VaR Calculation and Leverage Effect Analysis of New Third Board Market Based on EGARCH Model

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Keywords: VaR EGARCH model; new third board market; leverage effect.

Abstract: Although the new third board expands rapidly, it is necessary and urgent to analyze the risks of the new third board market because of its short time, imperfect mechanisms, low entry threshold, many types of industries and great differences in internal development. Based on the new three-board component index, this paper establishes the EGARCH model, evaluates the risk using VaR, a widely used risk measurement index in financial circles, and tests the validity of VaR calculation. Finally it analyzes the leverage effect of the new third board market.

1. Introduction

Establishing a multi-level capital market has always been the direction of China's financial reform. After years of efforts, the pattern of "two systems" (Shanghai Stock Exchange, Shenzhen Stock Exchange, New Third Board and China Stock Exchange Quotation System) has finally been formed, and the floor trading and over-the-counter trading have been perfected (see figure 1).

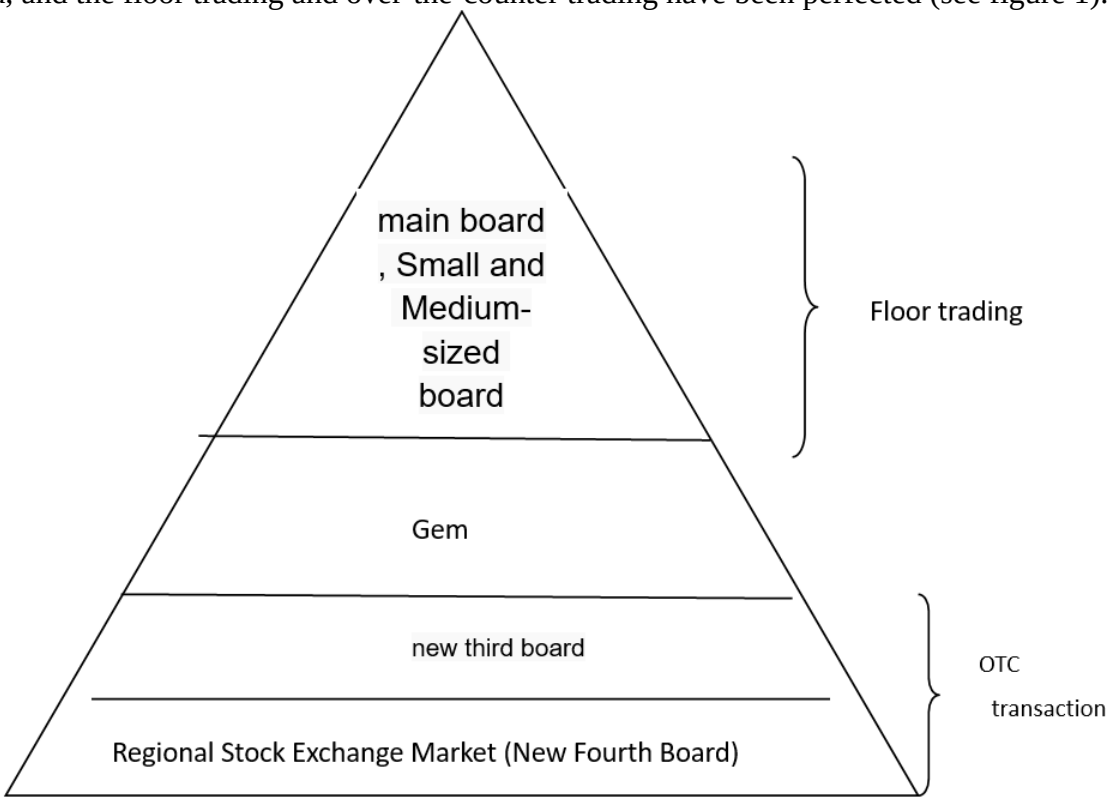


Fig. 1 Composition chart of China's multi-level capital market

The national stock transfer system for small and medium-sized enterprises (commonly known as the "new third board") is a national stock exchange approved by the State Council. The national small and medium-sized enterprises stock transfer system limited liability company is its operation and management organization. The establishment of the "new three-board" is an important measure to speed up the construction and development of China's multi-level capital market.

