

A Discussion on Whether Financial Contagion Exists Between US Financial Markets from 2006 to 2011

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Abstract—Financial crises have a devastating impact on the worldwide economy. They can not only spread across different countries, but can also be contagious across different financial markets within a country. This paper will use the financial risk data from 2006 to 2011 to investigate the financial transmission mechanism in the US among the bond market, the foreign exchange market and the stock market by constructing a VEC model. The aim of this paper is to find whether financial contagion can be found between these three financial markets in the US and how risk spreads between them. Furthermore, the empirical conclusion of this paper shows that there really exists contagion between the different financial markets, and it can provide important theoretical basis to against the financial risk contagion between these three financial markets.

Keywords—*financial contagion; financial markets; risk; crisis*

I. INTRODUCTION

Financial contagion is one of the hottest issues in the field of financial studies. With the inflation of hot money, currency and financial crises occurred frequently in recent years. According to the research of Bali and Michael (2001), the probability of erupting a financial crisis in a stochastic country is twice as large as in 1973. Besides, financial infection greatly enhanced as well, which likes an infectious disease spread quickly from initial country to the others. For instance, financial crisis happened firstly in Thailand in 1997 dragged the Asian economy into swamp. Interestingly, there are some exclusive words to describe this phenomenon, such as “Tequila Effect”, “Asian flu” and the “Russian Virus”.

The financial crisis in the US in 2007 influenced almost all the countries, and after that the global economy stepped into recession. This crisis occurred with a grievous crash in the real estate market and spread to the stock market soon. The main reason of this crisis is about the low cost direct financing and non-performing loans (NPL) mortgage, which fed bubbles tremendously and made the stock prices overrated gravely.

There are two reasons why I interested in this particular crisis. Firstly, this crisis in 2007 was spreading so far and fast in the US, and contagion of the financial risk was obvious in empirical strand. Hence, financial contagion between financial markets can be captured more easily. Secondly, this crisis was started in real estate market and stock market, and then spread to the other markets, the time

order makes it possible to focus on the contagion between these three markets. However, most of researches focusing on financial contagion across different countries, and few literatures concentrating on contagion between different financial markets in the same country. One of the contributions of this paper is to find the existence of contagion within a country. In addition, this paper can make it clear that how risk spreads across financial markets in a same country.

The empirical part of this paper focuses on testing if contagion can be found between these three financial markets by constructing vector error correction (VEC) model, which is the second contribution of this paper. One of the advantages of VEC model is that it can analyze the relationships between non-stationary series. Besides, it remains information of the disequilibrium errors, which is an improvement of the VAR model. By estimating the VEC model, co-integration equation and coefficient of error term can be obtained. Specifically, from co-integration equation the long-run relationship can be got, and from coefficient of error term the direction and speed to long-run equilibrium can be described.

From a more theoretical standpoint, this paper defines the mean of contagion by summarizing the definitions given by Marcello Pericoli and Massimo Sbracia (2001) and extending to the particular research area. Financial contagion in this paper is defined as a financial shock spreading from a financial market to another, with a significant increase in co-movements of prices and quantities. In other words, there is co-integration relationship of returns of the financial assets between different financial markets.

II. LITERATURE REVIEW

In general, the literature focusing on financial contagion can be divided into two strands — a theoretical one and an empirical one. Although the proportion of theoretical research is smaller than empirical research, the time range of theoretical research is really large. The earliest person who conducted a study on the feature of financial risk contagion is famous American economist Charles Kindleberger. His book *Manias, Panics, and Crashes* in 1978 is the first monograph about financial crisis. [1] In his book, it is the first time put forward the issue of financial risk contagion by analyzing connection of three different financial crises. In terms of the empirical research on financial contagion in his

book, his analyzed begin with the “Tulipomania” in Holland from 1636 to 1637, and then to the black Monday in the New York stock market in 19 October 1929 and the extremely drop of the Japanese stock market in November 1990. He considered that burst of financial crisis is closely connected with the economic cycle. In the boom times, investment and credit expand quickly, and price of stock and real estate increase continuously. People are lost in the prosperous situation, and economic bubble will be more and more inflated, and at last it must be solved by financial crisis.

