The Linkage between Currency, Stock, Bond and Commodity Markets: Evidence from China

Shan Wu[1, a], Jinhua Ye[1, b], Yuqin Zhou[2, c, *]

[1]School of Finance, Nanjing University of Finance and Economics, Nanjing, China

[2]School of Economics and Management, Chongqing Normal University, Chongqing, China

[a] wushaniam@outlook.com; [b] yejinhua0224@163.com; [c] zhouyuqin@cqnu.edu.cn

*Corresponding author

Keywords: Linkage, Var-garch model, Variance decomposition

Abstract: With the increasing degree of openness, and the fewer barriers between financial sub-markets, it is of considerable significance to study the linkage between financial markets, and to prevent the occurrence of significant financial risks. Based on theoretical research, this paper uses VAR model, Granger causality test, and GARCH model to analyze the stock market, bond market, money market, and commodity market in the past seven years. It is found that there is no apparent risk cross-infection between the stock and bond market as expected. At the same time, the empirical results show that there is evident risk cross-infection between the bond market and currency market, between the stock market and the commodity market risk of cross-infection.

1. Introduction

The global financial crisis in 2008 caused the subprime crisis in the American financial market by the default of a single financial sector, which affected the global financial market. In 2015, the abnormal fluctuation of China's stock market greatly influenced the development of other financial markets in China. Every economic crisis starts from one sector, one financial market, and spreads to other financial sectors and financial markets. The spillover effect of this risk has aroused the attention of scholars and insiders of various countries on the risk contagion between financial markets.

After the reform and opening up, the scale of China's financial market has been expanding day by day, which has become one of the important parts of the economy. The regulation of opening up has also been continuously liberalized, and the connection with the international financial market has become stronger and stronger, which is easy to be affected by the global financial market. Recently, the trade war between China and the United States, the spread of the primary election, and the new coronary epidemic in the United States have increased the instability of the global economy. It is of great practical significance to study the contagion of financial market risks to prevent systemic financial risks effectively.

From a long-term perspective, this paper uses the data of stock market, bond market, money market and bulk commodity market in the past seven years to study the risk contagion effect among the major financial markets in China. In this paper, VAR model is firstly established to study the interaction among the four markets. On the basis of VAR model, Granger causality test, impulse response analysis and variance decomposition are carried out. It is found that there is a two-way Risk Spillover relationship between the stock market and the commodity market. At the same time, there is a one-way spillover relationship between the money market and the bond market and a one-way spillover relationship between the commodity market and the bond market. In addition, GARCH (1,1) model is used to study the influence of conditional variance. It is found that the four markets have obvious fluctuations, and the impact of time is longer. The disadvantage of this paper is that in the GARCH (1,1) model, the GARCH coefficient and arch coefficient of money market and bond market are slightly greater than 1, which may be due to the autocorrelation effect of the two financial

  DOI: 10.25236/ieesasm.2020.053

markets themselves, and it also shows that the two markets need a long time to mitigate the impact of the impact.

2. Literature Review

The study of the cross market transmission of financial risk in foreign countries began earlier. Forbes et al. (2002) believed that financial risk transmission is the risk transfer between markets. Kodres (1998) uses the rational expectation model of an asset price, to study the determinants of financial risk cross market contagion, and finds that in the cross market financial risk transmission channel, the risk of one market is transmitted to another market through the behavior of investors. Freixas et al. (2000) used the complex network analysis method to study the cross market risk of financial risk and found that banks play an important role in financial risk contagion.

Stivers et al. (2002) took the U.S. stock market and bond market as the research object to explore the degree of connection between the stock market and bond market under different market conditions. It is found that when the degree of market certainty is high, the price of stock market and bond market has a positive correlation, while when the degree of market certainty is low, it has a negative correlation. Gilchrist (2009) studied the risk transmission of the stock market to the real economy, and found that the volatility of the stock market has a significant impact on the real economy market. Chiang (2014) studied the prices of the stock market and bond market in different periods and found that the correlation degree of stock market and bond market was different in different periods.[1][2][3][4][5][6]

Although cross-market financial risk transmission started late in China, the research results are also rich. On the one hand, we should understand the causes and transmission paths of cross market financial risks in theory, on the other hand, we should use empirical analysis to study the transmission direction and connection degree of cross-market analysis. Wang (2004) pointed out that the cross-market transmission of financial risk in China includes: risk transmission to financial products through cross market, and risk transmission to financial institutions participating in multi market. Ding et al. (2008) analyzed the causes of financial risk transmission in China's financial markets, and divided the forms of cross market financial risk transmission into: cross market financial risk caused by cross market financial products, cross market financial risk caused by open financial markets, cross market financial risk generated by financial companies through capital holding multi financial sectors.

