionary relationship may expectedly exist between insurance activity and stock market.

In empirical studies, a few attentions have been paid to the causal nexus between insurance activities and stock markets. Based on the panel data of 55 counties during the period 1976–2004, Arena(2008) shows that there are robust complementary relationships between both life and nonlife insurance activities and stock markets in the process of economic growth. Jawadi et al.(2009) test the independence of nonlife insurance activity to the financial markets in Canada, France, Japan, the UK, and the US. They find that there exists a significant long–term relationship between nonlife insurance premiums and stock markets. Using the TY–VAR procedure, Lee et al. (2013a) investigate the lead–lag relationships among stock markets, insurance markets, and bond markets in developed countries. Their empirical results show that there is a unidirectional causality running from life insurance premiums to the stock markets in Canada, the UK and the US, a unidirectional causality running from nonlife insurance premiums to the stock markets in France, the UK and the US, and a unidirectional causality running from the stock market to nonlife insurance premiums in Canada.

Based on the discussion above, we develop a hypothesis related to insurance activity and stock markets as follows:

H3: There is a significant relationship between insurance activity and stock market.

H3.1: A complimentary relationship exists between life insurance activity and *stock market.*

H3.2: A substitutionary relationship exists between life insurance activity and stock market.

H3.3: A complimentary relationship exists between nonlife insurance activity and stock market.

H3.4: A substitutionary relationship exists between nonlife insurance activity and stock market.

H4: There is no significant relationship between insurance activity and stock market.

3. The interaction between banking development and stock market

On one hand, a part of literature stresses that banks, rather than stock markets, play a critical role in reducing informational friction and transaction costs and the function of improving the allocation of resources(Boyd and Prescott, 1986 ; Stiglitz, 1985). On the other hand, Allen and Gale(2000) stress the role of stock markets, in contrast to banks, due to the competitive nature of the markets in encouraging innovative and growth-enhancing activities. Finally, within the literature of stressing the complementary effect, Levine(1997) points out that both banks and stock markets ameliorate information and transaction costs. Boyd and Smith(1998) model the increasing importance of equity markets as economy develops, showing that equity markets complement debt markets by making debt markets operate more efficiently. Huybens and Smith(1999) present a monetary growth model where banks and secondary capital markets have a crucial allocative function in the economy that affects the long-run real performance.

At the empirical level, some existing studies have discussed the causal nexus between banking credit and stock markets. Applying the VAR model, Kim and Moreno (1994) focus on whether there are interactions between stock price and bank lending in Japan before and after the mid−1980s. The results report that the stock price−bank lending relation is weak prior to the mid−1980s but is subsequently strengthened considerably. Estimating a six−variable VAR model and simulating general impulse response, Ibrahim(2006) assesses interactions between bank loans and stock prices in Malaysia. He finds that bank loans react positively to the increase of stock markets, but there seems to be no impact of bank loans on stock prices. Using the vector error correction model, Ibrahim and Shah(2012) examine the causal nexus among bank lending, macroeconomic conditions, and financial uncertainty in Malaysia, in which they find no causality between bank lending and the stock market. Employing monthly and quarterly data, Karim et al.(2012) use the Granger causality test proposed by Toda and Yamamoto(1995) to re−examine the interaction between bank loans and stock prices in Malaysia. Their empirical results show a lack of evidence of causal linkage between the two sectors, indicating that the stock market and bank loan in Malaysia are independent.

Based on the above views, we demonstrate the hypothesis related to banking credit and stock market as follows:

H5: There is a significant relationship between banking credit and stock market.

H5.1: A complimentary relationship exists between banking credit and stock market.

H5.2: A substitutionary relationship exists between banking credit and stock market.

H6: There is no significant relationship between banking credit and stock market.

III. Methodology

In this paper, our econometric models proceed with two steps. The former is to test the short−run causal linkages among insurance activity, banking credit, and stock markets, whereas the latter is to find the long−run relationships among the three series. First, we introduce the advantage of the TY−VAR method developed by Toda and Yamamoto(1995), and we then give its implementation steps. Second, based on the traditional fractional order model in the economic system, an extended nonlinear econometric model proposed by Chen(2008) is reconstructed and the multiple stepwise regression analysis is used to eliminate the multicollinearity for getting the optimal regression. In this way, we can detect their long−run nexus with the significance of the estimated coefficients.

1. The TY−VAR procedure

Generally speaking, while testing the Granger causality among different variables, vector autoregression(VAR) and vector error correction model(VECM) are two well−known methods. To that respect one could conduct a VAR in first−order differences of the variables if variables are known as $I(1)$(integrated of order one) with no cointegration, and one could conduct a VECM if the variables are in a cointegrated relation. Hence, before conducting the traditional VAR or VECM, it is a prerequisite to judge whether the variables are integrated, cointegrated, or stationary.

But, Toda(1995) shows that the pre−tests for cointegration rank in Johansen−type VECM are quite sensitive to the values of the nuisance parameters in finite sample. Hence causality inference in VECM may suffer from severe pretesting biases. Furthermore, Sims et al.(1990) and Toda and Phillips(1993) point out that, if the system contains unit roots, standard Wald statistics, based on ordinary least−squares

(OLS) estimation of a level VAR model for testing coefficient restrictions, have non−standard asymptotic distributions, which may involve nuisance parameters. Therefore, Toda and Yamamoto(1995) propose an augmented VAR approach, which has much practical appeal because it can be used for any arbitrary level of integration[4). Hence, we apply the TY−VAR procedure to examine the short−run linkages among insurance activity, banking development, and stock markets. The implementation steps of the TY−VAR procedure are concluded as follows:

Step 1: Determine the maximal order of integration d of variables by conducting unit root tests.

Step2: Select the optimum lag length k of a VAR. Since the lag length k is rarely known in practice, we can determine it by several criteria.

Step 3: Estimate the following lag−augmented $VAR(k+d)$ model:

$$V_t = \alpha + \beta_1 V_{t-1} + \beta_2 V_{t-2} + \ldots + \beta_k V_{t-k} + \ldots + \beta_{k+d} V_{t-(k+d)} + \varepsilon_t, \quad (1)$$

Where $V_t = \{\ln SP, \ln LP, \ln BC\}$ or $V_t = \{\ln SP, \ln NLP, \ln BC\}$ denotes a vector containing three endogenous variables; α is a vector of constant; β_1 is coefficient matrix, and ε_t is white noise residuals.

Step 4: In practice, several lag lengths are usually given. Check robustness of the above estimated augment $VAR(k+d)$ models by diagnostic tests, and we can get the final TY−VAR model.

Step 5: A Wald test is conducted on the first parameters instead of all parameters in the augment $VAR(k+d)$ model, and the statistics follows an

4) Yamada and Toda(1998) show that, the FM−VAR proposed by Phillips(1995) and ECM procedures are more powerful than the TY−VAR procedure. However, the actual size of Granger causality test based on the TY−VAR procedure is stable in sample sizes that are typical for time series, and the FM−VAR and ECM models tend to have larger size distortion.

asymptotic Chi−square distribution with k degrees of freedom. If $\beta_{ji \cdot p} = 0$ for $p = 1, 2, \ldots, k$, the jth element of V_t does not Granger cause the ithelement of V_t. Similarly, if $\beta_{ji \cdot p} = 0$ for $p = 1, 2, \ldots, k$, the ith element of V_t does not Granger cause the jth element of V_t.

2. A new nonlinear econometric model with fractional derivative

In the empirical literature, there are many methodologies(e.g., the Cobb−Douglas production function, the Logistic function, the quadratic function, and the exponential function) to investigate the nonlinear relationship among variables. However, traditional methods neglect the fact that the value of current state depends on both recent values and historical values of objective function which is the unique property of fractional derivative. This excellent property is suitable for modeling financial and economic series mainly due to the fact that the financial and economic variables always exhibit time−dependent memory effect(Anh and Inoue, 2005).

In the last few years, chaos supports an endogenous explanation of the complexity observed in economic series with tremendously increasing importance, and represents a radical change of perspective on business cycles(Chen, 2008). Furthermore, some scholars report a dynamic model of the financial system(including interest rate, investment demand, and price index) with three first−order differential equations(Ma and Chen, 2001a, 2001b). Then, a new fraction order model for financial system based on the fractional derivative is introduced(Chen, 2008), and some general forms are reconstructed later(Skovranek et al., 2012 ; Yue et al., 2013). In this paper, based on the Jumarie's(2007) fractional derivative, we reconstruct a new nonlinear econometric model by extending the fractional order model for economic system proposed by Chen(2008) to explore the long−run linkages of the financial system consisting of insurance activity, banking credit, and stock markets.