Pericoli and Sbracia (2001) summarized five definitions of contagion. [2] The third one is that the co-movement of the prices and quantities increase significantly cross markets, condition on the crisis occurred in one or more financial markets. It includes significant increases in co-movements of prices and quantities across markets, conditional on a crisis occurring in one or more financial markets. It is the definition chosen in this dissertation, since this paper focuses on contagion of different markets within a country.

With regard to the reasons why contagion happens, there are a large number of literatures which can be separated to two categories. The first one is that contagion is downlink interference of market spreading from one country to another. This kind of contagion is known as non-occasional financial risk contagion including trade channel and international finance channel. The other one is known as occasional risk contagion or pure contagion which not based on real connection across countries, including change of the investors’ behavior and change of expectations, because the correlation across markets, such as return of the portfolios and probability of the speculative attack, increases after a push. There are mainly six different channels: the trade channel, the financial channel, the expectation and risk appetite channel, the liquidity channel, the symmetric information channel and the change of the portfolio channel. Kyle and Xiong (2001) said that a financial crisis can change investors’ risk appetite through wealth effects, which can increase the correlation between the asset prices of different markets and different countries. [3] Besides, Allen and Gale (2004) found that the liquidity crisis of a particular bank can spread to the whole financial system across different countries if the risk of lending and bank run exists. [4] In addition, Kodres and Prisker (2002) explained financial contagion across different countries through asset prices. They thought that contagion is due to investors sharing financial risk by adjusting their portfolios in different markets. [5]

Generally, there are five mechanisms of financial contagion, including the financial spillovers effect, pure contagion, the monsoonal effect, the trade spillovers effect and the information conduction effect. The most significant mechanism to explain how financial risk spreads between the markets in the same country is the financial spillovers effect. More specifically, Kodres and Prisker (1999) considered that investors will change their asset portfolio if they are influenced by the crisis in one particular financial market, which causes the financial shock to spread to the other financial markets. [6]

For the empirical researches, there is a wealth of models to test the existence of contagion. Baig and Goldfajn (2003) analyzed several destructive financial crises using Copula method, and they found that the correlations of capital markets dramatically increase after a financial crisis occurred. [7] Gonzalo (2005) concluded that strict bidirectional transmission exists between the bond market and the stock market in the US by using Copula function. [8] In contrast, Forbes and Rigobon (2002) indicated that there was no contagion but the interdependence by analyzing the Asian crisis in 1997, the Mexican crisis in 1994, and the US market crash in 1987. [9]

Michael G. Arghrou and Alexandros Kontonikas offered a detail empirical investigation of EMU sovereign-debt crisis, and they found a marked shift in market pricing behavior from a “convergence- trade” model before August 2007 to one driven by macro-fundamentals and international thereafter. Andrade and Adelaide analyzed the fundamentals of the Portuguese crisis. They argued that the main problem the economy is facing is its output stagnation due to a kind of Dutch disease that has created high and increasing levels of indebtedness, low and decreasing levels of saving and has reduced Portuguese competitiveness. [10] From these literatures about change of “fundamentals” during financial crisis, we can conclude that the movements of returns of financial assets cannot represent financial risk accurately, as the movements of the observations include the change of fundamentals. Hence, if we want to research contagion of financial risk, it is necessary to avoid the influence of the change of fundamentals so that we can get the pure fluctuations without the trend term which represents the risk preferably. In this paper, HP filtering will be used to separate the trend term and the volatility so that the problem of the “fundamentals” can be evaded to some extent, and in next part it will be explained in detail.

III. DATASET AND METHODOLOGY

A. The Dataset Description

The dataset in this paper consists of weekly time series observations from 2006 to 2011. The weekly time series observations are chosen because this frequency can reflect the volatility more accurately. As in this high frequency, the fundamental problem can be relieved because the real value of the companies cannot easily change in one week.

