Research on Risk Spillover Effect of SSE 50ETF Volatility Index Based on Arch Family Model

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Abstract: With the rapid development of global economy, the risk of financial market is becoming more and more serious. The volatility index, which measures the expectation of market volatility, comes into being. This paper selects the Shanghai 50ETF volatility index data and the Shanghai 50ETF unit net value data from February 9, 2015 to June 9, 2017, constructs the optimal GARCH model and tarch model to conduct empirical research on the relationship between the Shanghai 50ETF volatility index and the underlying market impact, and draws the following conclusions: first, the operation of the Shanghai 50ETF volatility index is in line with expectations; second, the Shanghai 50ETF volatility index is in line with expectations Volatility index can stabilize the market, but the effect is not so good. Thirdly, there is a two-way volatility spillover effect between Shanghai 50ETF volatility index and Shanghai 50ETF unit net value. This paper aims to provide theoretical support for the majority of investors to avoid market risk according to the Shanghai 50ETF volatility index, and enrich the domestic research results on the Shanghai 50ETF volatility index, and on this basis, put forward suggestions on the Shanghai 50ETF volatility index for the time being

1. Introduction

In 1987, the New York Stock Exchange introduced a "circuit breaker" mechanism to reduce the volatility of the global stock market after a large amount of abnormal volatility. However, due to the lack of tools to measure the volatility of the market at that time, investors could not make an early expectation of the volatility of the market. Against this background, the volatility index has emerged in the global market to measure market volatility expectations. In 1993, the CBOE first launched the volatility index (VIX), which is used to measure the one month implied volatility of S & P 500 index options (Guojun Wu, Zhijie Xiao, 2002). The introduction of VIX Index helps to stabilize the market, so it has become the main barometer of investor psychology and market volatility in the world, and is called "investor panic index" (Guo Ning, 2011).

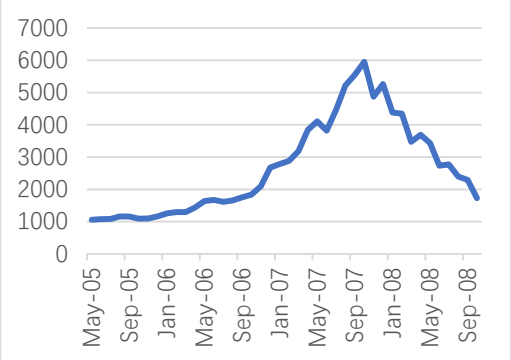

Figure 1. Trend of Shanghai Composite Index in 2005-2008

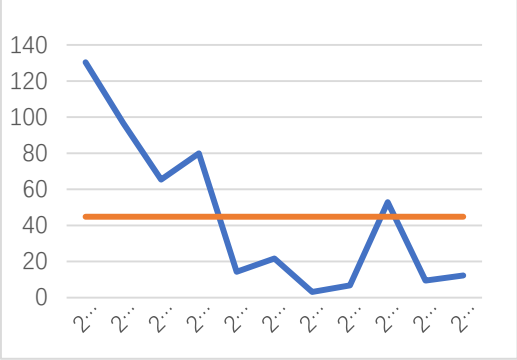

Figure 2. fluctuation (%) of Shanghai Composite Index

As shown in Figure 1, from June 2005 to November 2007, the Shanghai Composite Index rose

from 1060.74 to 5954.77, with a range of about 461%; by November 2008, the Shanghai Composite Index dropped to 1728.79, with a range of about 244%. As shown in Figure 2, from the data over the past 10 years, the annual amplitude of Shanghai stock index reached 45%, especially in 2006, the annual amplitude was as high as 130%. On November 28, 2016, the ivix index was officially listed on the Shanghai Stock Exchange, filling the gap of lacking volatility index in China. For the majority of A-share investors, it is particularly important to predict the sharp fluctuations of the stock market in advance through the ivix index and then take measures to prevent risks. Unfortunately, after more than two years of operation, ivix was suspended on February 14, 2018[1]. According to the staff of China Securities Index company, the reason for the suspension is that the option module of the index calculation system needs to be upgraded, but some insiders believe that because the A-share market experienced a big fall, the market was not stable at that time, and the ivix index may contribute to the market panic.

The rest of this paper is arranged as follows: the second part is a preliminary statistical analysis of Shanghai 50ETF and ivix index data, including data processing and model selection; the third part is an empirical study on the relationship between Shanghai 50ETF volatility index and the underlying market impact based on the establishment of arch family model; the fourth part is based on the empirical conclusion, and puts forward corresponding suggestions.