There exist several definitions of the fractional derivative and integral, while the Grunwald−Letnikov(GL), Riemann−Liouville(RL), and Caputo definitions are the three most frequently used definitions[5]. In this paper, we choose the modified RL derivative proposed by Jumarie(2006). The advantage of the Jumarie's fractional derivative over others is that it is convenient to remove the limit operation in its definition with a small step size so that we can depict the discrete from of fractional derivative by multiplying the classical difference of function with some coefficients. Specifically, the Jumarie's fractional derivative of order α for a continuously differentiable function $f:[0,+\infty)\to R$ is defined as:

$$D_t^{\alpha} f(t) = \Gamma(1+\alpha-m)\lim_{h\to 0}\frac{\triangle f^{(m)}(t)}{h^{\alpha-m}}, \quad (2)$$

where $m=[\alpha]$, which denotes the integer part of the real number α. Furthermore, if $0<\alpha<1$, then

$$D_t^{\alpha} f(t) = \Gamma(1+\alpha)\lim_{h\to 0}\frac{\triangle f(t)}{h^{\alpha}}. \quad (3)$$

Recently, there have been several fractional models for financial system. For instance, Chen(2008) proposes a chaotic fractional order model for the economic system consisted of investment, interest rate, and price index. The system is expressed as follows:

$$\begin{cases} D_t^{\alpha_1} x_t = z_t + (y_t - a)x_t \\ D_t^{\alpha_2} y_t = 1 - by_t - x_t^2 \\ D_t^{\alpha_3} z_t = -x_t - cz_t \end{cases}, \quad)4($$

5) More information about the relationships among the three definitions of fractional derivative can be seen in Podlubny(1999).

where x, y, z denote interest rate, investment, and price index, respectively.

In fact, one financial sector is influenced by its own development and the scale of other financial sectors[6]. Not only do we consider their individual impacts, but also take their interaction terms and quadratic terms into consideration[7]. Instead of taking the same expression in Chen's fractional chaotic system, we consider a more general form on the basis of the Jumarie's fractional derivative in Eq.(4) as follows:

$$(5)\qquad \begin{cases} \dfrac{x_{t_n}-x_{t_{n-1}}}{(t_n-t_{n-1})^{\alpha_1}} = f(x_t, y_t, z_t, A_1) + \xi_{1t} \\ \dfrac{y_{t_n}-y_{t_{n-1}}}{(t_n-t_{n-1})^{\alpha_2}} = g(x_t, y_t, z_t, A_2) + \xi_{2t} \\ \dfrac{z_{t_n}-z_{t_{n-1}}}{(t_n-t_{n-1})^{\alpha_3}} = h(x_t, y_t, z_t, A_3) + \xi_{3t} \end{cases},$$

with

$$\begin{aligned} f(x_t, y_t, z_t, A_1) &= c_1 + \beta_{12}x_t + \beta_{12}y_t + \beta_{13}z_t + \beta_{14}x_t y_t + \beta_{15}x_t z_t \\ &\quad + \beta_{16}y_t z_t + \beta_{17}x_t^2 + \beta_{18}y_t^2 + \beta_{19}z_t^2 \\ g(x_t, y_t, z_t, A_2) &= c_2 + \beta_{21}x_t + \beta_{22}y_t + \beta_{23}z_t + \beta_{24}x_t y_t + \beta_{25}x_t z_t \\ &\quad + \beta_{26}y_t z_t + \beta_{27}x_t^2 + \beta_{28}y_t^2 + \beta_{29}z_t^2 \\ h(x_t, y_t, z_t, A_3) &= c_3 + \beta_{31}x_t + \beta_{32}y_t + \beta_{33}z_t + \beta_{34}x_t y_t + \beta_{35}x_t z_t \\ &\quad + \beta_{36}y_t z_t + \beta_{37}x_t^2 + \beta_{38}y_t^2 + \beta_{39}z_t^2 \\ A_i &= (c_i, \beta_{i1}, \ldots, \beta_{i9}),\ i = 1,2,3 \end{aligned}$$

and $\xi_{it}(i=1,2,3)$are the white noise processes. Here, x_t denotes stock market, y_t denotes the insurance premiums, and z_t denotes the banking

6) In traditional methods, they often overlook the own effect of one series on its development in the long run which is the advantage of the new nonlinear econometric model.

7) Besides the fractional derivative, the interaction terms, and quadratic terms are also the source of nonlinearity in the new model. Meanwhile, they are also added for selecting the optimal regression with more precision.

credit.

To estimate the above nonlinear econometric model, Yue et al.(2013) derive the corresponding estimation method with the least squared principle[8]. In this paper, we assume the time step $\triangle t = 0.5$, and the multiple stepwise regression analysis is used to get the optimal regression.

8) Yue et al.(2013) give the optimal fractional orders with different time steps.

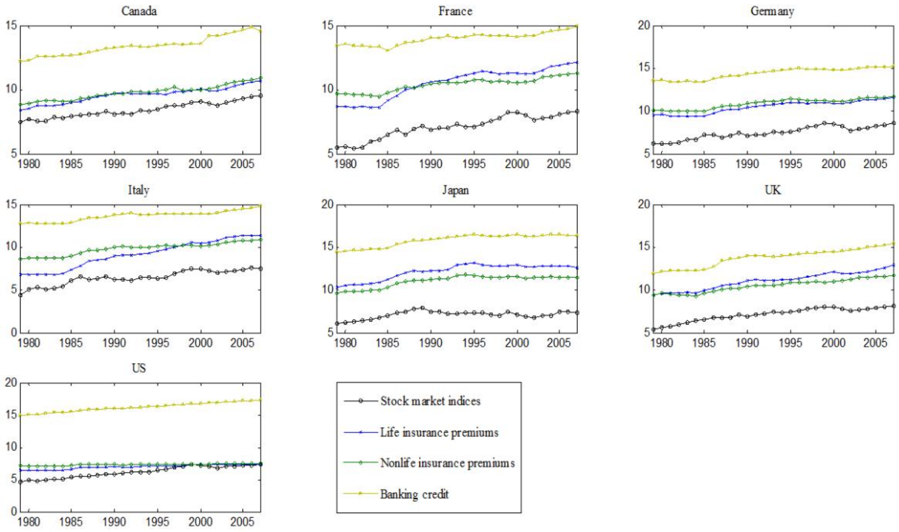
IV. Empirical Results

1. Data source and description

Our empirical application focuses on the linkages among insurance activity, banking credit, and stock markets for G-7 countries, namely, Canada, France, Germany, Italy, Japan, the United Kingdom and the United States. All the data are annual and cover the period from 1979 to 2007[9]. For the proxies of insurance and banking credit markets, we use real insurance(including life and non-life) premium per capita and real banking credit per capita. By definition, these variables are also referred to as real insurance density and real banking credit density, respectively. For simplicity, we use LP to denote real life insurance density and NLP for real non-life insurance density. Real insurance density represents the average annual premiums per capita pertinent to insurance products and real banking credit density(BC) reveals the average annual domestic credit provided by the banking sector to one inhabitant. The data for insurance activity can be obtained from the Swiss Reinsurance Company, Simga database(1980-2008). In addition, we obtain the annual data for banking credit from the World Development Indicators(WDI, 2008), and stock market indices(SP) are collected from the Global Financial Databank. Moreover, all variables are calculated in USD millions and are taken in natural logarithm. Especially, the unit is converted into the same scale of constant 2000 US dollars. The development trends of the three financial markets spanning the period from 1979 to 2007 are shown in Fig. 1.

9) Considering the undeniable roles of the 2008 financial crisis in the interactions among insurance, banking credit and stock markets, we conduct our empirical analyses over the period 1979-2007.

<Figure 1> The development trends of the three financial markets during 1979−2007(in logs)



From Fig. 1, we can find that the development trends of insurance premiums, banking credit and stock market keep increasing during the period 1979−2007 for G−7 countries. The size of stock market is the smallest, and the size of domestic credit provided by the banking sector is the largest. The nonlife insurance premiums are higher than the life insurance premiums in Canada, Germany and the US, while the latters are higher in Japan and the UK. In addition, the years 1989 and 1998 are two key structural points for the insurance industries in France and Italy. The nonlife insurance premiums are higher than the life insurance premiums before 1989 and 1998, while the life insurance premiums catch up with the nonlife insurance premiums after 1989 and 1998. Generally speaking, the three financial markets in G−7 countries have the similar growth pattern with tiny individual differences.

Table 1 gives the descriptive statistics and correlation coefficients of insurance activity, banking credit, and stock market for each country. Panel A shows the summary descriptive statistics for the mean, standard deviation(S.D.), skewness, and kurtosis. In general, the mean of banking credit is the largest, followed by insurance premiums and stock market indices. This suggests that domestic credit of the banking sector plays a dominant role in a country's financial system for promoting its economic growth, while the insurance activity and stock markets are also significant. According to the value of natural logarithms of insurance premiums, the G−7 countries can be divided into three classes: i) the nonlife insurance premiums are larger than the life insurance premiums in Italy and the US; ii) the life insurance premiums are larger than the nonlife insurance premiums in Japan and the UK; iii) the life and nonlife insurance premiums are approximately the same in Canada, France, and Germany. This implies that studying the linkages among insurance activity, banking credit, and stock markets in G−7 countries is representative in developed countries. Furthermore, panel B gives the test results of correlation coefficients among insurance activity, banking credit, and stock market. These coefficients are positive at the 1% significance level, implying that there indeed exist interactions among the three main financial markets in G−7 countries. Meanwhile, the correlation coefficients between insurance activity and banking credit are larger than those coefficients between stock market and the other two financial sectors, suggesting the possibly existing stronger causality between insurance premiums and banking credit.

