Research on Risk Spillover Effect of Stock Market and Exchange Market before and after "8.11" Exchange Reform——Copula-CoVaR Model

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Abstract: "8.11" new exchange rate reform plays a key role in the reform of RMB exchange rate formation mechanism.In this paper, GARCH (1,1) model and Copula-CoVaR model are used to change "8.11" into a boundary. Data from October 11, 2010 to July 31, 2015 and August 12, 2015 to September 29, 2017 are selected to measure the Risk Spillover Effect between stock market and foreign exchange market before and after the reform.The results show that before the exchange rate reform, the stock market has a positive risk spillover effect on the exchange market, and the spillover level is higher than the Risk Spillover Effect of the exchange market on the stock market.But after the exchange rate reform, although both sides still maintain a positive wind spillover, the Risk Spillover of the stock market to the foreign exchange market is smaller than the Risk Spillover of the foreign exchange market to the stock market.Overall, the risk Spillovers of both sides before and after the exchange rate reform remain relatively balanced.Based on the above conclusions, the following suggestions are put forward: the stock market should pay attention to the guidance of exchange market expectations, improve the exchange rate formation mechanism; strengthen the monitoring of international capital flows, coordinate financial supervision and cross-market supervision; develop financial derivatives can properly avoid risks.

1. Introduction

The "8.11" new exchange rate reform plays a key role in the reform of the RMB exchange rate formation mechanism.After the "8.11" exchange rate reform, the central bank relaxed the management of the intermediate price of exchange rate. The intermediate quotation of the RMB exchange rate against the US dollar should rationally refer to the closing rate of the inter-bank foreign exchange market of the previous day, that is, the closing price of the Sino-US exchange rate and the closing price of the RMB exchange rate against the basket currency.This adjustment makes the RMB-US dollar exchange rate mid-price mechanism further market-oriented, free from the impact of a single dollar, and can more truly and rationally reflect the current foreign exchange market supply and demand relationship.

With the further promotion of trade globalization and exchange rate marketization reform in China, exchange rate and stock index have become important indicators for domestic and foreign investors to evaluate China's financial market. Since 2015, the volatility of the stock market and the foreign exchange market has gradually strengthened, and many phenomena also show that the two markets have a certain linkage effect. Therefore, the purpose of this paper is to quantify the Risk Spillover Effect between the mainland stock market and the foreign exchange market by using Copula-CoVaR model. This will not only help to understand the Risk Spillover situation between the foreign exchange market and the stock market in China, help individual and institutional investors to make more reasonable investment decisions, but also help to promote the reform of the two cities in China, and help government departments to be flexible and macro-based on the actual market situation.View and control, promote the long-term and stable sustainable development of China's economy.

2. Model Design

2.1 Copula-CoVaR Model Principle

The CoVaR method, proposed by Adrian and Brunnermeier in 2008, uses the quantile regression method to calculate the Risk Spillover Effects of various financial institutions or one financial market on other financial markets or the whole financial system.However, quantile regression can only describe the linear correlation between quantile and regression variables, and it does not accurately describe the non-correlation between variables, so it is not suitable for describing the volatility of the stock market and exchange rate market, so this paper introduces Copula method which can describe the non-correlation based on CoVaR.

In this paper, Copula function is used to characterize the dependence structure between two variables, and ultimately Delta CoVaR and% CoVaR are obtained.In order to determine the optimal Copula function form, we first need to fit the edge distribution of two sequences. In this paper, GARCH model of normal distribution is used to fit the edge distribution of a single sequence. The residual is brought into nine Copula functions by probability integral. The optimal Copula function model and conditional density function of two random variables are obtained, and then CoVaR and CoVaR are obtained.