2. Preliminary Analysis of Data

2.1 Data Source and Processing

Because the target of ivix index is Shanghai 50ETF, this paper takes ivix index and Shanghai 50ETF as the research object. Since the ivix index was launched based on its underlying options, and the launch time of its underlying options was February 9, 2015, the ivix index was officially listed on November 28, 2016. Therefore, this paper selects February 9, 2015 to June 9, 2017 as the sample interval, and takes November 28, 2016 as the segmentation point, which is divided into two sub sample intervals before and after the launch of ivix index to study.

The data in this paper are all from wind database. The daily closing data of 50ETF unit net value of Shanghai Stock Exchange from February 9, 2015 to June 9, 2017 and the daily closing data of ivix index are selected, with 610 groups of data. From Figure 3, it can be seen that during February to June 2015, with the rise of 50ETF unit net value of Shanghai Stock Exchange, the ivix index rose sharply; while in the second half of 2015, i.e. from June to August, after A-share experienced abnormal fluctuations, the fluctuation of ivix index was extremely fierce, even reaching the maximum value since the issuance of ivix index[2]. It can be seen that its operation can directly reflect the A-share market A sharp fluctuation in transformation. However, after 2016, the A-share market has gradually stabilized, and the ivix index has slowly declined to a stable level.

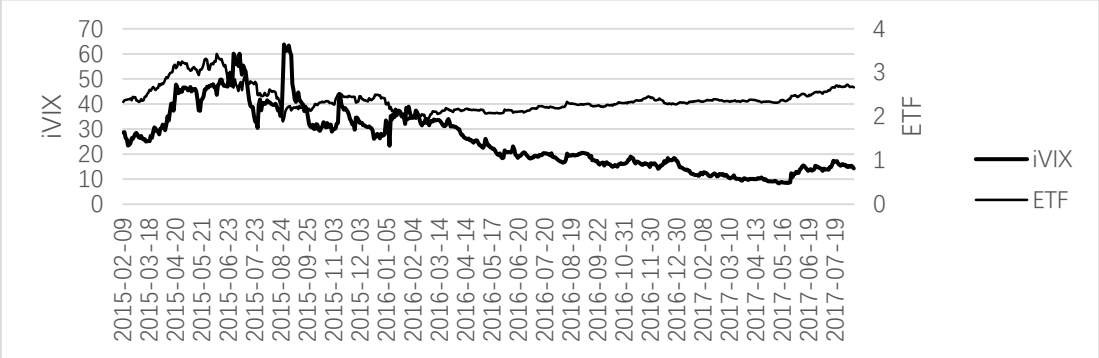

Figure 3. Fluctuation of Shanghai 50ETF and ivix index

2.2 Model selection

This paper establishes GARCH (1,1) model (such as Formula 1).

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \quad (1)$$

Where ε_{t-1}^2 is called "arch item" and σ_{t-1}^2 is called "GARCH item". The coefficient α_1 of arch term in GARCH model is defined as information shock parameter, which reflects the impact of new information on stock market; The "GARCH term" coefficient β_1 is defined as the persistent shock parameter, which reflects the magnitude of the persistent shock of the old news to the future market volatility; Then the sum of "arch term" coefficient and "GARCH term" coefficient $\alpha_1 + \beta_1$ reflects the impact of all information in the stock market on the market volatility. When α_1 is larger, it indicates that when new information appears in the stock market, the greater the impact of this information on the volatility of the stock market, which means the faster the market accepts new information[3]. When β_1 is larger, it shows that the effect of the old information in the past on the market volatility is stronger, which shows that the effect of the old information in the past on the current condition variance is increased. To sum up, when α_1 is larger and β_1 is smaller, it means that the fluctuation effect caused by the new information in the stock market is larger. On the contrary, the effect of the old information in the stock market on the market fluctuation is weaker, so the speed of information transmission and reception in the stock target market increases. When α_1 is smaller and β_1 is larger, it means that the fluctuation effect caused by the new information in the stock market is weakened. On the contrary, the extent of the persistent influence of the old information in the stock market on the market fluctuation is stronger, then the spread speed of the information in the stock target market is slowed down[4].

This paper introduces virtual variables based on the original GARCH (1,1) model, such as formula 2.

$$\sigma_t^2 = \alpha_0 + \alpha_1 * \varepsilon_{t-1}^2 + \beta_1 * \sigma_{t-1}^2 + \gamma * d_1 \quad (2)$$

Among them, D1 is the virtual variable introduced, which takes the time of ivix index to market as the node variable. Before November 28, 2016, the value is 0, and then the value is 1.