The data of bond market is reflected by the treasury Inflation-Indexed long-term average yield¹. It is based on the average bid yields for all types of long-term US treasuries. There are two reasons to choose it to reflect the bond market data. Firstly, according to the ways of offering, the US treasury securities can be divided to different types, such as certificate treasury bonds, physical bonds and book-entry treasury bonds. The average yield of different types is more accurate to describe overall condition of the bond market. Secondly, according to the repayment terms, the US treasury securities can be segmented into T-Bills (short-term), T-

¹ The data is from the Economic Research FEDERAL RESERVE BANK OF ST. LOUIS, the website link is <http://research.stlouisfed.org/fred2/series/DLTIIT>.

Notes (medium-term) and T-Bonds (long-term). The yields of long-term treasuries are selected as they have longer durations. Duration is the level of sensitivity to the change of the interest rate. Hence, the prices of the long-term bonds are more volatile with a same change of rate. In other words, the long-term bonds are more risky. So it is in favor of capturing the risk of the bond market, which is the target of this paper.

The data of stock market is selected as standard & Poor's 500 index during 2006 to 2011². S&P 500 index is an average record of the US stock market from 1957, which contains observations of 500 listed companies in the US. Compared with Dow Jones Industrial Average index (DJIA) and NASDAQ index, S&P 500 is more accurate to reflect the situation of the US stock market, as it is a weighted average based on the market value of a company. However, the DJIA is a simple arithmetic average, which will lead to a problem that the index will be noised by the companies with larger weight. In addition, the NASDAQ index mainly consist the stocks of the technology and internet companies such as Google and Apple.

The data of foreign exchange market is chosen by the US/Euro foreign exchange rate³. The exchange rate of US/Euro is significantly representative for the foreign exchange market in the US, as European Economic Community is a significant trade companion of US, besides, it is one of the most important parts of world economy.

However, the raw data which have been got above cannot be used directly, because this paper is discussing the hazard of the markets. It is necessary to capture the risk factor of the observations, in other words the pure volatility should be separated from the original series. The method of HP filtering was chosen to obtain cyclical component of the series, as it can separate trend term and pure random fluctuations of series. To some extent, the problem of trend effect (fundamental) can be treated by using HP filtering. Practically, it is possible to extract cyclical component of the bond, stock and foreign exchange series, which can reflect financial hazard in these three markets respectively. After HP filtering, the pure fluctuations of these three series can be described as three volatile series, and the volatile series are denoted as BV, SV and EV respectively to represents hazard of bond market, stock market and foreign exchange market.

B. The Econometric Model

Engle and Granger combined co-integration with the error correction model (ECM), and then constructed the Vector Error Correction (VEC) model. According to the conditions to build an ECM, it is necessary to get co-integration of the variables. Hence, the VEC model is a VAR model with co-integration constraints, and it is set up condition on the series are co-integrated but non-stationary.

VEC model is constructed based on the VAR model, so consider the following VAR (p) model firstly.

² The data is from the Economic Research FEDERAL RESERVE BANK OF ST. LOUIS, the website link is <http://research.stlouisfed.org/fred2/series/SP500>

³ The data is from the ONADA corporation official website, the link is <http://www.oanda.com/lang/cns/currency/historical-rates/>

$$Y_t = \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \dots + \Pi_k Y_{t-k} + U_t \quad (1)$$

$$U_t \sim \text{i.i.d.}(0, \Omega)$$

Y_t is a vector of variables in time t , Y_{t-k} ($k = 1, 2, \dots$) are the lags. Π_k ($k = 1, 2, \dots$) are coefficient matrixes and U_t is the error term. Without loss of generality, it is necessary to assume that $Y_t \sim I(1)$. If the order of a variable is greater than one, it can be transformed to $I(1)$ by the difference transformation.