<Table 1> Descriptive statistics and correlation coefficients

	lnSP	lnLP	lnNLP	lnBC	lnSP	lnLP	lnNLP	lnBC
Panel A								
Canada					Japan			
Mean	8.437	9.588	9.789	13.404	7.097	12.188	11.055	15.839
S.D.	0.597	0.605	0.582	0.734	0.446	0.900	0.696	0.726
Skewness	0.201	−0.243	0.187	0.333	−0.544	−0.898	−1.021	−0.848
Kurtosis	1.909	2.352	2.195	2.209	2.841	2.277	2.456	2.107
Panel B								
lnSP	1.000				1.000			
lnLP	0.941***	1.000			0.679***	1.000		

lnNLP	0.956***	0.972***	1.000		0.724***	0.994***	1.000	
lnBC	0.939***	0.956***	0.980***	1.000	0.661***	0.991***	0.985***	1.000
Panel A								
France					UK			
Mean	7.095	10.532	10.409	13.996	7.143	11.093	10.522	13.796
S.D.	0.904	1.187	0.532	0.477	0.795	1.016	0.758	1.046
Skewness	−0.472	−0.537	−0.259	−0.041	−0.650	−0.130	−0.218	−0.405
Kurtosis	2.165	1.883	2.104	2.273	2.303	1.938	1.811	1.967
Panel B								
lnSP	1.000				1.000			
lnLP	0.942***	1.000			0.951***	1.000		
lnNLP	0.900***	0.982***	1.000		0.928***	0.982***	1.000	
lnBC	0.850***	0.944***	0.966***	1.000	0.946***	0.985***	0.985***	1.000
Panel A								
Germany					US			
Mean	7.477	10.498	10.886	14.420	6.163	6.975	7.284	16.191
S.D.	0.745	0.726	0.579	0.648	0.877	0.338	0.165	0.720
Skewness	−0.234	−0.364	−0.457	−0.429	−0.178	−0.541	−0.408	−0.153
Kurtosis	2.062	1.686	1.751	1.605	1.629	2.057	2.465	1.915
Panel B								
lnSP	1.000				1.000			
lnLP	0.885***	1.000			0.953***	1.000		
lnNLP	0.851***	0.982***	1.000		0.840***	0.927***	1.000	
lnBC	0.885***	0.997***	0.993***	1.000	0.980***	0.965***	0.900***	1.000
Panel A								
Italy								
Mean	6.460	9.180	9.851	13.674				
S.D.	0.862	1.629	0.705	0.593				
Skewness	−0.546	−0.180	−0.467	−0.209				
Kurtosis	2.504	1.744	2.032	2.120				
Panel B								
lnSP	1.000							
lnLP	0.927***	1.000						
lnNLP	0.903***	0.976***	1.000					
lnBC	0.852***	0.954***	0.986***	1.000				

Note: Superscript *** represents the statistical significance at the 1% level.

2. Empirical results of the short-run linkage

It is a prerequisite to determine the maximal integration order of variables before conducting the TY-VAR procedure. In order to get a more reliable result, we utilize five different unit root tests, namely augmented Dickey-Fuller(1979; ADF), Dickey-Fuller GLS(1996; DF-GLS), Kwiatkowski-Phillips-Schmidt-Shin(1992; KPSS), Phillips-Perron(1988; PP), and Ng-Perron's MZa(2001; NP). The results of unit root tests are reported in Table 2.

According to Table 2, it is obvious that the results of the five unit root tests are slightly contradictory. All of these series are integrated of an order one process, except for the series of banking credit in Italy and the series of nonlife insurance premiums in the US. Then, the traditional VAR and VECM models are not suitable, and the classical linear cointegration test of Johansen is not appropriate to employ in the model. Therefore, the Granger causality test of Toda and Yamamoto(1995) should be a better method.

<Table 2> Unit root test results

Model	Variable	ADF	DF-GLS	PP	KPSS	MZa
Canada						
Levels	lnSP	−3.088(0)	−3.241**(0)	−3.113(1)	0.096(1)	−11.466(0)
	lnLP	−1.822(0)	−1.723(0)	−2.063(3)	0.112(4)	−4.336(0)
	lnNLP	−2.119(0)	−2.300(0)	−2.283(2)	0.087(2)	−8.268(0)
	LnBC	−2.100(0)	−2.181(0)	−2.100(0)	0.107(3)	−7.125(0)
First	lnSP	−6.480***(0)	−5.756***(0)	−6.539***(2)	0.199(7)	−13.038**(0)
difference	lnLP	−4.425***(0)	−4.337***(0)	−4.414***(1)	0.135(2)	−13.100**(0)
	lnNLP	−5.877***(0)	−5.978***(0)	−5.872***(1)	0.188(9)	−13.151**(0)
	LnBC	−4.758***(0)	−4.819***(0)	−4.758***(0)	0.076(4)	−13.379**(0)
France						
Levels	lnSP	−2.202(0)	−2.287(0)	−2.298(1)	0.128*(3)	−7.591(0)
	lnLP	−2.070(1)	−2.205(1)	−1.431(2)	0.140*(4)	−11.076(1)
	lnNLP	−2.507(1)	−2.595(1)	−1.713(0)	0.096(3)	−14.437*(1)
	LnBC	−1.887(0)	−1.980(0)	−1.972(1)	0.065(3)	−6.196(0)
First	lnSP	−5.027***(0)	−5.117***(0)	−5.031***(3)	0.091(2)	−13.500**(0)
difference	lnLP	−2.664*(0)	−2.634**(0)	−2.664*(0)	0.121(2)	−8.870**(0)

	lnNLP	−3.607**(0)	−3.670***(0)	−3.578**(2)	0.088(1)	−12.161**(0)
	LnBC	−4.692***(0)	−4.568***(0)	−4.692***(0)	0.157(0)	−13.332**(0)
Germany						
Levels	lnSP	−2.411(0)	−2.485(0)	−2.534(2)	0.099(2)	−8.387(0)
	lnLP	−1.512(0)	−2.235(1)	−1.771(2)	0.116(4)	−9.958(1)
	lnNLP	−2.198(1)	−2.268(1)	−1.603(1)	0.120*(4)	−11.057(1)
	LnBC	−1.269(0)	−1.362(0)	−1.509(2)	−0.129*(4)	−3.540(0)
First	lnSP	−5.074***(0)	−5.093***(0)	−5.074***(1)	0.090(5)	−13.430**(0)
difference	lnLP	−3.748***(0)	−3.763***(0)	−3.697**(3)	0.125(0)	−12.280**(0)
	lnNLP	−3.321**(0)	−3.369***(0)	−3.322**(2)	0.098(1)	−11.423**(0)
	LnBC	−4.061***(0)	−4.091***(0)	−4.085***(1)	0.127(1)	−12.832**(0)
Italy						
Levels	lnSP	−2.664(1)	−2.509(1)	−2.965(5)	0.095(3)	−11.232(1)
	lnLP	−3.208(1)	−3.383**(1)	−2.2003(1)	0.102(2)	−33.680***(1)
	lnNLP	−2.314(1)	−2.405(1)	−1.691(1)	0.124*(4)	−12.282(1)
	LnBC	−3.379*(4)	−3.556**(4)	−1.665(2)	0.091(4)	−19.486**(4)
First	lnSP	−4.772***(0)	−3.392***(0)	−4.804***(3)	0.245(5)	−10.191**(0)
difference	lnLP	−2.643*(0)	−2.502**(0)	−2.692*(2)	0.165(0)	−8.371**(0)
	lnNLP	−3.311**(0)	−3.375***(0)	−3.128**(4)	0.097(3)	−11.434**(0)
	LnBC	−3.592**(0)	−3.514***(0)	−3.592**(0)	0.125(1)	−12.059**(0)
Japan						
Levels	lnSP	−1.972(0)	−1.725(0)	−1.939(4)	0.140*(4)	−3.657(0)
	lnLP	−0.335(4)	−0.978(1)	0.082(8)	0.180**(4)	−4.986(1)
	lnNLP	−0.852(0)	−1.229(1)	−0.973(3)	0.175**(4)	−4.665(1)
	LnBC	−0.926(3)	−1.279(1)	−0.296(6)	0.177**(4)	−5.174(1)
First	lnSP	−4.545***(0)	−4.638***(0)	−4.543***(1)	0.226(1)	−13.905***(0)
difference	lnLP	−3.124**(0)	−3.030***(0)	−3.233**(2)	0.568**(1)	−10.369**(0)
	lnNLP	−3.263**(0)	−3.034***(0)	−3.263**(0)	0.441*(2)	−9.493**(0)
	LnBC	−3.122**(0)	−3.188***(0)	−3.173**(1)	0.498**(1)	−11.420**(0)
UK						
Levels	lnSP	−1.826(0)	−1.564(0)	−1.711(6)	0.165**(4)	−2.892(0)
	lnLP	−2.497(1)	−2.697(1)	−1.898(0)	0.095(2)	−15.542*(1)
	lnNLP	−2.048(0)	−2.111(0)	−2.234(1)	0.095(2)	−6.754(0)
	LnBC	−2.437(1)	−2.544(1)	−1.728(1)	0.119(4)	−13.833(1)
First	lnSP	−4.597***(0)	−4.336***(0)	−4.596***(1)	0.421*(0)	−12.452**(0)
difference	lnLP	−4.136***(0)	−3.902***(0)	−4.150***(1)	0.072(2)	−12.082**(0)
	lnNLP	−4.432***(0)	−3.950***(0)	−4.458***(1)	0.061(3)	−11.265**(0)
	LnBC	−2.936*(0)	−2.811***(0)	−2.936*(0)	0.103(1)	−9.418**(0)
US						
Levels	lnSP	−1.576(0)	−1.741(0)	−1.690(1)	0.120*(3)	−5.510(0)
	lnLP	−4.893***(4)	−2.627(1)	−1.629(1)	0.120*(3)	−14.362*(1)
	lnNLP	−4.319**(1)	−4.632***(1)	−2.289(1)	0.074(3)	−25.248***(1)
	LnBC	−3.372*(2)	−1.793(0)	−2.110(3)	0.131*(4)	−3.917(0)