The new third board market originated from the "agent stock transfer system" established on July

16, 2001 (to solve the historical legacy of corporate stock in the main board delisting enterprises and the original STAQ and NET systems, namely the "old third board"). At the beginning of 2006, a new stock transfer system was established in Beijing Zhongguancun Science and Technology Park, known as the "new third board". In September 2012, the State Council promulgated the Regulations on Supervision and Management of Unlisted Public Companies, which approved the new third board to be a nationwide off-site market under unified supervision. In December 2013, the State Council promulgated the Decision on Issues Relevant to the National Share Transfer System for Small and Medium-sized Enterprises, which clarifies the legal status and market orientation of the national share transfer system, namely, mainly providing services for innovative, entrepreneurial and growing small and medium-sized enterprises. This decision also means that the new third board will be formally expanded to the whole country and become the real national OTC market in China.

With the expansion of the new third board market to the whole country, the number of listed companies has increased rapidly. By the end of 2016, the number of listed companies had reached 10,163 from the 349 of the beginning, and the number of listed companies had exceeded 10,000. In August 2017, the number of listed companies increased to 11,523, with a total market value exceeding 500 billion yuan and reaching 50,628 million yuan.

Although the new third board expands rapidly, due to the short time, various mechanisms are not perfect, the entry threshold is low, the types of industries accommodated are many , and the internal development is quite different, showing great volatility in the trading process, so it is very necessary and urgent to analyze the risk of the new third board market.

Previous scholars such as Tian Juanjuan analyzed liquidity risk in the new third board market after expansion, but only with the help of several stock analysis. Based on the new three-board component index, this paper uses VaR, a widely used risk measurement index in financial circles, to evaluate the risk, and tests the validity of VaR calculation. Finally, analyzes the leverage effect of China's new third board market.

2. Model Construction

Since Engle (1982) established ARCH model, scholars at home and abroad have been using ARCH and expanding it. They have established GARCH, TGARCH, EGARCH and other models. By using these models, a large number of empirical analysis proves that the time series of stock returns has the following characteristics: high apex and thickness tail, volatility aggregation and leverage effect.

This paper uses EGARCH (Nelson, 1991), which is an asymmetric ARCH model, to analyze the volatility of stock returns in China's new three-board market, calculates the VaR of risk according to the assumptions of normal distribution and t distribution, and evaluates its validity. Finally, it further illustrates the asymmetry of stock returns in the new three-board market.

(1) Establishing an ARMA (p, q) model of logarithmic return

$$r_t = \ln P_t - \ln P_{t-1} \tag{1}$$

$$r_t = c_0 + \sum_{i=1}^{p} \alpha_i r_{t-i} + q\sum_{j=1} \beta_j \varepsilon_{t-j} + \varepsilon_t \tag{2}$$

(2) Establish EGARCH (p, q) model:

$$\varepsilon_t = \sqrt{\sigma_t^2} * z_t \tag{3}$$

$$\ln \sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \left| \frac{\varepsilon_{t-i}}{\sqrt{\sigma_{t-i}^2}} \right| + \sum_{j=1}^{q} \gamma_j \frac{\varepsilon_{t-j}}{\sqrt{\sigma_{t-j}^2}} + \sum_{j=1}^{q} \beta_j \ln \sigma_t^2 \tag{4}$$

γ_j in the EGARCH model is an asymmetric parameter,there is no asymmetry when γ_j =0;

there is leverage effect when γ_j <0, and the fluctuation caused by negative impact is stronger than that caused by positive impact; when γ_j >0 the fluctuation caused by positive impact is stronger than that caused by negative impact. [4]

(3) Calculating VaR [4]: We assume that $z_t$is a sequence of independent identically distributed random variables with mean value of 0 and variance of 1. When the distribution is normal, the calculated value of risk VaR_t is:

$$VaR_{t+1|t} = \hat{\mu} + \Phi^{-1}(\alpha)\hat{\sigma}_{t+1|t}. \tag{5}$$

When the distribution is t-distribution of degree of freedom v, the calculated value of VaR is adjusted to:

$$\mathrm{VaR}_{t+1|t} = \hat{\mu} + \sqrt{\frac{v-2}{v}}\, t_v(\alpha)\ \widehat{\sigma_{t+1|t}} \tag{6}$$

Among them, $t_v(\alpha)$ is the corresponding quantile of the distribution discussed (1%, 5%), $\widehat{\sigma_{t+1|t}}$is the conditional variance value of the time t┼1 predicted according to the information before the time t.