Ba et al. (2009) used the mean spillover model and the volatility spillover model to study the domestic stock market and financial market, and found that the foreign exchange market has a one-way mean and volatility spillover effect on the stock market, but through the co integration test, it was found that there is no co integration relationship between the exchange rate and the stock price in China at present. Shi et al. (2013) studied the risk transmission between the Shanghai stock index and the bond index based on the 2008 financial crisis. They believed that the risk transmission between the stock market and the bond market has a time-varying feature.

Han (2014) conducted systematic analysis from a macro perspective to find out the source of risk. Wen (2015) studied the relationship between the commodity market and the stock market, and believed that under the background of commodity financialization, the relationship between the commodity market and the stock market was strengthened, and it was connected with the stock market through capital circulation and information transmission. Xu et al. (2017) analyzed the risk contagion relationship between China's major financial markets by building China's financial stress index. The study found that there are two different regional systems in China's financial stress index and they affect the transmission effect of interest rates.

Wu (2018) studied the transmission mechanism between money market and capital market from the perspective of money channel, and found that the transmission mechanism of interest rate and money supply between money market and capital market was not obvious. Wang (2018) used the method of combining complex network and DCC-GARCH model to study several financial markets during the subprime mortgage crisis in the United States and the stock disaster in 2015 in China. They found that the risk contagion in the financial market has significant time-varying characteristics,

with the strongest degree of connection during the crisis, the fastest and the most smooth risk contagion. When the global economy is unstable and the systemic financial risk is rising, not only the linkage between the international markets is stronger, but also the linkage between the domestic financial markets is significantly strengthened. The one-way spillover relationship between the stock market and the bond market becomes a two-way spillover relationship. [7] [8] [9] [10] [11] [12] [13] [14] [15]

Based on the previous research, this paper mainly defines the cross-market transmission of financial risk, analyzes the carrier, theory, and transmission way of cross-market transmission of financial risk. From the perspective of research methods, the mainstream methods include two categories: (1) Statistical modeling analysis, such as establishing VAR model and GARCH model to analyze the connection and impact degree of cross market financial risks, and using Granger causality test to get the transmission direction. (2) Complex network analysis, through the complex network analysis before and after the crisis to find out the source and wind of financial risks among financial markets Insurance approach.

3. The Theoretical Approach of Cross Market Contagion of Financial Risk

In the real economy, when an enterprise or economic subject in the industrial chain breaches the contract credit risk, it will quickly affect the upstream and downstream enterprises or economic subjects , also it will infect the whole industrial chain. In the financial market, when the economic subject of one financial market has credit risk, it will cause the economic item of other financial markets to have credit crisis. For example, a listed company in the stock market is unable to repay bank loans due to lack of liquidity, which will not only cause the stock price to fall. The interests of investors to be damaged, and the possibility of credit risk of the investment institutions holding the company's shares to increase. Also, it will increase the bank's liquidity risk and credit risk, and urge the bank to make prudent loans, Other markets have been affected. Then we will discuss the risk contagion among different industries.

3.1 Risk Contagion between Stock Market and Bond Market

The risk of stock market and bond market is often transmitted through the behavior of cross market investors. Both the stock market and bond market belong to the long-term capital market, and the investors' repetition rate is very high. Generally speaking, the return on investment in the stock market is high and the risk is large; the return on investment in the bond market is low and the risk is small. Investors often allocate assets between the stock market and bond market to obtain expected returns. When there is a risk in one market, investors often operate in another market, bringing the risk to another market. For example, when there is a risk in the stock market and the stock price falls, investors are often unable to throw it out decisively. In order to make up for the shortage of short-term funds, they will choose to sell bonds in the bond market, resulting in the decline of bond price. In addition, when the stock market price falls, it will make investors have the same expectation on the bond market, sell bonds, resulting in the decline of bond price.

3.2 Risk Contagion between Stock and Money Market

Banks are the main participants in the money market. The risks of the stock market and the money market are often transmitted through the participation of banks. Although the bank's capital cannot be directly invested in the stock market because of the separate operation and management, the bank can make loans to fund companies, enterprises and individuals, so that the bank's capital can enter the stock market. When there is a risk in the stock market and the stock price falls, the loan applicant may be unable to repay the loan on time due to the lack of liquidity, resulting in bad debts of the bank, bringing stock market risk into the banking system and the money market. When there is a risk in the money market, the bank will tighten the monetary base and reduce the loan, which will not only lead to the shortage of enterprise or individual funds, but also transmit the risk signal to the society and affect the investors' expectation, so as to reduce the capital scale of the stock market and the stock price.