In order to analyze the asymmetry of the market response to different information before and after the introduction of ivix index, this paper uses tarch (1,1) model to test (such as formula 3).

$$\sigma_t^2 = \alpha_0 + \alpha_1 * \varepsilon_{t-1}^2 + \alpha_2 * \sigma_{t-1}^2 + \gamma * \varepsilon_{t-1}^2 * d_{t-1} \quad (3)$$

Among them, d_{t-1} is a dummy variable, that is, when there is good news in the stock market, $\varepsilon_t \geq 0, d_{t-1} = 0$, there is no asymmetric effect item in the formula, that is to say, good news has α_1 times effect on the stock market; if there is bad news in the stock market, then $\varepsilon_t < 0, d_{t-1} = 1$, there is asymmetric effect item in the formula, that is to say, bad news has $\alpha_1 + \gamma$ times effect on the stock market.

In GARCH model, we add the lag term of other financial market's return residual to analyze the impact of other market's volatility on this market's volatility. Therefore, we can add the residual lag term of the other party's return series as exogenous variables. Using σ_{1t}^2 and σ_{2t}^2 is taken as the variance of the logarithm return on unit net value and the logarithm return on ivix index of Shanghai Stock Exchange 50ETF respectively, then the conditional variance equation can be expressed as:

$$\sigma_{1t}^2 = \alpha_0 + \alpha_1 * \varepsilon_{1t-1}^2 + \alpha_2 * \sigma_{1t-1}^2 + \alpha_3 * \varepsilon_{2t-1}^2 \quad (4)$$

$$\sigma_{2t}^2 = \alpha_0 + \alpha_1 * \varepsilon_{2t-1}^2 + \alpha_2 * \sigma_{2t-1}^2 + \alpha_3 * \varepsilon_{1t-1}^2 \quad (5)$$

3. Empirical analysis of the relationship between ivix index and market impact

3.1 ARMA model

First of all, we use ADF test to test the ARMA model for the logarithm return of unit net value of Shanghai Stock Exchange 50ETF under the condition that both groups of series are stable.

Combining the sample autocorrelation coefficient (ACF), partial correlation coefficient (PACF) and information criterion AIC or BIC, we choose to build ARMA (2,2) model. The regression results are as follows:

$$R_t = 0.1096 * R_{t-1} - 0.9720 * R_{t-2} - 0.1352 * \varepsilon_{t-1} + 0.9144 * \varepsilon_{t-2} + \mu_t \quad (6)$$

Chi square test of model residual sequence shows that ARMA model has a good fitting effect. Therefore, in order to study the log return volatility, the author conducts the archlm test on the residual series and finds that there is arch effect in the residual series.

In this paper, Fourier analysis is used to process the data. Since the number of data required by Fourier analysis is the power of 2, and the logarithmic yield of ivix index used in this paper has a total of 609 values, so the first 512 values are selected for research and analysis, and the obtained spectrum is shown in Figure 6.

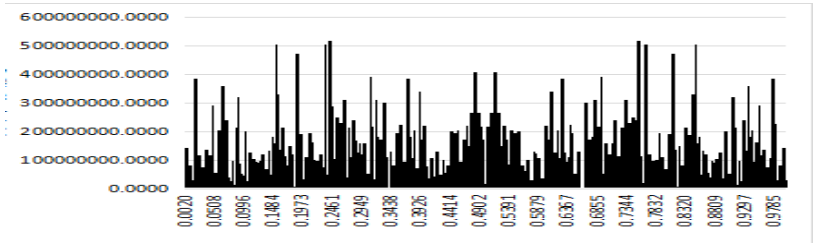

Figure 4. ivix index yield spectrum

It is not difficult to find that the intensity of each frequency point is not the same, especially in cycle 4 (frequency 0.25) and other cycles, which reflects that the ivix index return series has a certain regularity of periodicity. Therefore, this paper considers that the ivix index sequence is not a white noise sequence, and ARMA model can be established for this sequence. In the same way, according to the autocorrelation coefficient and the partial correlation coefficient, it is found that the model fitting effect is the best when AR (2), AR (4), MA (2), MA (4) is added with intercept term, and AIC is the smallest, so formula 7 is obtained[5].

$$IR_t = -8.26E-04 + 1.3224 * IR_{t-2} - 0.9570 * IR_{t-4} - 1.3097 * \varepsilon_{t-2} + 0.9830 * \varepsilon_{t-4} + \mu_t \quad (7)$$

At the same time, chi square test of the residual of the model shows that ARMA model has a good fitting effect. The archlm test of the residual sequence shows that the F statistic is significantly larger than the critical value at the 5% significance level. So we can think that there is arch effect in the residual series of the model[6]. We should use arch family model to accurately fit the volatility of the logarithmic yield of ivix index. Therefore, GARCH (1,1) model can be further established to fit.