First difference	lnSP	−4.935***(0)	−4.687***(0)	−4.941***(1)	0.137(1)	−13.587**(0)
	lnLP	−3.512**(0)	−3.466***(0)	−3.534**(1)	0.132(1)	−11.646**(0)
	lnNLP	−3.818***(1)	−2.166**(0)	−2.825*(0)	0.118(0)	−5.767*(0)
	LnBC	−4.604***(0)	−4.589***(0)	−4.660***(2)	0.227(1)	−13.577**(0)

Note: The regressors include intercept term and time trend for the original series, while only include intercept term for the first differences. The ADF, DF−GLS, PP and MZa tests hold the hypothesis that the series has a unit root, while the KPSS test assumes that the series is stationary. The lag lengths determined via SIC for the four unit root tests(including ADF, DF−GLS and MZa) are in parentheses, and the Newey−West bandwidths determined by Bartlett kernel for the other two methods also are in parentheses. Superscripts *, ** and *** denote the statistical significance at the 10%, 5% and 1% levels.

To apply the TY−VAR approach, the optimum lag length of a VAR model has to be decided firstly. Here, we use five different lag length criteria to select the lag length, namely sequential modified LR test statistic(LR), Final prediction error(FPE), Akaike information criterion(AIC), Schwarz information criterion(SC), and Hannan−Quinn information criterion(HQ). The results show that different VAR models hold various optimum lag lengths.[10] By employing diagnostic tests, it is appropriate to estimate the TY−VAR procedure with lag length 2(including the maximum integration order 1) for most cases. For the US, the TY−VAR model with lag length 3 is stable, which is also suitable for the nonlife insurance premiums in Germany and the UK. Then, we conduct the TY−VAR procedure to investigate the linkages among insurance activity, banking credit, and stock markets in G−7 countries. Table 3 provides the results of Granger causality test.

<Table 3> Granger causality test of TY−VAR approach

	Life insurance premiums			Nonlife insurance premiums			
	lnSP	lnLP	lnBC		lnSP	lnNLP	lnBC
Canada							
lnSP	−	1.050 (0.306)	6.017** (0.014)	lnSP	−	0.026 (0.871)	4.693** (0.030)
lnLP	3.727* (0.054)	−	0.238 (0.626)	lnNLP	0.340 (0.560)	−	2.270 (0.132)
lnBC	0.390 (0.533)	0.300 (0.584)	−	lnBC	1.013 (0.314)	0.002 (0.969)	−

10) The results of lag length selection for the TY−VAR procedure are not listed in the paper, and it is available from the authors upon request.

France							
lnSP	–	0.453 (0.501)	0.469 (0.494)	lnSP	–	1.537 (0.215)	0.897 (0.344)
lnLP	0.742 (0.389)	–	0.354 (0.552)	lnNLP	0.691 (0.406)	–	0.008 (0.929)
lnBC	0.074 (0.785)	11.804*** (0.001)	–	lnBC	0.002 (0.968)	19.821*** (0.000)	–
Germany							
lnSP	–	0.694 (0.405)	0.741 (0.389)	lnSP	–	1.684 (0.431)	1.768 (0.413)
lnLP	0.968 (0.325)	–	0.064 (0.800)	lnNLP	3.277 (0.194)	–	12.811*** (0.002)
lnBC	0.884 (0.347)	0.080 (0.778)	–	lnBC	3.334 (0.189)	14.408*** (0.001)	–
Italy							
lnSP	–	3.834** (0.050)	1.059 (0.303)	lnSP	–	1.068 (0.301)	2.150 (0.143)
lnLP	0.652 (0.420)	–	1.190 (0.275)	lnNLP	1.695 (0.193)	–	0.064 (0.800)
lnBC	0.210 (0.646)	1.293 (0.256)	–	lnBC	0.542 (0.462)	7.689*** (0.006)	–
Japan							
lnSP	–	2.605 (0.107)	0.010 (0.920)	lnSP	–	1.613 (0.204)	0.028 (0.867)
lnLP	0.784 (0.376)	–	1.459 (0.227)	lnNLP	0.036 (0.849)	–	0.150 (0.699)
lnBC	0.124 (0.725)	6.308** (0.012)	–	lnBC	0.007 (0.933)	13.568*** (0.000)	–
UK							
lnSP	–	0.171 (0.679)	0.458 (0.499)	lnSP	–	1.330 (0.514)	0.106 (0.949)
lnLP	8.440*** (0.004)	–	1.879 (0.170)	lnNLP	0.295 (0.863)	–	10.683*** (0.005)
lnBC	1.918 (0.166)	0.589 (0.443)	–	lnBC	−0.185 (0.263)	6.260** (0.044)	–
US							
lnSP	–	2.760 (0.252)	5.182* (0.075)	lnSP	–	1.171 (0.557)	3.114 (0.211)
lnLP	0.354 (0.838)	–	1.694 (0.429)	lnNLP	2.278 (0.320)	–	0.254 (0.881)
lnBC	2.740 (0.254)	2.123 (0.346)	–	lnBC	7.327** (0.026)	9.201*** (0.010)	–

Note: Significance implies that the column variable Granger causes the row variable. P−values are in parentheses. Superscripts *, ** and *** denote the statistical significance at the 10%, 5% and 1% levels.

For Canada, there is a unidirectional causality running from stock market to life insurance premiums and a unidirectional causality also running from banking credit to the stock market. The results suggest that the domestic credit provided by the banking sector serves as a leading index in the financial system in Canada. Indeed, banking sector can impact life insurance activity indirectly through the stock market. As for France and Japan, a unidirectional causality running from life and nonlife insurance premiums to banking credit exists. This supports our hypothesis H1 and indicates that insurance activities affect domestic credit provided by the banking sector. Moreover, there is a bi-directional Granger causality between nonlife insurance premiums and banking credit in Germany and the US. These results suggest that insurance activity and banking credit do not influence the development of the stock markets. In addition, it demonstrates that Germany and the US have the similar financial system. Finally, in Italy and the UK, it holds the opposite conclusions approximately. Specifically, the nonlife insurance premiums Granger cause banking credit in Italy, while there is a bi-directional causality in the UK. Meanwhile, a unidirectional causality runs from the life insurance premiums to stock market in Italy, but it is contrary in the UK. This phenomenon shows the notable difference between the financial systems of Italy and the UK. Generally speaking, the results of Granger causality test reveal diverse function mechanisms in the financial systems of G-7 countries. Among the financial sectors of insurance activity, banking credit, and stock markets, various Granger causal relationships are existed.

Table 4 summarizes the empirical findings of Table 3 and concludes our hypothesis according to the coefficients of the estimated TY-VAR models[11]. The results report

11) When we conduct the TY-VAR procedure, various lag lengths are selected for G-7 countries. Here, following the Granger causality test of Toda and Yamamoto(1995), it is appropriate to use the cumulative values of the first k parameters to detect the substitutionary or complementary relationship among insurance activity, banking credit, and stock markets.

that the linkages among insurance activity, banking credit, and stock market exhibit a substitutionary relationship in some countries, while there is a complementary relationship in another countries, and no causal effect in the other countries.