3.3 Risk Transmission between Stock Market and Commodity Market

On the one hand, the risk transmission between the commodity market and the stock market can be conducted through the relevant listed enterprises in the commodity production chain. When there is a risk in the commodity market, the operation of related enterprises is in danger, the stock price of the company drops, even affects the whole stock market. When the stock market has risks, the fluctuation of the stock price will also affect the actual production of the enterprise, and spread the risk of the stock market to the commodity market. On the other hand, in the context of commodity financialization, commodities can not only be used as investment products, but also derive commodities futures and other instruments to invest and hedge risks, making the relationship between commodity market and stock market more and more close.

4. Methodology and Data

4.1 Basic Assumptions

Based on the above theoretical analysis, this paper assumes that:

There is a strong correlation between stock market and bond market, and there is a two-way risk transmission relationship

There is a strong correlation between the stock market and the commodity market, and there is a two-way risk transmission relationship

There is a strong correlation between the stock market and the money market, and there is a risk transmission relationship between the stock market and the money market.

4.2 Introduction to Empirical Model

This paper chooses VAR-GARCH (1,1) model to study the mean spillover effect and volatility spillover effect of money market, stock market, bond market and bulk commodity market respectively

4.2.1 Var Model

In this paper, VAR model is used as mean spillover model, and all influencing factors and their lagged items are introduced into the model as explanatory variables to estimate the dynamic relationship of all variables in the system, so as to avoid the model error caused by distinguishing endogenous variables and exogenous variables. Var (P) model is constructed as follows:

$Y_t=A_1*Y_{t-1}+A_2*Y_{t-2}+\ldots+A_p*Y_{t-p}+B*X_t+\mu_t$

Among them, Yt is the k-dimensional exogenous variable, Xt is the d-dimensional endogenous variable, μ_t is the k-dimensional error vector, P is the lag order, A1, A2, B is the coefficient to be estimated.

4.2.2 Garch Model

In order to further study the volatility spillover effect between markets, this paper uses GARCH (1,1) model to empirically study the residual of VAR model on the basis of VAR model. GARCH (1,1) model is constructed as follows:

Mean equation: $Y = c_1 + \gamma * Y_{t-1} + \mu_t$

Variance equation: $\sigma_t^2 = c_2 + \alpha * \mu_{t-1}^2 + \beta * \sigma_{t-1}^2$

4.3 A First Look of the Data

In this paper, the daily closing price of Shanghai overnight interbank offered rate is selected as the money market interest rate. The daily closing price and one-year treasury bond interest rate of Shanghai and Shenzhen 300 index respectively represent the stock market and bond market, and reflect the capital market comprehensively. The Shenzhen commodity producer index is selected to represent the commodity market. Among them, the data of Shanghai overnight inter-bank lending rate comes from Dongfang wealth.com, the daily closing price of Shanghai and Shenzhen 300 index, the one-year treasury bond interest rate, and the Shenzhen commodity producer index, the UK

financial information website. In this paper, from January 1, 2013 to January 1, 2020, 1677 effective date data are obtained.

In general, the fluctuation of the daily closing data of financial market is small, so it can be considered that the logarithmic yield is approximately equal to the general yield, and the data of four markets are logarithmically processed, that is, r = lny-lny(-1).The logarithm yield of Shanghai overnight interbank offered rate is recorded as rmoney, the logarithm yield of one-year treasury bond is recorded as rbond, the logarithm yield of Shanghai Shenzhen 300 index is recorded as rstock, and the logarithm yield of Shenzhen commodity producer index is recorded as rgood.

4.4 Descriptive Statistical Analysis

Table 1 Descriptive Statistical Analysis Results

	Rstock	Rbond	Rmoney	Rgood
Average	0.000287	-9.8E-05	-0.00045	-0.00016
Median	0.000387	0	0	0.001011
Standard deviation	0.015034	0.017552	0.070356	0.017837
Variance	0.000226	0.000308	0.00495	0.000318
Kurtosis	5.889202	17.68167	17.65444	3.099585
Skewness	-0.82536	0.278377	1.311877	-0.84689
J-B statistics	2632.18***	21915.729***	22728.443***	871.63491***
ADF test	-39.276***	-40.739***	-34.555***	-39.051***

Note: * * *, * *, *, which means significant at 1%, 5%, 10%.