2.2 Brief Introduction of Risk Spillover Effect Measurement Indicators

CoVaR (Conditional Value at Risk) refers to a given holding period and confidence level when the financial market j At the level of value at risk VaR^j Financial markets i The maximum loss is $CoVaR^{ij}$ .For example, formula 1, where q For confidence level:

$$P\left(X^i < CoVaR^{ij} \mid X^j = VaR^j\right) = 1-q \tag{1}$$

Copula is conditional risk $CoVaR^{ij}$ Unconditional risk VaR^i The difference represents the absolute extent of risk spillover.It can describe accurately. $CoVaR^{ij}$ In addition to its own unconditional risk, subject to financial markets j At the level of value at risk VaR^j Times to Financial Markets i Risk spillover values, such as formula 2:

$$\Delta CoVaR^{ij} = CoVaR^{ij} - VaR^i \tag{2}$$

% Copula (risk spillover) refers to when the financial market j At the level of value at risk VaR^j On the financial market i Marginal contribution rate of risk, such as formula 3:

$$\%CoVaR^{ij} = \frac{\Delta CoVaR^{ij}}{VaR^i} \times 100\% \tag{3}$$

2.3 Copula-CoVaR Model Setting

2.3.1 Edge Distribution Fitting

Fitting with GARCH (1,1) model of normal distribution, this paper establishes the following AR (1) model for the Shanghai Composite Index and the sequence of exchange rate return of RMB to US dollar, such as formula 4:

$$r_t = \phi_0 + \phi_1 r_{t-1} + \mu_t \tag{4}$$

The variance model of each return series is shown in formula 5, 6.

$$\mu_t = v_t \delta_t \tag{5}$$

$$\delta_t^2 = \alpha_0 + \alpha_1 a_t^2 + \beta_1 \delta_{t-1}^2, 0 \leq \alpha_1, \beta_1 \leq 1, \alpha_1 + \beta_1 < 1 \tag{6}$$

In this paper, the maximum likelihood estimation method is used to solve the parameters.

$$r_t \mid (\phi_0, \phi_1, r_{t-1}, \delta_t^2) \square N(\phi_0 + \phi_1 r_{t-1}, \delta_t^2)$$

Because the GARCH (1,1) model of normal distribution is adopted in this paper, the marginal density is shown in formula 7.

$$f(r_t \mid \theta) = \frac{1}{\delta_t \sqrt{2\pi}} \exp(-\frac{(r_t - \phi_0 - \phi_1 r_{t-1})^2}{2\delta_t^2}) \tag{7}$$

Because of time series r When sampling is independent, then for all joint probability density functions $f(r_t \mid \theta)$ Equal to the product of marginal density, as in formula 8:

$$L(\theta) = \prod_{t=1}^{T} f(r_t \mid \theta) = \prod_{t=1}^{T} \frac{1}{\delta_t \sqrt{2\pi}} \exp(-\frac{(r_t - \phi_0 - \phi_1 r_{t-1})^2}{2\delta_t^2}) \tag{8}$$

The logarithmic likelihood function is constructed to solve the parameters, such as formula 9, 10:

$$\max L(\theta) \Leftrightarrow \max \ln L(\theta)$$

$$\ln L(\theta) = \sum_{t=1}^{T} \ln \left(\frac{1}{\delta_t \sqrt{2\pi}} \exp(-\frac{(r_t - \phi_0 - \phi_1 r_{t-1})^2}{2\delta_t^2}) \right) \tag{9}$$

$$\max_{\theta} \ln L(\theta) = -\sum_{t=1}^{T} \ln \delta_t^2 + \frac{(r_t - \phi_0 - \phi_1 r_{t-1})^2}{2\delta_t^2} \tag{10}$$

2.3.2 Dependent Structure-Copula Function

The binary Copula function must satisfy the following three conditions:

(1) C The domain of definition is $\left[0,1\right]^2$;

(2) C It has zero base surface and increases in two dimensions.

(3) For arbitrary $u, v \in \left[0,1\right]$ Satisfy $C(u,1) = u, C(1,v) = v$.