<Table 4> The summary of null hypothesis based on the short-run causal relationships

Null hypothesis	Insurance activity is lead	Insurance activity is lag
H1	France, Germany, Italy, Japan, US	Germany, UK
H1.1	France, Japan	-
H1.2	-	-
H1.3	France, Germany, Italy, Japan, UK	UK
H1.4	US	Germany
H2	Canada, UK	Canada, France, Italy, Japan, US
Null hypothesis	Stock market is lead	Stock market is lag
H3	Canada, UK	Italy
H3.1	Canada, UK	Italy
H3.2	-	-
H3.3	-	-
H3.4	-	-
H4	France, Germany, Italy, Japan, US	Canada, France, Germany, Japan, UK, US
Null hypothesis	Banking credit is lead	Banking credit is lag
H5	Canada, US	US
H5.1	US	-
H5.2	Canada	US
H6	France, Germany, Italy, Japan, UK	Canada, France, Germany, Italy, Japan, UK

For the linkage between insurance activity and banking credit in the lead insurance activity model, we find a complementary effect between the life insurance premiums and banking credit in France and Japan, which provides empirical evidence supporting the hypothesis H1.1. That is the development of life insurance industries can increase the demand for banking credit in France and Japan. In France, Germany, Italy, Japan, and the UK, a complementary effect exists between the nonlife insurance premiums and banking credit supporting the hypothesis H1.3, and a substitutionary effect exists in the US supporting the hypothesis H1.4. The results show that banking credit is increasing with nonlife insurance premiums growth in France, Germany, Italy, and Japan, while in the US it holds the opposite way. In the lag insurance activity model, there is a complementary effect between the nonlife insurance activity and banking credit in the UK, supporting the hypothesis H1.3, while a substitutionary effect in Germany supporting the hypothesis H1.4. The results suggest a positive effect of banking credit on the nonlife insurance activity in the UK and a negative effect existing in Germany.

For the linkage between insurance activity and stock market, a complementary causal relationship between the life insurance activity and stock market exists in Canada and the UK when the stock market is lead, whereas a complementary effect exists in Italy when the stock market is lag. The results support the hypothesis H3.1. This means that the life insurance premiums growth is increasing with a more developed stock market in Canada and the UK, and the stock market will be more attractive along with the development of life insurance industries in Italy.

For the linkage between banking credit and stock market in the lead banking credit model, there is a complementary relationship in the US, supporting the hypothesis H5.1, and a substitutionary relationship in Canada, supporting the hypothesis H5.2. In addition, the result of a substitutionary effect in the US for banking credit lagged supports the hypothesis H5.2. That is to say, the development of banking credit can increase the demand of stock market in the US, while the stock market growth inhibits the demand of banking credit. And, the banking credit restricts the expansion of the stock market in Canada.

By applying the Granger causality test proposed by Toda and Yamamoto(1995), the results of the short−run linkages among insurance activity, banking credit, and stock markets imply five major conclusions.

First, there are various causal nexus among insurance activity, banking credit, and the stock markets in G−7 countries. For example, there is a unidirectional causality running from insurance premiums to banking credit in France, Italy and Japan, a unidirectional causality running from banking credit to insurance premiums in the UK and the US, a bi−directional causality between the two series in Germany, and no causality in Canada.

Second, the causal relationships in the financial system are diverse across G−7 countries. For example, a substitutionary effect exists between banking credit and stock market in Canada, while a complementary effect exists in the US.

Third, the linkage between two series may be different in one country. For the causal nexus in the US, there is a unidirectional causality running from banking credit to stock market with the life insurance activity, and no causality with the nonlife insurance activity. For the causal relationship between two financial sectors in one country, there may be opposite effects of one on another. In Germany, the growth of the nonlife insurance premiums promotes the development of banking credit, but in turn banking credit has a negative effect on the nonlife insurance premiums. In the US, the development of banking credit can increase the demand of the stock market, and the stock market restricts the domestic credit provided by the banking sector.

Forth, owing to the fact that life and nonlife insurance sectors have different economic roles, hence we get the different linkages between them and other financial markets(including banking credit and stock market). For example, there is a unidirectional causality between the life insurance premiums and the stock markets in Canada, Italy and UK, while there has no causality between the nonlife insurance premiums and other financial markets.

Fifth, as a whole, the linkage between insurance activity and banking credit in G−7 countries is stronger than the linkage between insurance activity and stock market or than the linkage between banking credit and stock markets. There are six countries (France, Germany, Italy, Japan, the UK, and the US) with significant causal relationships between insurance premiums and banking credit, three countries (Canada, Italy, and the UK) with significant causal relationships between insurance premiums and stock markets, and only two countries(Canada and the US) with significant causal relationships between banking credit and stock markets. However, in terms of individual heterogeneity, it has a different conclusion. For example, in Canada, there is no causality between insurance activity and banking credit.

3. Empirical results of the long-run nonlinear linkage

Employing the multiple stepwise regression method, we estimate the nonlinear econometric model with fraction derivative for exploring the long-run relationships among insurance activity, banking credit, and stock markets in G-7 countries. Model 1 represents the stock market equation, model 2 represents the life or nonlife insurance premiums equation, and model 3 represents the banking credit equation. Tables A1-A7 in Appendix report the multiple stepwise regression results for each country. The results show that there indeed exist nonlinear relationships among insurance activity, banking credit, and stock markets in the long run. Hence we can get more reliable results about the long-run relationship than the traditional methods. In this paper, we detect the long-run relationships among the three financial sectors according to the coefficients of the individual effects[12].

Table 5 summarizes the long-run nexus among insurance activity, banking credit,

12) In fact, the interaction terms and quadratic terms may also affect their long-run relationships. However, it is difficult to analyze the long-run nexus owing to the complexity, so we only detect the long-run linkages among insurance activity, banking credit, and stock market based on their individual effects. In this paper, we take their interaction terms and quadratic terms into regression models for more precision.

and stock market in each G−7 country.

<Table 5> The impact directions of the long−run linkages

Country	Life insurance premiums	Nonlife insurance premiums
Canada	lnSP→lnBC lnLP↔lnBC lnLP→lnSP	lnSP→lnBC lnNLP→lnSP lnNLP→lnBC
France	lnSP→lnBC lnLP→lnSP lnBC→lnLP	lnBC→lnNLP
Germany	lnSP→lnLP lnLP→lnBC	lnSP↔lnNLP lnSP↔lnBC lnNLP→lnBC
Italy	lnSP→lnBC lnLP→lnSP lnBC→lnLP	lnNLP→lnSP lnBC→lnSP lnBC→lnNLP
Japan	lnSP↔lnLP lnSP→lnBC lnLP↔lnBC	lnSP↔lnBC lnNLP↔lnBC
UK	lnBC→lnSP	lnSP→lnNLP lnBC→lnSP lnBC→lnNLP
US	lnSP→lnLP lnBC→lnLP	lnSP↔lnNLP lnSP↔lnBC lnNLP↔lnBC

For Canada, there is a unidirectional effect of stock market on banking credit when the proxy of insurance activity is life or nonlife insurance premiums. The result indicates that the stock market impacts the social demand of the domestic credit provided by the banking sector. When investors suffer from the severe volatility in the stock market, they will turn to the banking sector for financial support. Meanwhile, unidirectional effects of both life and nonlife insurance activities on stock market exist. The development of insurance industries ensures someone more confident to invest stock markets. In addition, there is a bi−directional relationship between life insurance activity and banking credit, and a unidirectional effect between nonlife insurance activity and banking credit. This shows that the relationship between banking credit and life insurance premiums is stronger than that between banking credit and nonlife insurance premiums.

For France, there exists a unidirectional impact of stock market on banking credit and a unidirectional impact of life premiums on stock market. Furthermore, banking credit affects life and nonlife insurance activities, while the opposite direction does not exist. The results suggest that the development of life insurance industries may impact banking credit business through stock markets, and banking credit can affect the demand of life insurance product directly. Also, the wide range of business outlets and effective payment system of banking credit may be conductive to the development of nonlife insurance industries.

For Germany, there is a bi-directional relationship between stock market and banking credit, and a bi-directional relationship between stock market and nonlife insurance premiums. Moreover, unidirectional effects of life and nonlife insurance activities on banking credit exist at the same time, while a unidirectional effect of stock market on life insurance premiums also exists. These results show that the linkage between stock market and nonlife insurance premiums is stronger than the linkage between stock market and life insurance premiums. Meanwhile, the linkages between both life and nonlife insurance activities and banking credit are the same.

For Italy, unidirectional effects of both life and nonlife insurance premiums on stock market and unidirectional effects of banking credit on life and nonlife insurance premiums exist, which reveals that the linkage between life insurance activity and stock market or banking credit is the same with that between nonlife insurance activity and stock market or banking credit. Furthermore, there is a unidirectional effect of stock market on banking credit when the proxy of insurance activity is life insurance premiums, whereas there is a unidirectional effect of banking credit on stock market when the proxy of insurance activity is nonlife insurance premiums. The result suggests that the different economic roles of life and nonlife insurance activity may lead to different causal nexus between stock market and banking credit.

For Japan, there is a bi-directional relationship between stock market and life insurance premiums, while no relationships between nonlife insurance premiums and banking credit exists. The result reflects the different roles of life and nonlife insurance activity in the process of economic growth, which leads to the conclusion. In addition, bi-directional relationships between both life and nonlife insurance premiums and banking credit are proved, which reports that the linkage between life insurance activity and banking credit keeps the same with that between nonlife insurance activity and banking credit. However, there exist different relationships between stock markets and banking credit. A unidirectional effect of the stock market on banking credit exists in the financial system with life insurance market, while there is a bi-directional linkage between stock market and banking credit in the financial system with nonlife insurance market. The results may show the different intermediary roles of life and nonlife insurance activities.