3.2 GARCH model

In this paper, GARCH (1,1) model is established for the log yield sequence of Shanghai 50ETF. The parameter estimation results are shown in Table 1.

Table 1. GARCH and TARCH model parameter estimation

variable	GARCH				TARCH	
	Original model	With dummy variable	Before the launch of ivix index	After the launch of ivix index	Before the launch of ivix index	After the launch of ivix index
α_0	5.96E-07**	1.9E-05***			1.70E-06	-6.45E-07
α_1	0.059***	0.151***	0.068***	0.069***	0.0509***	0.0235***
α_2					0.9057***	1.0287***
β_1	0.939***	0.786***	0.931***	0.922***		
γ		-1.57E-05***			0.0552***	-0.0653***
$\alpha_1 + \gamma$					0.1061	-0.0418

Note: * * *, * *, * represent significant at 1%, 5% and 10% confidence levels respectively.

As can be seen from table 1, GARCH (1, 1) Each coefficient of the model is significant, and the

coefficient and coefficient in the conditional variance are highly significant, and the sum of them is 0.998, which satisfies the precondition that the sum of the two is less than 1, and is almost the same as 1, which shows that the impact on the conditional variance is not a short-term but a long-term process, that is to say, through the model, it can be proved that the impact on the future volatility of the stock market has This model can be considered to fit the data well[7]. Therefore, GARCH (1,1) is selected to establish the conditional variance equation, and formula 8 is obtained.

$$\sigma_t^2 = 5.96E-07 + 0.059 * \varepsilon_{t-1}^2 + 0.939 * \sigma_{t-1}^2 \quad (8)$$

To study the impact of the introduction of ivix index on the volatility of the underlying market. The sum of coefficient α_1 and coefficient β_1 is 0.937 less than 1, which meets the preconditions of parameters, indicating that the model fitting effect is good, and the model is shown in formula 9.

$$\sigma_t^2 = 0.0002 + 0.151 * \varepsilon_{t-1}^2 + 0.786 * \sigma_{t-1}^2 - 0.0000157 * d_1 \quad (9)$$

The coefficient of dummy variable is -0.0000157, which is negative and significant at 1% significance level.

On the one hand, before the introduction of ivix index, the arch coefficient was 0.068. After the ivix index is launched, the value of information parameter increases to 0.069, which indicates that the volatility will absorb new information in the market faster in the future; on the other hand, before the ivix index is launched, the value of GARCH coefficient is 0.931. After the introduction of ivix index, the corresponding continuous parameter value is 0.921. This shows that the impact of information that has occurred in the target market on market volatility has weakened. Therefore, it can be considered that the introduction of ivix index can accelerate the speed of information transmission in the target market.

3.3 TARCH model

In this paper, TARCH (1,1) model is used to analyze the asymmetry of market response to different information before and after the introduction of ivix index. Before and after the launch of ivix index, γ is significantly not zero, which reflects that there is asymmetric information impact in GARCH model before and after the launch of ivix index, that is, the impact of information on the volatility of the underlying market is asymmetric. Further, before the launch of ivix index, $\gamma > 0$, which shows that bad news can make the target market more volatile than good news. After the launch of the ivix index, $\gamma < 0$， , which means that the emergence of good news can make the target market more volatile than bad news[8]. And after the ivix index is launched, the value of α_1 becomes smaller; after the ivix index is launched, the value of $\alpha_1 + \gamma$ also becomes smaller. To sum up, this paper believes that the introduction of ivix index reduces the degree of asymmetry of the impact of information on the volatility of the target market, which is inconsistent with the conclusions drawn by Liu Yaming, fan pengying and Chen Min (2017). This may be related to Liu Yaming, fan pengying and Chen Min (2017) using SSE 50ETF options for empirical research. The ivix index is based on the real trading data of Shanghai 50ETF options, which measures investor psychology and market volatility, and better forecasts the trend of the stock market.

3.4 Spillover effect model

Combined with the sequence data of the residual square lag term of the conditional variance of the ivix index return sequence in formula (4) above, the spillover effect models are established for the Shanghai Stock Exchange 50ETF and the ivix index return sequence respectively, and the estimation results are shown in Table 2.