From the mean value and standard deviation of the four return series, the mean value of the four markets is close to 0, indicating that the return series of the four markets are mean regression series. The standard deviation of money market is the largest, which indicates that the fluctuation of money market is more frequent. From the median point of view, the median of the three markets' yield series is also about 0, which shows that in the past 10 years, the days of money market and capital market rising and falling are approximately equal.

From the perspective of skewness, the skewness of stock market and commodity market is negative, while that of bond market and money market is positive. It shows that the stock market and the commodity market are on the left, while the bond market and the money market are on the right. The kurtosis of the four markets are greater than three, showing a sharp peak distribution. From the perspective of JB statistics, the original hypothesis of “the series is normal distribution” is rejected, which shows that the return series of four markets are not normal distribution series.

Generally, the variable form of VAR model requires a stationary sequence to avoid the phenomenon of “pseudo regression”. In this paper, ADF unit root test is used to judge whether the data sequence is stable before the actual modeling. According to the ADF unit root test results in Table 1, the T values of the ADF unit root test of rstock, rbond, rmoney and rgood are greater than the critical value under 1%, which means that the original hypothesis of “the sequence has unit root” is rejected, indicating that the four sequences are stable.

5. Empirical Results

5.1 Unconditional Correlation

Before the VAR models of stock market, bond market, money market and bulk commodity market are established, the limited analysis of the correlation of the selected variable data is shown in Table 2

Table 2 Unconditional Correlation

	rstock	rbond	rmoney	rgood
rstock	1			
rbond	0.0330	1		
rmoney	0.00400	0.822***	1	
rgood	0.822***	0.0220	0.0330	1

Note: * * *, * *, *, which means significant at 1%, 5%, 10%.

From the correlation coefficient matrix of each variable in Table 2, under the significant level of 10%, there is a positive correlation between bond market yield and money market yield, under the significant level of 1%, there is a positive correlation between stock market and commodity market, while the correlation between other markets is not significant. This shows that bond market and money market, stock market and commodity market are more correlated and risk contagion is more likely.

5.2 Adf Test

The ADF test proves that the data is stable, so VAR model can be established to study the risk contagion relationship among stock market, bond market, money market and bulk commodity market. From the results of VAR optimal lag order in Table 3, it is reasonable to select VAR (3) model according to FPE principle and AIC principle, and the model results are shown in Table 4.

Table 3 Results of Optimal Lag Order

lag	LL	LR	FPE	AIC	HQIC	SBIC
0	16364.2		3.50E-14	-19.6401	-19.6353	-19.6271*
1	16419	109.64	3.30E-14	-19.6867	-19.6626*	-19.6216
2	16445.4	52.777	3.30E-14	-19.6992	-19.6558	-19.5821
3	16461.7	32.532	3.3e-14*	-19.6995*	-19.6368	-19.5304
4	16476.4	29.507*	3.30E-14	-19.698	-19.616	-19.4768

Table 4 Results of The Var (3) Model: Var (3) out

	rstock	rbond	rmoney	rgood
L.rstock	0.138***	0.0505	-0.0164	0.213***
	(0.0431)	(0.0496)	(0.197)	(0.0511)
L2.rstock	-0.00498	0.0583	0.237	0.0585
	(0.0432)	(0.0497)	(0.198)	(0.0513)
L3.rstock	0.0492	0.0128	-0.197	0.0356
	(0.0432)	(0.0497)	(0.197)	(0.0512)
L.rbond	0.0124	-0.0202	0.0490	0.0240
	(0.0213)	(0.0245)	(0.0971)	(0.0252)
L2.rbond	-0.00717	0.0749***	-0.107	-0.0197
	(0.0213)	(0.0245)	(0.0971)	(0.0252)
L3.rbond	-0.0233	0.0641***	0.0382	-0.0208
	(0.0212)	(0.0244)	(0.0970)	(0.0252)
L.rmoney	0.00209	0.0300***	0.172***	0.00517
	(0.00534)	(0.00614)	(0.0244)	(0.00633)
L2.rmoney	0.00142	0.0208***	-0.0613**	-0.00238
	(0.00545)	(0.00627)	(0.0249)	(0.00646)
L3.rmoney	-0.00657	0.00339	-0.0945***	-0.00894
	(0.00541)	(0.00622)	(0.0247)	(0.00641)
L.rgood	-0.101***	-0.0886**	-0.0713	-0.105**
	(0.0364)	(0.0418)	(0.166)	(0.0431)
L2.rgood	-0.0400	-0.0666	-0.181	-0.0677
	(0.0364)	(0.0419)	(0.166)	(0.0432)
L3.rgood	-0.0353	-0.0413	0.0477	-0.00525
	(0.0363)	(0.0417)	(0.166)	(0.0430)
Constant	-0.000168	0.000111	0.000750	0.000310
	(0.000367)	(0.000422)	(0.00167)	(0.000434)

Note: * * *, * *, *, which means significant at 1%, 5%, 10% conditions.