According to nine different AIC values of Copula function, the best choice is Clayton Copula function.The distribution function of Clayton Copula function is shown in formula 11.

$$C(u,v,\theta) = \left(u^{-\theta} + v^{-\theta} - 1\right)^{-\frac{1}{\theta}} \tag{11}$$

$\theta \in [-1,0) \cup (0,+\infty)$ yes u and v Coefficient of correlation.Clayton Copula function can be used to describe the asymmetric correlation between variables. The lower tail correlation is much higher than the upper tail correlation, and it is more sensitive to the change of the tail of variables.

2.3.3 Risk Spillover Measurement-CoVaR Function

In the second part, the definitions of Delta Copula and% Copula have been introduced. In this part, specific calculation methods will be given.use X and Y Separately Express u and v Two sets of return series.According to Sklar theorem, let the density function of Copula function C be c For example, formula 12:

$$c(u,v) = \frac{\partial^2 C(u,v)}{\partial u\, \partial v} \tag{12}$$

The joint distribution function of two sets of return series is shown in formula 13.

$$f_{uv}(X,Y) = c\left(F_u(X), F_v(Y)\right) \times f_u(X) \times f_v(Y) \tag{13}$$

When v Under certain conditions u The probability density function, as shown in formula 14:

$$f_{u|v}(X \mid Y) = \frac{f_{uv}(X,Y)}{f_v(Y)} = c\left(F_u(X), F_v(Y)\right) \times f_u(X) \tag{14}$$

So the yield sequence X stay Y The conditional distribution function under given conditions is shown in 15:

$$F_{u|v}(X \mid Y) = \int_{-\infty}^{x} c\left(F_u(X), F_v(Y)\right) \times f_u(X)\, dX \tag{15}$$

among $F_u(X)$ and $F_v(Y)$ For the edge distribution of the Copula function, c It is the density function of Copula. According to the definition of CoVaR, formula 16 can be obtained:

$$CoVaR_q^{u|v} = F_{u|v}^{-1}(q \mid VaR_q^v) \tag{16}$$

Then CoVaR and% CoVaR can be obtained from the definitions.

3. Data Selection and Description

The purpose of this paper is to study the Risk Spillover Effect between the mainland stock market and the foreign exchange market before and after the "8.11" exchange rate reform. The daily closing price of the Shanghai Composite Index (SHZ) is selected in the stock market, and the daily closing price of RMB against US dollar (CNY) is selected in the foreign exchange market. The time span of the data is divided into two parts: 11 October 2010 - 31 July 2015 and 12 August 2015 - 29 September 2017.Excluding the discrepancies of holidays and market time, 1172 and 530 observations were obtained for each market. All market data comes from Reiss database. The daily yield of the two markets is derived from the first order logarithmic difference of the closing price, where p_t by t Daily closing price:

$$r_t = 100 \cdot \ln\left(\frac{p_t}{p_{t-1}}\right)$$

4. Empirical Analysis

4.1 Empirical results

4.1.1 GARCH (1, 1) parameter estimation results

The fitting results of the edge distribution of the four yield series are shown in Table 1.From the results of parameter estimation, we can see that all parameters have passed the t-test. In the second time period, the GARCH model of Shanghai Composite Index has passed the t-test. α_0 At the level of 10% significance, the others passed the test at the level of 5%.Therefore, it can be proved that GARCH (1, 1) model is reasonable to fit the marginal distribution of return series.

Table 1 Estimated results of GARCH (1,1) parameters

time	variable	α_0	α_1	β_1
First time period	SHZ Logarithmic Return Rate	0.015** (2.039)	0.945** (91.835)	0.049** (6.194)
	CNY Logarithmic Return Rate	0.001** (5.154)	0.854** (70.291)	0.121** (10.186)
Second time period	SHZ Logarithmic Return Rate	0.002* (1.536)	0.948** (172.487)	0.046** (6.744)
	CNY Logarithmic Return Rate	0.143** (6.812)	0.466** (7.024)	0.263** (5.811)

4.1.2 Clayton Copula parameter estimation results

After fitting the edge distribution, nine Copula functions are selected appropriately in this paper. According to AIC criterion, the AIC value of Clayton Copula function is the smallest in the two periods of 2010.10.11-2015.07.31 and 2015.08.12-2017.09.29, so this paper uses Clayton Copula function to describe joint distribution. As shown in Table 2, the parameters of the Copula function are obtained. θ And passed the significance test (5%).