By subtracting Y_{t-1} on both sides of equation (1), we get

$$\Delta Y_t = (\Pi_1 - I)Y_{t-1} + \Pi_2 Y_{t-2} + \dots + \Pi_k Y_{t-k} + U_t \quad (2)$$

And then, it is possible to plus and minus $(\Pi_1 - I)Y_{t-2}$ on the right side of equation (2) at the same time.

$$\Delta Y_t = (\Pi_1 - I)\Delta Y_{t-1} + (\Pi_2 + \Pi_1 - I)Y_{t-2} + \dots + \Pi_k Y_{t-k} + U_t \quad (3)$$

Continuing, the following equation can be concluded by plus and minus $(\Pi_2 + \Pi_1 - I)Y_{t-3}$ on the right side of equation (3).

$$\Delta Y_t = (\Pi_1 - I)\Delta Y_{t-1} + (\Pi_2 + \Pi_1 - I)\Delta Y_{t-2} + (\Pi_3 + \Pi_2 + \Pi_1 - I)Y_{t-3} + \dots + \Pi_k Y_{t-k} + U_t \quad (4)$$

It is not difficult to do the same process as above continuously.

Next, we denote that

$$A_i = \Pi_i + \dots + \Pi_1 - I \quad (i = 1, 2, \dots, k - 1)$$

$$\Pi = \Pi_k + \dots + \Pi_1 - I$$

Then the VEC model can be showed as the equation (5).

$$\Delta Y_t = A_1 \Delta Y_{t-1} + A_2 \Delta Y_{t-2} + \dots + A_{k-1} \Delta Y_{t-k+1} + \Pi Y_{t-k} + U_t \quad (5)$$

In the above equation, Π is the impact matrix, and it is a polynomial matrix of the difference between parameter matrix and identity matrix. All of the elements in impact matrix are polynomials. The impact matrix indicates the existence of co-integration relationships. In the next part, ADF test and co-integrating test will be used to certify the VEC model can be constructed in the particular case of this paper.

C. ADF Test and Co-integration Test

As described above, the weekly data from 06 January 2006 to 30 December 2011 of these three financial markets which are 939 observations has been disposed by HP filtering. The volatility of these series has been extracted and denoted as BV, SV and EV to reflect hazard of the bond market, stock market, and foreign exchange market respectively. Firstly, running the Unit root test (ADF) for these three variables, and the results are shown in "Table I". According the results, it is clear that the series of BV and SV are stationary, but EV is non-stationary. Only after first order difference, it can be stationary. Hence, VEC model is necessary to research the relationships of these series.

However, before constructing VEC model, it is indispensable to do co-integration test to make sure that it is

not spurious regression. The co-integration indicates that there are long-run equilibrium relationships of the time series. The co-integration test in this paper is the Jonhamson (1995) con-integration test. The results of Jonhamson co-integration test are described in "Table II".

TABLE I. ADF TEST OF THE VARIABLES

Variable	ADF test statistic	5% critical value	1% critical value	Prob.	Stationarity
BV	-5.574625	-2.8710	-3.4533	0.0000	stationary
SV	-5.265534	-2.8710	-3.4533	0.0000	stationary
EV	-1.303146	-2.8710	-3.4533	0.1935	Non-stationary
D(EV)	-3.9814	-2.8710	-3.4533	0.0098	stationary

TABLE II. JONHAMSON CO-INTEGRATION TEST

Eigenvalue	Likelihood Ratio	5% critical value	1% critical value	Hypothesized No. of CE(s)
0.110866	65.84436	42.44	48.45	None**
0.080661	29.65194	25.32	30.45	At most 1*
0.012098	3.748990	12.25	16.26	At most 2

^a. Notes: (***) denotes rejection of the hypothesis at 5% (1%) significance level.