From the perspective of VAR (3) model, firstly, there is an autocorrelation between bond market and money market, while stock market and commodity market are more random walk models, which

are not affected by their own lagged items. Secondly, the stock market will be affected by the commodity market, the bond market is more affected by the money market, the commodity market will also be affected by the stock market, while the money market is not easily affected by other financial markets.

5.3 Granger Causality Test

Based on VaR (3) model, Granger causality test is carried out to study the transmission direction between financial market risks. The results are shown in Table 5.

Table 5 Results of the Granger Causality Test

Original hypothesis	chi2	P value
rbond is not the Granger cause of rstock	1.588	0.662
rmoney is not the Granger cause of rstock	1.731	0.630
rgood is not the Granger cause of rstock	9.719	0.0210**
rstock is not the Granger cause of rbond	2.426	0.489
rmoney is not the Granger cause of rbond	42.23	0***
rgood is not the Granger cause of rbond	7.825	0.0500**
rstock is not the Granger cause of rmoney	2.465	0.482
rbond is not the Granger cause of rmoney	1.651	0.648
rgood is not the Granger cause of rmoney	1.450	0.694
rstock is not Granger's reason for rgood	18.87	0***
rbond is not Granger's reason for rgood	2.122	0.547
rmoney is not the Granger cause of rgood	3.007	0.391

Note: * * *, * *, *, which means significant at 1%, 5%, 10%.

It can be seen from table 5 that at a significant level of 1% , reject the original hypothesis that “rmoney is not the Granger cause of rbond” and the original hypothesis that “rstock is not the Granger cause of rgood”. At a significant level of 5%, reject the original hypothesis that “rgood is not the Granger cause of rbond” and the original hypothesis that “rgood is not the Granger cause of rstock”. Table 5 shows that there is a two-way spillover relationship between the stock market and the commodity market, as well as a one-way spillover relationship between the money market and the bond market and a one-way spillover relationship between the commodity market and the bond market.

5.4 Model Stability Test

If the eigenvalues of VAR model are greater than 1, the model is stable. The result of stationarity is shown in Figure 1 below. The reciprocal of the characteristic root is in the unit circle. In other words, the characteristic root is greater than 1, that is, the VAR model is stable.

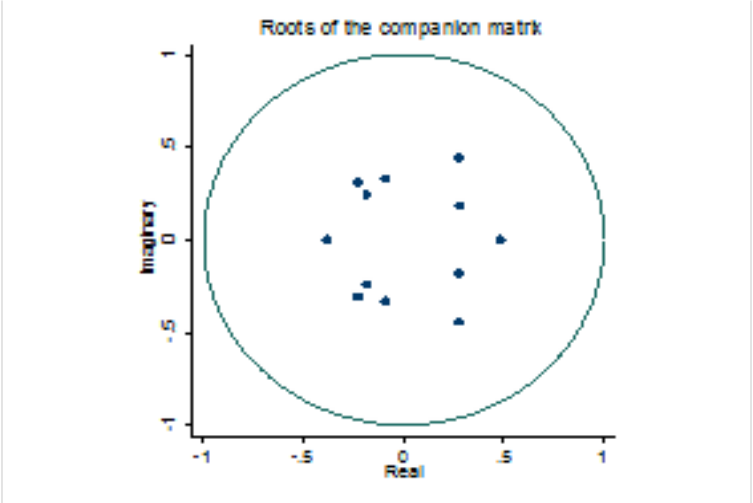

Fig.1 Results of Stationarity Test

5.5 Impulse Response Analysis

On the basis of VAR model, the paper analyzes the impulse response function of bond market, commodity market, money market and stock market, and studies the impact of one market shock on other markets. The results are shown in Figure 2.