For the UK, there is a unidirectional impact of banking credit on the stock market, and unidirectional impacts of the stock market and banking credit on nonlife insurance premiums are proved. The results show that the domestic credit provided by the banking sector plays an important role in the financial system, and the linkage between nonlife insurance activity and other financial sectors is stronger than that between life insurance activity and other financial sectors.

For the US, a bi-directional relationship between nonlife insurance premiums and the stock market and a unidirectional effect of the stock market on life insurance premiums are proved. Meanwhile, there is a unidirectional effect of banking credit on life insurance premiums and a bi-directional relationship between banking credit and nonlife insurance premiums. These results reveal that different economic roles of life and nonlife insurance activities lead to the different nexus between them and other financial sectors. Moreover, a bi-directional relationship between the stock market and banking credit exists for the financial system with life insurance market, while no linkage exists for the financial system with nonlife insurance market. These results also strength the differences of life and nonlife insurance activities in the financial system.

Table 6 concludes our hypothesis according to the coefficients of the estimated nonlinear econometric models with fractional derivative based on the empirical findings of Table 5.

<Table 6> The summary of null hypothesis based on the long-run relationships

Null hypothesis	Insurance activity is active	Insurance activity is passive
H1	Canada, Germany, Japan, US	Canada, France, Italy, Japan, UK, US
H1.1	Canada, Germany	Italy
H1.2	Japan	Canada, France, Japan, US
H1.3	Canada, US	US
H1.4	Germany, Japan	France, Italy, Japan, UK
H2	France, Italy, UK	Germany
Null hypothesis	Stock market is active	Stock market is passive
H3	Germany, Japan, UK, US	Canada, Germany, France, Italy, Japan, US
H3.1	Germany, Japan, US	-
H3.2	-	Canada, France, Italy, Japan
H3.3	Germany, UK	Germany, US
H3.4	US	Canada, Italy
H4	Canada, France, Italy	UK
Null hypothesis	Banking credit is active	Banking credit is passive
H5	France, Germany, Italy, Japan, UK, US	Canada, Germany, Italy, Japan, US
H5.1	Germany, Italy	Germany, Japan
H5.2	France, Japan, UK, US	Canada, Italy, US
H6	Canada	UK, France

For the linkage between insurance activity and banking credit in the active insurance activity model, a complementary effect exists between the life insurance premiums and banking credit in Canada and Germany. The results show that the development of life insurance industries will promote the expansion of the domestic credit provided by the banking sector that supports the hypothesis H1.1. On the contrary, we find a substitutionary effect in Japan, indicating that the demand of banking credit is subject to the development of life insurance activity and the hypothesis H1.2 is proved. When the nonlife insurance activity is active for the linkage between insurance activity and banking credit, there is a complementary effect between the nonlife insurance premiums and banking credit in Canada and the US, while a substitutionary effect exists in Germany and Japan. This means that the demand of banking credit is increasing with the development of nonlife insurance industries in Canada and the US, but it is decreasing in Germany and Japan. In the passive insurance activity model, a complementary relationship between life insurance premiums and banking credit exists only for Italy, supporting the hypothesis H1.1, while a substitutionary effect exists for most G−7 countries, including Canada, France, Japan, and the US, supporting the hypothesis H1.2. The results suggest that the growth of the domestic credit provided by the banking sector will speed up the life insurance industries in Italy and impede it in Canada, France, Japan, and the US. Meanwhile, there is a complementary relationship between nonlife insurance activity and banking credit supporting the hypothesis H1.3 in France, Italy, Japan, and the UK, and a substitutionary effect in Germany, supporting the hypothesis H1.4. This illustrates that the nonlife insurance premiums have a positive effect on the development of banking credit in France, Italy, Japan, and the UK, and a negative effect in Germany.

For the linkage between insurance activity and stock market, in the active stock market model, there exists a complementary effect between the life insurance premiums and the stock markets in Germany, Japan, and the US, supporting the hypothesis H3.1, and there exist no substitutionary effects in G−7 countries. The result indicates that the demand of stock market is increasing with the development of life insurance activity in Germany, Japan, and, the US. In addition, a complementary effect between the nonlife insurance premiums and the stock market exists in Germany, and the UK, while a substitutionary effect exists in the US. The results reveal that the nonlife insurance industry can promote the development of stock market in Germany and the UK and restrain it in the US, supporting the hypothesis H3.3 and H3.4, respectively. In the passive stock market model, a substitutionary effect between the life insurance activity and the stock market, supporting the hypothesis H3.2, exists in Canada, France, Italy, and Japan. This means that the demand of the stock markets is decreasing with the growth of life insurance premiums in these countries. Besides, there is a complementary effect between the nonlife insurance premiums and the stock markets in Germany and the US, supporting the hypothesis H3.3, and a substitutionary effect exists in Canada and Italy, supporting the hypothesis H3.4. These results suggest that the development of nonlife insurance premiums can raise the demand of the stock markets in Germany and the US, while it can have a negative effect on the stock markets in Canada and Italy.

For the linkage between banking credit and stock markets when banking credit is active, there is a complementary effect in Germany and Italy, supporting the hypothesis H5.1, and a substitutionary effect in France, Japan, the UK, and the US, supporting the hypothesis H5.2. The results show that in Germany and Italy, the domestic credit provided by the banking sector impacts the demand of the stock market positively, while in France, Japan, the UK, and the US affects negatively. In the passive banking credit model, a complementary effect exists in Germany and Japan and a substitutionary effect exists in Canada, Italy, and the US. This means that the development of the stock market can stimulate the demand of the domestic credit provided by the banking sector in Germany and France, while it curtails the demand of the banking credit in Canada, Italy, and the US.

By employing a more general form of the traditional fractional order approach for economic system proposed by Chen(2008) and the multiple stepwise regression method, the long-run linkages among insurance activity, banking credit, and stock markets in G-7 countries are investigated and can be concluded by five major aspects.

First, the linkage between any two series in G-7 countries is various. For example, there is a unidirectional effect of the stock market on banking credit in Canada and France, while there is a bi-directional relationship between the two financial sectors in Italy and the US.

Second, for the significant relationship, variant results exist for the same two series. For example, there is a complementary effect between the nonlife insurance premiums and banking credit in Canada and the US, while a substitutionary effect exists in France, Germany, Italy, Japan, and the UK.

Third, in one country, the linkage between two series may be different. For the linkage in Italy, there is a unidirectional effect of the stock market on banking credit with the life insurance premiums, while a unidirectional effect of banking credit on the stock market with the nonlife insurance premiums. This means that life and nonlife insurance activities play different intermediary roles for the linkage between stock markets and banking credit. For the significant relationship, there is a positive effect of life insurance activity on banking credit while a negative effect of banking credit on life insurance activity in Canada, and the domestic credit provided by the banking sector promotes the development of the stock market, and in turn the stock market impedes the development of banking credit in Italy. The results suggest that each financial market has its unique development process, implying that the effect of one on another may be opposite.

Forth, the results of the financial system with life insurance activity differ from the results of the financial system with nonlife insurance activity. In France, there is a unidirectional effect of the life insurance premiums on the stock market and no linkage between the nonlife insurance premiums and the stock market. A unidirectional effect of the stock market on the life insurance premiums and a bi−directional effect between the stock market and the nonlife insurance premiums exist in Germany. These results may be caused by the different economic roles of life and nonlife insurance industries.

Fifth, as a whole, the linkage between stock market and banking credit is the strongest, followed by the linkage between insurance activity and banking credit and the linkage between insurance activity and stock markets. There is a bi−directional relationship between the stock markets and banking credit in Germany, Italy, Japan, and the US, and a unidirectional relationship in Canada, France, and the UK. Meanwhile, a bi−directional relationship between the life insurance premiums and banking credit in Canada and Japan and a bi−directional relationship between nonlife insurance premiums and banking credit in Japan and the US are proved, while a unidirectional effect exists in other G−7 countries.

In addition, there is a bi−directional relationship between life insurance activity and stock market in Japan, a bi−directional relationship between nonlife insurance activity and the stock markets in Germany and the US, and unidirectional effects exist in other G−7 countries. Furthermore, in terms of one country, it has individual heterogeneity. For example, in Germany, the linkage between insurance activity and the stock market is stronger than the linkage between insurance activity and banking credit.

4. The difference between the short−run and long−run linkages

Using the TY−VAR procedure and the new nonlinear econometric model with fractional derivative, we investigate the short−run and long−run linkages among insurance activity, banking credit, and the stock markets in G−7 countries. Empirical results show that the short−run and long−run linkages among the three financial sectors appear to differ across countries. In addition, owing to the different economic roles of life and nonlife insurance activities, the linkage between life insurance activity and other financial markets significantly differs from the linkage between nonlife insurance activity and other financial markets. Meanwhile, there are greatly differences between the short−run causal nexus and the long−run relations. We conclude the comparisons of null hypothesis in the short−run and long−run, and the results are shown in Table 7.