According to the result of co-integration test, there is unique co-integration relationship of these variables, and the co-integrating equation is shown by the following equation (6).

$$EV = 0.023372 - 0.017035 SV + 8.566126 BV + 5.51E-05@trend+u_t \quad (6)$$

As made clear by equation (6), if the risk in foreign exchange market increases by 1%, the risk in stock market will decrease by 0.017035%, and the risk in bond market will rise by 8.566126%. Besides, @trend is the time trend term, and the risk of financial market is positively correlated with time trend as the coefficient of @trend is positive. In other words, the risk of financial market will go up over time.

For the negative correlation between risk of foreign exchange market and stock market, an appropriate explanation is about "flight to safety". To be more specific, the exchange rate of US dollar is market-leading completely, risk in the foreign exchange market is not only from influence factors in the US, such as inflation, trade, and the macroeconomic policy, but also from the European countries. For instance, if the inflation in European countries increases, euro dollar will devalue, hence the rate of US/Euro will increase. On the point of investors, risk in the foreign exchange market is more difficult to be avoided. For the risk adverse investors, if the risk in foreign exchange market goes up, they will change their asset portfolio to evade hazard. The most possible way to avoid risk is that they can change the risky asset to a safer one, such as stock. And for another reason, stock market of the US is open and transparent, the automatic repair ability is strong relatively, investors are

more intend to put their money in the stock market. As a conclusion, the negative correlation of foreign exchange market can be explained by the statement of "flight to safety", but not the exact risk contagion.

In contrast, there is a strong positive risk contagion mechanism between foreign exchange market and bond market in the long-run. One of the most important reasons for positive correlation is that central bank can control the right of issuing and repaying state treasuries. Hence, if monetary authority realized the risk of foreign exchange market, it will take some measures in bond market to control the quantity of free domestic currency, and by this way the drastic volatility of exchange rate can be remitted a little. But at the same time, the risk of foreign exchange market will spread to bond market. Hence, there exist exact severe contagion between foreign exchange market and bond market.

In conclusion, from the results of Jonhamson co-integration test, there are co-integration relationships of these three variables.

D. VEC Model

First and foremost, lagged difference should be chosen before the construction of VEC model. According to AIC, the second order lagged difference is selected as its AIC is smallest. Hence, a second order lagged VEC model can be constructed. Based on general model defined above, the exact second order VEC model can be obtained as in equation (7).

$$\Delta Y_t = A_0 + A_1 \Delta Y_{t-1} + A_2 \Delta Y_{t-2} + \Gamma ECM_{t-1} + \varepsilon_t \quad (7)$$

In this equation, ΔY_t , ΔY_{t-1} and ΔY_{t-2} are all the vectors of the differential variables, A_0 is a three by one matrix, A_1 and A_2 are both three by three matrix, Γ is the coefficient matrix of the error correction term, and the ε_t is the random term. The following expression describes the VEC model in the matrix form.

$$\begin{bmatrix} \Delta BV \\ \Delta EV \\ \Delta SV \end{bmatrix} = A_0 + A_1 \begin{bmatrix} \Delta BV_{t-1} \\ \Delta EV_{t-1} \\ \Delta SV_{t-1} \end{bmatrix} + A_2 \begin{bmatrix} \Delta BV_{t-2} \\ \Delta EV_{t-2} \\ \Delta SV_{t-2} \end{bmatrix} + \Gamma ECM_{t-1} + \varepsilon_t \quad (8)$$

By analyzing the coefficient matrix of error correction term (ECM_{t-1}), direction and speed of the risk in these three markets to long-run equilibrium can be concluded.