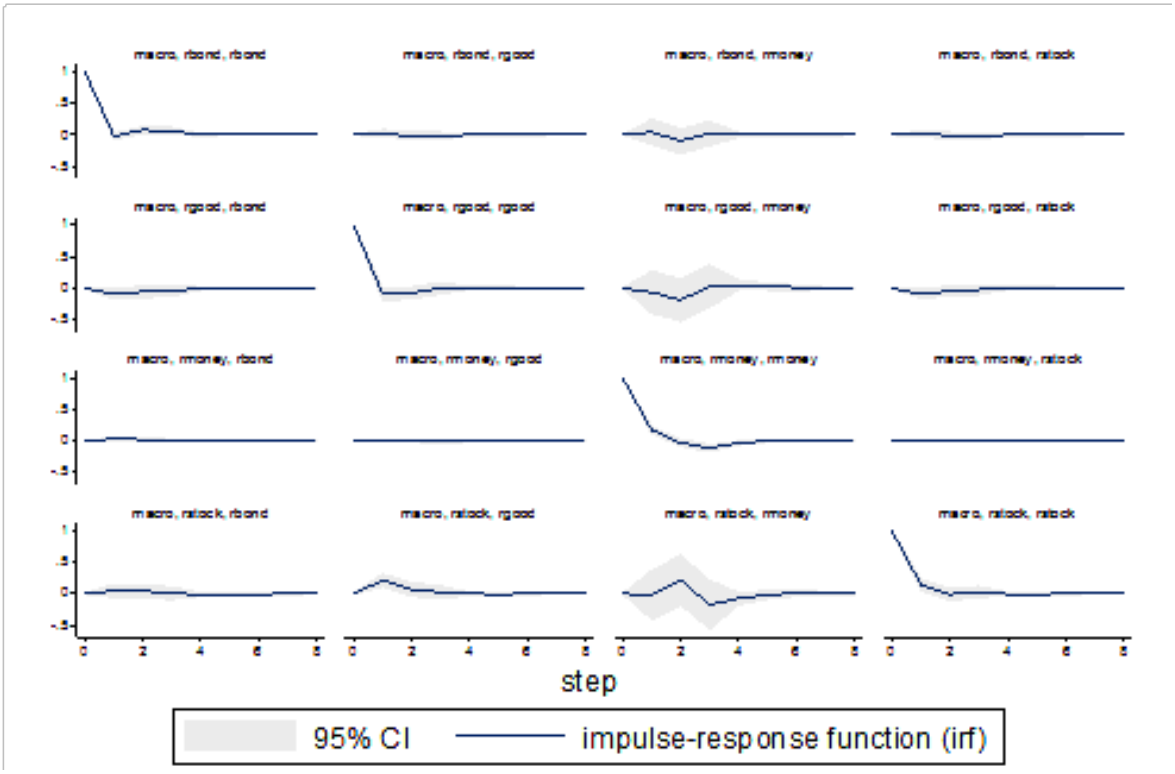

Fig.2 Impulse Response Diagram

From the impulse response results in Figure 2, we can see that from the perspective of bond market, bond market is not only obviously impacted by itself, but also has a significant positive impact in the first period, and has a significant impact on the money market. However, the impact of bond market on commodity market and stock market is not significant. From the perspective of commodity market, there is also an autocorrelation effect, which is strongly caused by its own impact, and also obviously impacted by the money market. It has some response to the impact of bond market and bond market, but the impact degree is limited. From the perspective of money market, the response time of money market to its own shocks is the longest, and the response to bond market, stock market and commodity market is not obvious. From the perspective of the stock market, different from the VAR model, the impulse response function indicates that the stock market is affected by its own shocks and has a strong positive effect in the first period, which lasts until the end of the fourth period. In addition, the impact of the commodity market on the stock market is more obvious, reaching a peak in the second period. To sum up, the impact of the money market on other markets is not obvious, only affected by its own historical data, while the impact of other markets on the money market is significant, and the response time is also long.The impact of stock market and commodity market on each other is more significant than other markets.

5.6 Variance Decomposition

The variance decomposition is based on VAR (3) model, and the results are shown in table 6-9.

Table 6 Variance Decomposition of Rstock

Step	rstock	rbond	rmoney	rgood
1	1	0	0	0
2	0.995127	0.000223	0.000040	0.004610
3	0.994129	0.000298	0.000094	0.005479
4	0.992220	0.001002	0.000928	0.005850
5	0.992115	0.001003	0.001024	0.005850
6	0.992	0.00100	0.00102	0.005859
7	0.992	0.00101	0.00103	0.005859
8	0.992	0.00101	0.00103	0.005859
9	0.992	0.00101	0.00103	0.005859
10	0.992	0.00101	0.00103	0.005859