Table 2 Clayton Copula parameter estimation results

time	θ	AIC
First time period	0.123** (0.037)	-11.384
Second time period	0.107** (0.052)	-3.073

4.1.3 CoVaR,%CoVaR Solution

According to the Copula-CoVaR calculation method, the Risk Spillover values of VaR, CoVaR, CoVaR and% CoVaR in stock and foreign exchange markets are calculated respectively.Table 3 shows the calculation results of the risk Spillovers of the stock market and the foreign exchange market in excellent conditions, respectively.It should be noted that the calculation results in the table are all calculated at 95% significance level.

Table 2 Logarithmic Return Risk Spillover Measurements for Stock and Exchange Markets (Market Excellence)

time	variable	VaR	CoVaR	Delta CoVaR	%CoVaR
First time period	SHZ Logarithmic Return Rate	3.882	4.044	0.162	4.38%
	CNY Logarithmic Return Rate	0.140	0.159	0.0186	14.22%
Second time period	SHZ Logarithmic Return Rate	1.539	1.645	0.107	8.50%
	CNY Logarithmic Return Rate	0.424	0.423	-0.002	-0.28%

According to Table 3, it is noteworthy that both VaR and CoVaR of stock and foreign exchange markets are positive in two periods. From the data, we can see that before the exchange rate reform, the higher stock market will have a stronger positive effect on the exchange market (14.22%) than when the exchange market is in excellent condition (4.38%).However, after the exchange rate reform, the excellent exchange market has brought a positive impact on the stock market, which proves that the "8.11" exchange rate reform not only improves the exchange rate system, but also brings a good situation to the stock market.

5. Conclusions and Suggestions

Comparing the calculation results before and after the exchange rate reform, this paper concludes two conclusions:

Firstly, the risk Spillovers of the stock market to the foreign exchange market before the "8.11" reform are obviously greater than that of the foreign exchange market to the stock market; after the reform, the situation is opposite, and the stock market presents a slight reverse risk spillovers to the foreign exchange market.

Secondly, the Risk Spillover Effect of the stock market on the foreign exchange market is greater when the market is very poor before the "8.11" reform; after the reform, the Risk Spillover Effect of the foreign exchange market on the stock market is greater than the Risk Spillover Effect of the stock market on the foreign exchange market.After the exchange rate reform, the next day value of the exchange rate between China and the United States is determined not only by the closing price of the previous day, but also by the closing price of the previous day's basket of exchange rates, which will weaken the impact of the stock market on the exchange market to a certain extent.

Thirdly, there has been a slight asymmetry in the spillover relationship between the stock market and the foreign exchange market, but on the whole, the spillover relationship between them is in equilibrium before and after the exchange reform.

The above conclusions are based on the GARCH model of normal distribution, and the t distribution and partial t distribution will be further discussed in the future research.

With the gradual improvement of the exchange rate formation mechanism and the gradual opening of the capital market in China, although the Risk Spillover Effect of the stock market and the exchange market fluctuates slightly, its mutual spillover relationship is still mainly affected by the policy and economic environment.

1) On the basis of exchange rate reform, we should further improve the formation mechanism of China's exchange rate, stabilize investors'expectations, and avoid the sharp fluctuation of foreign exchange market caused by risk exposure.

2) The model construction and empirical part of this paper can show the non-linearity of financial market models and the complexity of financial market itself.Stock market and foreign exchange market depend on capital connection, so it needs to be prevented and monitored by relevant parts in the way of capital flow.

3) Develop and improve financial derivatives, such as RMB exchange rate derivatives, so that Chinese enterprises can use derivatives as an effective hedging tool to avoid the risk exposure of stock prices caused by the sharp fluctuation of foreign exchange.

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