IV. EMPIRICAL STRATEGIES

A. Model Estimation and Results

As described above, VEC model is an improvement of VAR model as VEC model equips the error correction mechanism. The lagged variables can impair autocorrelations of error term. The co-integrating equation can reflect long-run equilibrium relationship of the risk in bond market, foreign exchange market and stock market. However, co-integrating equation cannot indicate the effect path of stochastic disturbance, instead, the effect of stochastic disturbance can be reflected in the path of short-run deviation from equilibrium. According to AIC, a second

order lagged VEC model has been constructed above. The estimation of this VEC model is shown as follows.

$$\begin{aligned}
 & \begin{bmatrix} \Delta BV \\ \Delta EV \\ \Delta SV \end{bmatrix} = \\
 & \begin{bmatrix} 0.000565 \\ 8.53E-05 \\ 0.140091 \end{bmatrix} + \\
 & \begin{bmatrix} 0.149368 & 1.065618 & -0.001115 \\ -0.002772 & 0.039542 & -1.21E-05 \\ 0.986003 & 146.9655 & 0.11946 \end{bmatrix} \begin{bmatrix} \Delta BV_{t-1} \\ \Delta EV_{t-1} \\ \Delta SV_{t-1} \end{bmatrix} \\
 & + \begin{bmatrix} 0.032752 & 0.446173 & -5.30E-05 \\ 0.003876 & 0.066361 & -7.58E-06 \\ -12.99827 & -87.84017 & -0.008547 \end{bmatrix} \begin{bmatrix} \Delta BV_{t-2} \\ \Delta EV_{t-2} \\ \Delta SV_{t-2} \end{bmatrix} + \\
 & \begin{bmatrix} -0.138858 \\ -0.00479 \\ 13.77376 \end{bmatrix} ECM_{t-1} + \varepsilon_t \quad (9)
 \end{aligned}$$

As shown above, the co-integrating equation reflects long-run equilibrium relationships of the risk in bond market, stock market and foreign exchange market. But in the above equation (9), the coefficients of error correction term (ECM_{t-1}) describes direction and speed of the risk in these three financial markets to long-run equilibrium. In other words, by analyzing the coefficient matrix of error correction term (ECM_{t-1}), the mechanism of how these three variables (risk in bond market, stock market and foreign exchange market) move to the long-run equilibrium can be concluded.

In terms of the first coefficient (-0.138858), it implies that the risk in bond market is moving oppositely to the risk in stock market and foreign exchange market in short-run. As in short-run, if the risk of bond market dramatically increases, the investors will change their asset portfolio to stock asset or foreign exchange asset. In addition, the change of expectations of investors cannot have significant effect on the whole situation of the financial markets in short-run.

Similar to the first coefficient, the second coefficient (-0.00479), which is also negative, implies that the risk in foreign exchange market is moving against the risk in bond market and stock market in the short-run. Different from the first coefficient, the second is smaller, which indicates that the speed of the risk in foreign exchange market moving to long-run equilibrium is slower than the risk in bond market.

In contrast, the third coefficient (13.77376) is a significant positive number, which implies a specific risk contagion from stock market to bond market and foreign exchange market even in the short-run. In other words, if the risk in stock market rises, risk in the other two markets will ascend quickly and dramatically in short-run. The most important reason may be the co-movement between stock market and other financial markets is greater than the other ones. The risk in stock market can spread quickly and severely to other financial markets. Hence, from this particular result about the short-run risk contagion from stock market to bond market and foreign exchange market, it is clear that to avoid the risk in stock market is really significant to ensure the safety of the whole financial markets.

More empirical, the financial crisis in 2007 occurred with a terrible crash in stock market. The main reason is that the low cost direct financing and the non-performing loans (NPL) mortgage led to an inefficient economic development, which fed the bubbles tremendously and made prices of stock assets overrated gravely. Hence, if stocks were undersold in quantity because of the bankrupt companies, the price and dividend of stocks will drop unlimitedly.

In order to response to the stock market crash, the US government has to purchase NPL and expand financial deficits. According to data from the FMS, the financial deficit increases to incredible 455 billion dollars in 2008. There are three ways to repay the vast debt. Firstly, FED purchase new national debt, in other words, it is the way of printing paper money. However, it may cause a severe inflation, and the US dollar will be devalued seriously, which will spread the risk to foreign exchange market and bond market. Secondly, the government can increase revenue substantially. But a sluggish economy needs decreasing revenue to stimulate the economy, so it is less possible to use this method. Finally, the national debt can be purchased by the investors in the other countries.