Table 7 Variance Decomposition of Rbond

Step	rstock	rbond	rmoney	rgood
1	0.00103	0.999	0	0
2	0.00202	0.982	0.0134	0.00264
3	0.00212	0.972	0.0223	0.00390
4	0.00300	0.969	0.0230	0.00462
5	0.00314	0.969	0.0230	0.00464
6	0.00318	0.969	0.0230	0.00464
7	0.00320	0.969	0.0230	0.00465
8	0.00320	0.969	0.0230	0.00465
9	0.00320	0.969	0.0231	0.00465
10	0.00320	0.969	0.0231	0.00465

Table 8 Variance Decomposition of Rmoney

step	rstock	rbond	rmoney	rgood
1	1.30e-06	0.00105	0.999	0
2	0.000338	0.00134	0.998	0.000107
3	0.000385	0.00200	0.997	0.000849
4	0.00132	0.00198	0.996	0.000854
5	0.00137	0.00198	0.996	0.000893
6	0.00138	0.00198	0.996	0.000906
7	0.00139	0.00198	0.996	0.000906
8	0.00139	0.00198	0.996	0.000906
9	0.00139	0.00198	0.996	0.000907
10	0.00139	0.00198	0.996	0.000907

Table 9 Variance Decomposition of Rgood

step	rstock	rbond	rmoney	rgood
1	0.677	1.20e-05	0.000710	0.322
2	0.677	0.000594	0.000990	0.321
3	0.675	0.000949	0.00102	0.323
4	0.674	0.00135	0.00227	0.322
5	0.674	0.00136	0.00241	0.322
6	0.674	0.00136	0.00241	0.322
7	0.674	0.00136	0.00242	0.322
8	0.674	0.00136	0.00242	0.322
9	0.674	0.00136	0.00242	0.322
10	0.674	0.00136	0.00242	0.322

In the analysis of variance, from table 6, we can see that the stock market is greatly affected by its own price changes, reaching 99%, while the bond market, money market and bulk commodity market have less than 1% total impact on the stock market. From table 7, it can be seen that the bond market was affected by its own price changes by 99% in the first two periods, dropped to about 97% in the third period, and the contribution of the money market to the bond market reached2.3%about.It can be seen from table 8 that the money market is also largely affected by its

own price changes, reaching 99%.From table 9, it can be seen that the contribution of commodity market by itself is weaker than that of other markets, with only 32%, 67% and2.4%.

5.7 Garch Model

Prior to the establishment of GARCH model, autocorrelation test shall be carried out for the square of residual error of VAR model to verify the rationality of the establishment of GARCH model. The autocorrelation test results are shown in Figure 3.

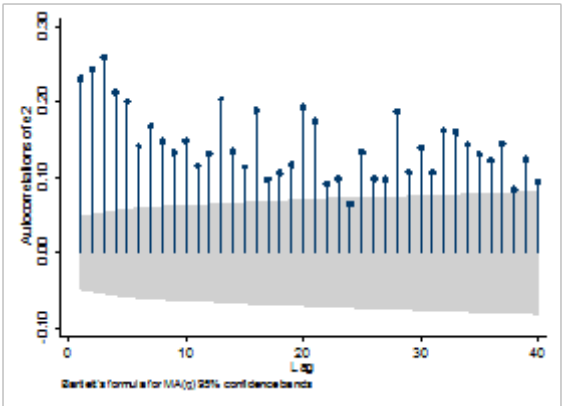

Fig.3: Residual Square Autocorrelation Results

From Figure 3, it can be seen that there is autocorrelation in the square of VAR model residual. For rstock, rbond, rmoney and rgood, respectively, the branch (1,1) model is established. The results are shown in table 10.

Table 10 Results of Garch (1, 1) Model

Variables	Rstock	Rbond	Rmoney	Rgood
L.rstock	0.0317	-0.0261	0.246***	0.0264
	(1.19)	(-0.96)	(10.17)	(1.01)
L2.rstock	-0.0181	0.0317	-0.0495	-0.0292
	(-0.70)	(1.19)	(-1.46)	(-1.16)
L3.rstock	0.00797	0.0111	-0.106***	-0.00492
	(0.32)	(0.35)	(-3.49)	(-0.20)
Constant	-0.000513**	0.000452*	0.000229	0.000131
	(-2.05)	(1.89)	(1.28)	(0.35)
ARCH				
L.arch	0.0645***	0.173***	0.305***	0.0630***
	(10.96)	(15.99)	(29.38)	(8.28)
L.garch	0.934***	0.838***	0.815***	0.918***
	(184.23)	(113.64)	(256.28)	(104.51)
Constant	8.07e-07***	7.18e-06***	1.74e-06***	5.35e-06***
	(3.19)	(12.20)	(6.52)	(4.63)

Note: * * *, * *, *, which means significant under the conditions of 1%, 5% and 10%, within () is the statistical value of Z.