<Table 7> Comparison of null hypothesis in the short−run and long−run

Country	Short−run linkage	Long−run linkage	Identical hypothesis
Canada	H3.1 H5.2	H1.1 H1.2 H1.3 H3.2 H3.4 H5.2	−
France	H1.1 H1.3	H1.2 H1.4 H3.2 H5.2	−
Germany	H1.3 H1.4	H1.1 H1.4 H3.1 H3.3 H5.1	−
Italy	H1.3 H3.1	H1.1 H1.4 H3.2 H3.4 H5.1 H5.2	−
Japan	H1.1 H1.3	H1.2 H1.4 H3.1 H3.2 H5.1 H5.2	−
UK	H1.3 H3.1	H1.4 H3.3 H5.2	−
US	H1.4 H5.1 H5.2	H1.2 H1.3 H3.1 H3.3 H3.4 H5.2	H5.2

Compared with the short−run and long−run linkages from Table 7, we can get the following conclusions. First, the long−run linkage is stronger than the short−run linkage. For each G−7 country, the number of supporting the null hypothesis in the long run is larger than that in the short run. For example, in Canada, there are six null hypotheses and two null hypotheses proved in the long−run and short−run. Second, the linkage between insurance activity and banking credit is the strongest among the short−run causal nexus, while the linkage between banking credit and stock market is the strongest in the long−run nexus. However, the individual heterogeneity exists. For example, the short−run causal nexus in the US show that the linkage between stock market and banking credit is the strongest, which the long−run relationships in Canada report that the linkage between insurance activity and banking credit is the strongest. Third, for one country, the short-run linkage between any two financial markets is almost completely different from their long-run linkage. From the column 4, we can find that the null hypotheses supported in the short run differ from that in the long run entirely, except the null hypothesis H5.2 in the US.

V. Conclusions and Implications

Previous works mainly focused on the linkage between insurance activity and economic growth, the interactive effects among different financial sectors in the process of economic growth. However, few attentions have been paid on the linkages between insurance activity and other financial markets from the perspective of industry development. In this paper, we model the linkages among insurance activity, banking credit and stock market for G-7 countries over the period 1979-2007 in a unified framework. Our empirical results provide some useful insight for short-term and long-term investors to diversify risk away as well as earn abnormal returns, and for policy makers to promote the synergetic development of financial markets and realize the interactive effects among different financial sectors on economic growth. Considering the different economic roles of life and nonlife insurance activity, we categorize the insurance premiums into life and property premiums, and discuss them separately.

In order to examine the causal nexus among insurance activity, banking credit, and stock markets, we use the TY-VAR approach proposed by Toda and Yamamoto(1995), which is stable for sample size and variable integrations. The empirical results indicate that the short-run causal nexus among them varies across countries, and the relationships are also diverse for the same two financial markets. For instance, in

France and Japan, there is a unidirectional causality between life and property insurance activities and banking credit, and the insurance activities are the leading indexes. In contrast, a unidirectional causality running from banking credit to nonlife insurance activity exists in Germany and the UK, and no causality between life insurance activity and banking credit is proved. And, there is a substitutionary effect between banking credit and the stock market in Canada, while a complementary effect exists in the US. But, even in one country, the linkage between two series may be different. In the US, a unidirectional causality running from banking credit to the stock market with the life insurance activity, and there has no causality with the nonlife insurance activity. Moreover, the linkages between life insurance activity and other financial markets differ from that between property insurance activity and other financial markets, suggesting that it is necessary to distinguish life and nonlife insurance activities. In addition, as a whole, the linkage between insurance activity and banking credit in G-7 countries is the strongest.

Furthermore, according to the unit root test results, all the series are not integrated of the same order, revealing that the classical cointegration test of Johansen is not suitable in our model. To some extent, the result implies that there may be nonlinear relationships among the three financial sectors. To investigate the long-run nonlinear linkages among insurance activity, banking credit, and stock market, we reconstruct the fractional order model for economic system proposed by Chen(2008), and the multiple stepwise technique is employed to obtain the optimal functions. We find that the long-run linkages are also country-specific. However, differing from the short-run linkage, the linkage between banking credit and stock market in the long run is the strongest. What's more, the long-run linkage is stronger than the short-run linkage, and they are almost completely different.

For empirical modeling, when the series are not integrated with the same order, the traditional cointegration tests are not able to be used. That is to say, the traditional linear methods may not be suitable to model multiple variables. Meanwhile, some traditional nonlinear functions neglect the fact that the current value of economic and financial series depends on both recent and historical values. To overcome these drawbacks, a new nonlinear econometric introduced in this paper is based on the fractional order model with differential equations. The findings suggest that linear model may not be appropriate to analyze the long-run linkage between insurance activity and other financial markets, and researchers should pay attentions on nonlinear models to investigate the relationships among different financial markets.

As to policy implications, our empirical results benefit investors and policymakers. For investors, taking Germany as example, there is no causal linkage among life insurance premiums, banking credit, and stock market indices. The result indicates that the underlying financial assets of investors in Germany are more diversified. Furthermore, under complementary cases, if the financial markets are growing as in the cases of insurance activity or banking credit, investors should either long insurance or bond assets, and then short their stock assets to regulate their hedging strategy, or else long stock and other financial assets to earn abnormal return. According to our findings for the relationships among insurance activity, banking credit, and stock markets, policymakers needs to reform the financial systems to strength their cooperated relationships, and to achieve their interactive effects on economic growth. And, the government should actively encourage financial products combined insurance markets with other financial markets to promote their synergistic developments.

Note that, based on the significantly different empirical results of the linkages in the short-term and long-term linkages among insurance, banking credit, and stock markets, the investment strategy for investors and the government's financial policies should be implemented discriminately in the short run and long run. Meanwhile, the investment strategies and financial policies in different countries should also heterogeneous. In addition, when we analyze and forecast the fragility of banks and other financial sectors, taking their linkages into consideration is necessary, as well as the financial linkages between banks. In this paper, our findings show that there exist some linkages among insurance activity, banking development, and stock market, and hence it is important to realize the financial linkages within and between the three financial sectors for financial stability. Therefore, while estimating system risk linkages among different financial sectors, it is necessary to take their linkages into account.

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요 약

본 연구는 G7국가들을 대상으로 보험, 은행, 주식시장 간의 장단기 관련성을 분석하였다. 단기적인 인과관계를 분석하기 위하여 Toda and Yamamoto (1995)가 제안한 그레인저 인과관계(Granger causality)를 적용하였다. 장기적인 연관성 분석을 위해서는 분수차(fractional) 재무모형에 기반한 Jumarie의 분수차 미분을 적용한 확장 비선형 계량경제모형을 도입하였다. 또한 최적 회귀를 분석하기 위하여 다중 다단계 회귀(multiple stepwise regression) 기법을 사용하였다. 연구결과 보험, 은행, 주식시장 간에는 다양한 형태의 동태적 연관성이 존재함을 알 수 있었다. 특히 장단기 연관성에는 국가별 고유효과가 존재했으며, 장기적인 연관성은 단기적인 연관성에 비해 강한 것으로 나타났다. 한편 단기적인 인과관계에서는 보험과 은행 간의 인과관계가 가장 강하게 나타났고, 장기적으로는 주식시장과 은행의 연관성이 가장 강한 것으로 나타났다. 이러한 연구결과는 위험을 분산하고자 하는 투자자들뿐만 아니라 경제성장 과정에서 금융 시스템의 상호협력적인 발전을 실현하려는 정책당국에도 시사점을 제공할 것이다.

※ 국문 색인어: 다중 다단계 회귀, 보험, 비선형관계, 은행, 인과관계, 주식시장

Appendix

<Table A1> Multiple stepwise regression results for Canada

	Life insurance premiums				Nonlife insurance premiums		
Variable	Model 1	Model 2	Model 3		Model 1	Model 2	Model 3
Constant		34.3551***			12.0013**		
		(0.0009)			(0.0313)		
x_t	6.5325**		−18.3579***				−4.6207*
	(0.0271)		(0.0006)				(0.0913)
y_t	−5.7385**	4.5994*	22.7914***		−2.3523**		8.4339**
	(0.0283)	(0.0653)	(0.0000)		(0.0362)		(0.0265)
z_t		−8.3221***	−4.5843**				−3.2335*
		(0.0064)	(0.0113)				(0.0938)
$x_t * y_t$	−0.6422**		−2.9102***		−3.5336***		−2.4050**
	(0.0344)		(0.0021)		(0.0015)		(0.0283)
$x_t * z_t$			3.4859***		2.4736***		2.1109**
			(0.0007)		(0.0014)		(0.0164)
$y_t * z_t$	0.8207**	−0.3121*	−5.3633***		2.3262***		−1.4720*
	(0.0333)	(0.0832)	(0.0022)		(0.0009)		(0.0653)
x_t^2							
y_t^2			3.8224***			0.0129*	1.5955*
			(0.0034)			(0.0891)	(0.1000)
z_t^2	−5.7385**	0.4068**	0.9845**		−1.6525***	−0.0103*	
	(0.0283)	(0.0176)	(0.0498)		(0.0011)	(0.0991)	

Note: x_t denotes the stock market; y_t denotes the life or nonlife insurance premiums; z_t denotes the banking credit. Superscripts *, ** and *** denote the statistical significance at the 10%, 5% and 1% levels. P−values are in parentheses.