Most importantly, the market-based financial system makes the risk can spread unlimitedly from capital market to banks, which have accelerated risk contagion between different financial markets. Because banks are the most crucial joints of different financial markets, such as bond market, foreign exchange market and stock market.

B. Granger Causality Test

According to the results of Granger Causality test, which described in table III, two null hypotheses can be rejected. Hence, it can be concluded that there exists unidirectional contagion between stock market and bond market. To be specific, the unidirectional contagion is from stock market to bond market. In other words, if a crisis occurs in stock market, bond market will be likely to be infected. Besides, a unidirectional contagion also exists between foreign exchange and bond market, which implies that the risk can spread from foreign exchange market to bond market. If foreign exchange market is fallen in crisis, the bond market will be affected with high probability.

In addition, the results of Granger Causality test also imply that contagion is not significant from bond market to stock market. The risk in the stock market was mainly caused by the risk from companies and banks in the 2007 financial crisis. The breakup of the two large house property companies (Freddie Mac and Fannie Mae) led to a radical drop of price of the stocks. The basic reason of the crisis is because of substandard loan, which brought bubbles in real estate market and stock market. Hence, as shown by the results of Granger Causality test, risk in the stock market was basically not influenced by bond market.

Moreover, the results of Granger Causality test indicate that null hypothesis of BV dose not Granger Cause of EV cannot be rejected. In other words, the risk in foreign exchange market is not significantly affected by the risk in bond market, because the risk in foreign exchange market is

closely connected by foreign exchange rate. The foreign exchange rate is influenced by international balance of payment, foreign currency reserve, interest rate and the political situation. Even though the volatility in the bond market may affect the interest rate, the risk in bond market does not have an obvious effect on foreign exchange market from the results of Granger Causality test.

TABLE III. GRANGER CAUSALITY TEST

Null hypothesis	Lag	Observations	F-statistic	Probability
SV does not Granger Cause BV	2	311	12.3516	6.9E-06
BV does not Granger Cause SV	2	311	0.60248	0.54810
EV does not Granger Cause BV	2	311	11.9263	1.0E-05
BV does not Granger Cause EV	2	311	2.51077	0.08288
EV does not Granger Cause SV	2	311	1.48428	0.22829
SV does not Granger Cause EV	2	311	0.91598	0.40122

^a. Notes: According to the results, two null hypotheses can be rejected at the rejection of the hypothesis at 5% significance level. The first one is SV does not Granger Cause BV, and the second one is EV does not Granger Cause BV.

Furthermore, based on the Granger Causality test, there is no significant contagion between stock market and foreign exchange market. The reason is that risk in the stock market was come from the risk of companies, but not directly from the situation in foreign exchange market. Similarly, risk in foreign exchange market is basically not affected by stock market, as the risk in foreign exchange market is influenced by international political situation and international balance of payment.

C. Impulse Response Analysis

In the practical application of VEC model, it is not usual to analyze influence of a change of a variable to another one, but to analyze dynamic effect of the system after a shock or after a change of a particular error term. And this method is known as impulse response function (IRF). The impulse response function describes reaction of an endogenous variable to the residual impact.

As made clear by the impulse response of variables, the response of risk in financial markets to the shocks can be concluded. After introducing a positive shock to the risk of bond market (BV), there is a positive push to itself and it is decreasing over time. However, there is a negative push to the risk in the stock market. It gets to the lowest point in second period and then increases without convergence. With regard to the response of the risk in foreign exchange market, it is positively pushed and it gets to the highest point at period four. After the peak value, it decreases and then converges.

After introducing a shock to the risk of stock market (SV), there is a positive push to the risk in bond market and it increases without convergence. And there is also a positive push to itself, but after the peak value at period two it converges. In addition, a positive push exists in the risk of

foreign exchange market, and it increases without convergence.