According to table 10, in the wave equation of L.arch, L.garch are significant at a significant level of 1%, which indicates that the four markets present a peak thick tail distribution, and the volatility is clustering. And the coefficients of arch and GARCH in stock market and commodity market are less than 1 and close to 1. Under the premise of satisfying the constraints, the impact of conditional variance is lasting. The sum of bond market and money market coefficients is greater than 1, which may be caused by the existence of autocorrelation effect, which also shows that bond market and money market need to adjust for a long time after being impacted.

6. Conclusions

This paper shows that: the bond time and money market have obvious autocorrelation effect, and the stock market has great randomness. From the perspective of correlation, there is a positive correlation between stock market and commodity market, bond market and money market. From the perspective of risk transmission, there are two-way spillover relations between stock market and commodity market, one-way spillover relations between money market and bond market, and one-way spillover relations between commodity market and bond market. From the perspective of VAR model, impulse response analysis and variance decomposition, the money market is greatly affected by itself and less affected by other markets, which has a certain risk spillover effect on bond market and bulk commodity market; the stock market and bulk commodity market have a deep mutual influence, and the risk transmission is obvious; the risk transmission of other financial markets is not significant in the long term.

Acknowledgment

The authors gratefully acknowledge the support of the National Social Science Foundation Major Project of China (Grant no. 17ZDA037), the Social Science Planning Project of Chongqing Province of China (Grant no. 2018BS57), Science and Technology Research Program of Chongqing Municipal Education Commission (Grant No. KJQN201900537) and Fund Project of Chongqing Normal University (Grant no. 19XWB017).

References

[1] Forbes K, Rigobon R. No contagion only interdependence. The Journal of Finance, vol.57, no.5, pp.2223-2261, 2002.

[2] Laura E. Kodres, Matthew Pritsker. A rational expectations model of financial contagion Board of Governors of the Federal Reserve System (U.S.), 1998, pp,123-125.

[3] Xavier F, Bruno M, and Jean-Charles R. Systemic Risk, Interbank Relations, and Liquidity Provision by the Central Bank[J]. Journal of Money, Credit and Banking, vo.32, no.3, pp. 611-638, 2000.

[4] Stivers C, L.Sun. Stock Market Uncertainty and Bond Returns: Evidence of Flight- to- Quality. Working Paper, University of Georgia, 2002.

[5] Gilchrist S, Yankov V, Zakrajek E. Credit market shocks and economic fluctuations: evidence from corporatebond and stock markets[J].Journal of Monetary Economics, vol.56, no.4, pp.471 -493, 2009.

[6] Chiang T C, Li J, Yang S Y. Dynamic stock–bond return correlations and financial market uncertainty[J]. Review of Quantitative Finance & Accounting, vol.45, no.1, pp.59-88, 2015.

[7] Wang S Z. Foreign cross market financial risk supervision and Its Enlightenment. Hainan finance, vol.2004, no.02, pp. 9-13, 2004.

[8] Ding H, Xu C X. On the transmission carrier of cross market financial risk at present in China. Shanghai finance, vol.2008, no.03, pp.53-57, 2008.

[9] Ba S S, Yan M. dynamic relationship between stock price and exchange rate based on empirical analysis of Chinese market. Nankai economic research, vol.2009, no.3, pp.46-62, 2009.

[10] Shi Y D, Ding W, Yuan S F. Market interconnection, Risk Spillover and financial stability: Based on the analysis of spillover effect of stock market and bond market. Financial research, vol.2013, no.3, pp.170-180, 2013.

[11] Han D M, Wang W. Analysis of structural characteristics of international securities market

from the perspective of complex network. Complex system and complexity science, 2014, vol.11 , no.03, pp.50-57 + 78, 2014.

[12] Wen Y C, Wang J, Cheng T X. Spillover effects of domestic stock market, international stock market and commodity market. Global finance, vol.2015, no.8, pp.31-43, 2015.

[13] Xu G X, Li B. Research on the construction and dynamic conduction effect of China's financial stress index. Statistical research, vol.2017, no.4, pp. 61-73, 2017.

[14] Wu T. Research on risk transmission mechanism of financial market based on monetary channel. Time finance, vol.709, no.27, pp.44-46, 2018.

[15] Wang W, Zhang J Q, Li B, Tian Y L. Research on cross market transmission and prevention of systematic risk in capital market. Financial economics research, vol.33, no.01, pp.60-71, 2018.