Table 2. Parameter estimation results of spillover effect model

	Parameter value	Z-statistics
α_0	-8.18E-07***	-2.033
α_1	0.062***	6.499

	Parameter value	Z-statistics
α_2	0.926***	117.018
α_3	0.001***	4.066
β_0	0.001***	6.530
β_1	0.139***	3.237
β_2	0.249***	6.271
β_3	5.441***	10.889

Note: * * *, * *, * represent significant at 1%, 5% and 10% confidence levels respectively.

It can be seen from table 2 that the estimated values of each parameter in the model are significant at 95% of the set level, so the parameter estimation results are substituted into the model to get formula 10 and formula 11.

$$\sigma_{1t}^2 = \text{-}8.18E-07 + 0.062 * \varepsilon_{1t-1}^2 + 0.926 * \sigma_{1t-1}^2 + 0.001 * \varepsilon_{2t-1}^2 \quad (10)$$

$$\sigma_{2t}^2 = 0.001 + 0.139 * \varepsilon_{2t-1}^2 + 0.249 * \sigma_{2t-1}^2 + 5.441 * \varepsilon_{1t-1}^2 \quad (11)$$

Formula 10 indicates that the square lag term of the logarithmic return of unit net worth of Shanghai Stock Exchange 50ETF is added to the conditional variance model of the logarithmic return of Shanghai Stock Exchange, and formula 11 indicates that the square lag term of the logarithmic return of Shanghai Stock Exchange 50ETF is added to the conditional variance of the logarithmic return of Shanghai Stock Exchange 50ETF, which means that the square lag term of one market affects the volatility of the other market Noise level. It can be seen from table 2 that, on the one hand, the Z statistic corresponding to the coefficient α_3 of ivix index log return residual square lag ε_{2t-1}^2 is 4.066, which is greater than the critical value of 2.58 under the significance level of 1%, but the value of α_3 is relatively small, which is only 0.001, which indicates that ivix index log return has volatility spillover effect on Shanghai 50ETF log return, but the degree is small; on the other hand, Shanghai 50ETF unit The Z statistic corresponding to the coefficient β_3 of the square lag term ε_{1t-1}^2 is 10.889, which is also greater than the critical value of 2.58 under the significance level of 1%, and the value of β_3 is 5.441, which shows that the Shanghai Stock Exchange 50ETF logarithmic yield has a volatility spillover effect on the ivix index logarithmic yield to a large extent. To sum up, there is a two-way volatility spillover effect between Shanghai 50ETF and ivix index, and there is a two-way volatility spillover effect between Shanghai 50ETF and ivix index[9].

4. Conclusions and suggestions

In order to explore the impact of ivix index on the underlying market and the volatility spillover effect between the two, this paper takes February 9, 2015 to June 9, 2017 as the sample space, uses logarithmic return to reflect the characteristics of market volatility, establishes ARMA model for time series to verify whether there is arch effect in the series, and then combines arch family model to launch Shanghai Stock Exchange 50ETF This paper studies the change of unit net value logarithm return volatility and the volatility spillover relationship between them, and draws the following conclusions:

1. The ivix index is operating as expected. First of all, during the period of abnormal fluctuation of the stock market, the government used administrative means such as restricting stock index futures and "fusing" to intervene in the market, which increased the uncertainty and risk of the market, led to the investor's panic when the net value of Shanghai Stock Exchange 50ETF unit went down, and led to the rise of ivix index, which also showed that ivix index can effectively reflect the market sentiment. After February 2016, the stock market returned to a stable state, and the options

market continued to develop, the ivix index continued to decline, and the operation was in line with expectations.

2. Ivix index plays the role of stabilizing the market, but the effect is not obvious. Specifically, the introduction of ivix index reduces the volatility of the target market; secondly, the introduction of ivix index accelerates the speed of information transmission of the target market; finally, the introduction of ivix index reduces the asymmetry of the target market volatility.

3. There is a two-way volatility spillover effect between Shanghai 50ETF and ivix index. Specifically, the volatility spillover effect of Shanghai 50ETF on the ivix index is far greater than that of the ivix index on Shanghai 50ETF, which shows that Shanghai 50ETF plays a leading role in the volatility spillover relationship between Shanghai 50ETF and ivix index at this stage. To sum up, this paper believes that there is an obvious risk spillover effect between the ivix index and the target market, which can better reflect market sentiment, have a certain ability to predict market trend, and can reduce market volatility and reduce the asymmetry of market volatility[10]. Therefore, this paper suggests that the release of the ivix index should be restored as soon as possible.

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