After introducing a shock to foreign exchange market (EV), there is a negative push to the risk in bond market and it decreases over time. Besides, there is also a negative push to the risk in stock market, but different from the last case, it increases over time and converges in period eight. In addition, there is a positive shock to itself and gets to the peak value in period three.

In conclusion, the bond market is more easily to be effected by the risk in other financial markets. If the crisis exists in stock market or in foreign exchange market, bond market is easily to be infected and the probability of increasing on the risk in bond market goes up. In addition, the risk in stock market or foreign exchange market is more likely to be effected by itself.

V. CONCLUSION

A. Conclusion

According to the empirical results, there really exists contagion between these three different financial markets.

Firstly, based on the co-integrating function, if the risk of foreign exchange market increases by 1%, the risk of bond market will rise by 8.566126%. It implies a strong positive risk contagion mechanism between foreign exchange market and bond market in the long-run. However, there is a opposite mechanism between the risk in foreign exchange market and stock market, if the risk of foreign exchange market increases by 1%, the risk of stock market will decrease by 0.017035%.

Secondly, according to the coefficient of error terms in VEC model, the coefficient of error term of SV is a significant positive number, which implies a specific risk contagion from stock market to bond market and foreign exchange market in the short-run. However, the risk in other markets such as bond market and foreign exchange market does not significantly spill in the short-run. Hence, it can be concluded that if the risk in stock market increases, the risk in bond market and foreign exchange market will rise with high probability. The uncertainty in the stock market is a threat to consistency of bond market and foreign exchange market.

Thirdly, based on the results of Granger Causality test, there is a unidirectional contagion from stock market to bond market. If a crisis occurs in stock market, bond market will be likely to be infected. Besides, a unidirectional contagion also exists between the foreign exchange and the bond market, which implies that risk can spread from foreign exchange market to bond market. That is, if the foreign exchange market is fallen in crisis, bond market will be affected with high probability.

Finally, according to impulse response analysis, these three different financial markets have different response after a shock. If introducing a random shock to the risk in bond market (BV), there is a negative push to the risk in stock market and a positive push to the risk in foreign exchange

market. In addition, if introducing a random shock to stock market (SV), there is a positive push to the risk in bond market, and a negative push to the risk in foreign exchange market. Moreover, by introducing a shock to the risk in foreign exchange market (EV), there is a negative push to stock market and bond market.

B. Policy Recommendations

According to conclusions, there exists significant risk contagion in the US between these three different financial markets, which may cause fearful financial crisis. The safety of financial system will be influenced, and then real economy will possibly have an unhealthy development. The financial regulation should take into account risk contagion between different financial markets, and take different regulations to financial markets based on financial risk contagion mechanism and the action direction of contagion.

In terms of the most influential stock market, it is necessary to enhance regulations and risk management. As it turns out, the volatility of risk in stock market is significant, and it has a serious influence to the other financial markets. Hence, it is necessary to enhance regulations of stock market and regulate investment behaviors. In addition, speculations should be restrained and short selling mechanism should be completed. In terms of bond market, it can assimilate some risk from stock market, but the huge structural risk cannot be ignored.

Most importantly, financial derivatives market should be regulated more seriously. One of the most important reasons of the financial crisis in 2007 in the US is the low cost direct financing and the non-performing loans (NPL) mortgage which led to an inefficient economic development. Because of bankrupt of companies, prices and dividend of stocks dropped unlimitedly. Hence, regulations of financial derivatives market is worthy of attention.

In reality, after the financial crisis in 2007, the International Organization of Securities Commission has put forward a set of reform plan of financial derivatives. In 2009, the G20 summit in Pittsburgh put forward some measures to complete derivatives market, such as enhance the regulations on financial derivatives, over-the counter (OTC) derivatives, the rating firms and hedge funds. In addition, in 2010, the Financial Stability Board (FSB) established the report "Implementing OTC Derivatives Market Reforms" to enhance market function and transparency of the OTC derivatives. The most important regulation will be discussed in future may be the regulations on shadow banking which is not in the regulation system now.

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