<Table A2> Multiple stepwise regression results for France

	Life insurance premiums				Nonlife insurance premiums		
Variable	Model 1	Model 2	Model 3		Model 1	Model 2	Model 3
Constant			−9.6013*** (0.0017)		2.4353** (0.0347)	5.2672*** (0.0000)	
x_t	0.2725** (0.0386)		1.7348** (0.0077)				
y_t	−0.1760** (0.0472)	−6.9288*** (0.0004)					
z_t		5.4624*** (0.0003)				−0.6125*** (0.000)	
$x_t{}^*y_t$					1.9709** (0.0222)	−0.0077** (0.0287)	
$x_t{}^*z_t$		−0.0085* (0.0916)	−0.1200*** (0.0084)		−1.0489** (0.0387)		
$y_t{}^*z_t$		0.9477*** (0.0001)	0.1535*** (0.0012)		0.6776** (0.0357)		0.0003** (0.0292)
x_t^2					−0.3853** (0.0178)		
y_t^2		−0.2945*** (0.0003)	−0.1194*** (0.0012)		−1.1358** (0.0242)	0.0362*** (0.0000)	
z_t^2		−0.5591*** (0.0001)					

Note: x_t denotes the stock market; y_t denotes the life or nonlife insurance premiums; z_t denotes the banking credit. Superscripts *, ** and *** denote the statistical significance at the 10%, 5% and 1% levels. P−values are in parentheses.

<Table A3> Multiple stepwise regression results for Germany

	Life insurance premiums				Nonlife insurance premiums		
Variable	Model 1	Model 2	Model 3		Model 1	Model 2	Model 3
Constant		−7.8398**					
		(0.0112)					
x_t	0.2241*	1.5570**				2.3833**	1.7374*
	(0.0618)	(0.0178)				(0.0274)	(0.0631)
y_t		0.8076***	36.0733*		−16.6315*	−1.6620**	−1.1640*
		(0.0071)	(0.0699)		(0.0682)	(0.0241)	(0.787)
z_t			−26.3920*		12.8446*		
			(0.0682)		(0.0610)		
$x_t * y_t$			−0.4979**				−0.01657*
			(0.0274)				(0.0573)
$x_t * z_t$		−0.1129**	0.3556**		0.0254***	−0.1712**	
		(0.0130)	(0.0298)		(0.0067)	(0.0223)	
$y_t * z_t$			−10.5655*		1.2321*	0.1198**	0.1880**
			(0.0776)		(0.0508)	(0.0194)	(0.0293)
x_t^2							
y_t^2			5.6939*				
			(0.0736)				
z_t^2	−0.0077*		4.6873*		−0.9633**		−0.0782**
	(0.0734)		(0.0809)		(0.0429)		(0.0179)

Note: x_t denotes the stock market; y_t denotes the life or nonlife insurance premiums; z_t denotes the banking credit. Superscripts *, ** and *** denote the statistical significance at the 10%, 5% and 1% levels. P−values are in parentheses.

<Table A4> Multiple stepwise regression results for Italy

	Life insurance premiums				Nonlife insurance premiums		
Varible	Model 1	Model 2	Model 3		Model 1	Model 2	Model 3
Constant						104.8126***	
						(0.0088)	
x_t	0.2406**		−0.4001**		13.0942**		
	(.0133)		(0.0364)		(0.0155)		
y_t	−0.1588**	−1.4960**			−26.7778**	26.6776**	
	(0.0189)	(0.0399)			(0.0133)	(0.0290)	
z_t		1.4033**			12.9829**	−34.1833**	
		(0.0102)			(0.0185)	(0.0175)	
$x_t{}^*y_t$		−0.4052***	−0.3128***			−0.6829**	
		(0.0000)	(0.0044)			(0.0422)	
$x_t{}^*z_t$			0.0359**		−0.9291**	0.4866**	
			(0.0334)		(0.0176)	(0.0468)	
$y_t{}^*z_t$		0.3153***			1.8898**	−5.9794**	0.0003**
		(0.0018)			(0.0164)	(0.0178)	(0.0292)
x_t^2		0.2821***	0.2159***				
		(0.0001)	(0.0049)				
y_t^2			0.1064***			3.0660**	
			(0.0058)			(0.0135)	
z_t^2		−0.1741***			−0.9135**	3.2528**	
		(0.0021)			(0.0241)	(0.0193)	

Note: x_t denotes the stock market; y_t denotes the life or nonlife insurance premiums; z_t denotes the banking credit. Superscripts *, ** and *** denote the statistical significance at the 10%, 5% and 1% levels. P−values are in parentheses.

<Table A5> Multiple stepwise regression results for Japan

	Life insurance premiums				Nonlife insurance premiums		
Varible	Model 1	Model 2	Model 3		Model 1	Model 2	Model 3
Constant			−77.8380** (0.0310)		88.9577** (0.0338)	96.1738*** (0.0017)	
x_t	22.6051*** (0.0093)	12.7839* (0.0649)	11.1336** (0.0262)				7.1952** (0.0496)
y_t	−13.4606*** (0.0099)		−10.1859** (0.0365)			30.8161*** (0.0045)	−4.5629* (0.0578)
z_t		−5.3288* (0.0863)	12.7092** (0.0335)		−11.4103** (0.0347)	−33.4754*** (0.0022)	
$x_t * y_t$	1.8772*** (0.0096)	1.8518* (0.0728)	1.4310** (0.0344)				1.6983** (0.0434)
$x_t * z_t$	−2.8447*** (0.0097)	−2.2312* (0.0653)	−1.7975** (0.0301)				−1.6342** (0.0362)
$y_t * z_t$		−0.7845* (0.0895)				−6.1510** (0.0204)	−0.4566* (0.0987)
x_t^2					0.0300*** (0.0082)		
y_t^2						3.0412** (0.0333)	
z_t^2	0.6411** (0.0105)	0.9400* (0.0831)			0.3592** (0.0368)	3.1837** (0.0109)	0.5173* (0.0506)

Note: x_t denotes the stock market; y_t denotes the life or nonlife insurance premiums; z_t denotes the banking credit. Superscripts *, ** and *** denote the statistical significance at the 10%, 5% and 1% levels. P−values are in parentheses.

<Table A6> Multiple stepwise regression results for the UK

	Life insurance premiums				Nonlife insurance premiums		
Variable	Model 1	Model 2	Model 3		Model 1	Model 2	Model 3
Constant	19.7811*** (0.0008)				0.6985** (0.0322)		
x_t						7.4314*** (0.0003)	
y_t						4.0429* (0.0638)	
z_t	−2.8973*** (0.0010)				−0.0443* (0.0566)	−6.9438*** (0.0013)	
$x_t * y_t$	−0.0820*** (0.0007)		−0.0088* (0.0993)				
$x_t * z_t$						−1.1664*** (0.0081)	−0.0108* (0.0740)
$y_t * z_t$						−0.2590* (0.0918)	
x_t^2	0.0891*** (0.0004)					0.5946** (0.0427)	
y_t^2		0.0009*** (0.0001)					
z_t^2	0.1162*** (0.0009)		0.0043* (0.0600)			0.6435*** (0.0010)	0.0062* (0.0508)

Note: x_t denotes the stock market; y_t denotes the life or nonlife insurance premiums; z_t denotes the banking credit. Superscripts *, ** and *** denote the statistical significance at the 10%, 5% and 1% levels. P−values are in parentheses.

<Table A7> Multiple stepwise regression results for the US

	Life insurance premiums				Nonlife insurance premiums		
Variable	Model 1	Model 2	Model 3		Model 1	Model 2	Model 3
Constant	4.3222*** (0.0002)					−50.8721** (0.0330)	−137.1075** (0.0499)
x_t		4.6698** (0.0324)				−3.5753* (0.0747)	−6.4257** (0.0323)
y_t		5.1315* (0.0964)			35.1488** (0.0120)		43.0683** (0.0461)
z_t		−4.0881** (0.0185)	0.0779** (0.0124)		−15.2963** (0.0131)	7.4926** (0.0401)	
$x_t * y_t$	−1.3584*** (0.0081)		−0.2213* (0.0711)		10.7367** (0.0223)		3.4368** (0.0342)
$x_t * z_t$	0.7373*** (0.0014)	−0.6010** (0.0211)	0.0995* (0.0653)		−5.7265** (0.0255)	0.2104* (0.0814)	−1.4656** (0.0380)
$y_t * z_t$			0.0707* (0.0927)		−16.9244** (0.0450)		−3.9421** (0.0420)
x_t^2	−0.1542* (0.0915)	0.3980** (0.0143)			1.2620** (0.0453)		0.4254** (0.0448)
y_t^2	0.5368** (0.0139)	−0.3647* (0.0932)			11.9489* (0.0955)		
z_t^2	−0.1511*** (0.0011)	0.2450** (0.0117)	−0.0366* (0.0803)		5.3223** (0.0300)	−0.2647** (0.0470)	1.1588** (0.0410)

Note: x_t denotes the stock market; y_t denotes the life or nonlife insurance premiums; z_t denotes the banking credit. Superscripts *, ** and *** denote the statistical significance at the 10%, 5% and 1% levels. P−values are in parentheses.