(4) Verification of accuracy of VaR model [4]

The accuracy test of VaR model refers to the coverage of actual loss by the measurement results of VaR model. For example, given a 95% confidence level of VaR, the accuracy of the VaR model refers to whether the probability of actual profit and loss outcomes exceeding VaR is less than 5%. The general method of VaR test is the failure frequency test proposed by Kupiec (1995).

Definition: Assuming $N = \sum_{t=1}^{T}(I_t)$ is the days in which the loss value of time T assets exceeds the estimated value of VaR, there are:

$$I_{t+1} = \begin{cases} 1, y_{t+1} > VaR_{t+1|t}, \\ 0, y_{t+1} < VaR_{t+1|t}. \end{cases} \tag{7}$$

Here y_{t+1} is the loss value of assets at t+1 time, and the number of failures N can be regarded as an independent binomial distribution $N \sim B(T, p)$.

The zero hypothesis of Kupiec test is $\hat{p} = \frac{N}{T} = p$ that the statistics of likelihood ratio test are:

$$LR_{uc} = -2\ln[(1-p)^{T-N} p^N] + 2\ln[(1-\hat{p})^{T-N} \hat{p}^N] \sim \lambda^2(1) \tag{8}$$

3. Empirical Analysis of Market Risk in New Third Board

(1) Data selection

This paper takes the logarithmic return rate of the new three-board index as the sample data for empirical analysis, calculates the VaR value and tests its validity.

The sample data is modeled and predicted by 440 new three-board index data from May 19, 2014 to March 4, 2016. The validity of the data is tested by 100 data from March 7, 2016 to July 28, 2016. The data is from Wind consultation. The processing software is Eviews 8.0 and excel.

(2) Data processing

The flow chart of data processing is shown in Figure 2.

(3) Descriptive statistics of logarithmic returns:

Table 1. Descriptive statistics of logarithmic returns

name	mean value	Variance	skewness	kurtosis	J-P statistics	probability
Logarithmic Return Rate	0.001604	0.026044	0.622763	14.24749	2342.384	0.0

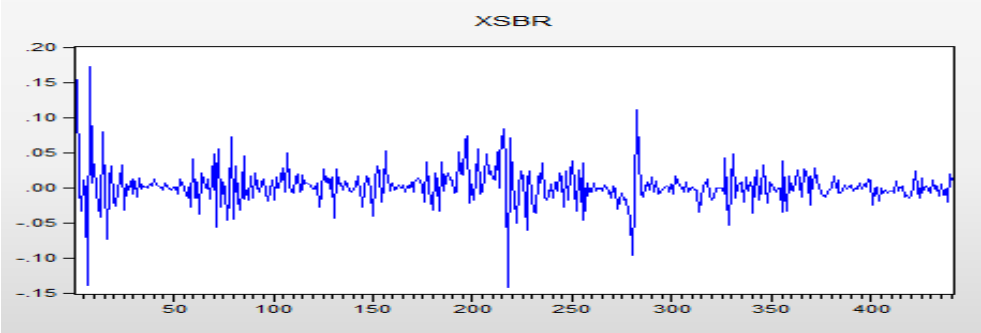


Fig. 2 Logarithmic Return Curve of New Third Board

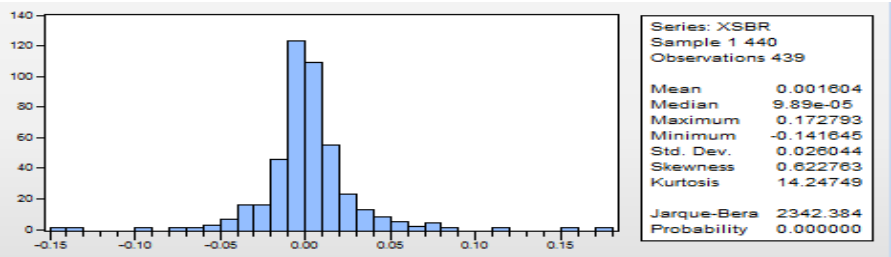


Fig 3. Histogram of Logarithmic Return Distribution of New Third Board Index

Through the statistical analysis of logarithmic return rate, it is not difficult to find that the logarithmic return rate of the new three-board index has a peak and a thick tail (see Tables 1 and 6), and is accompanied by data aggregation. Therefore, we can not establish a simple regression model for the return rate. We need to test the stationarity, correlation and conditional heteroscedasticity of the data

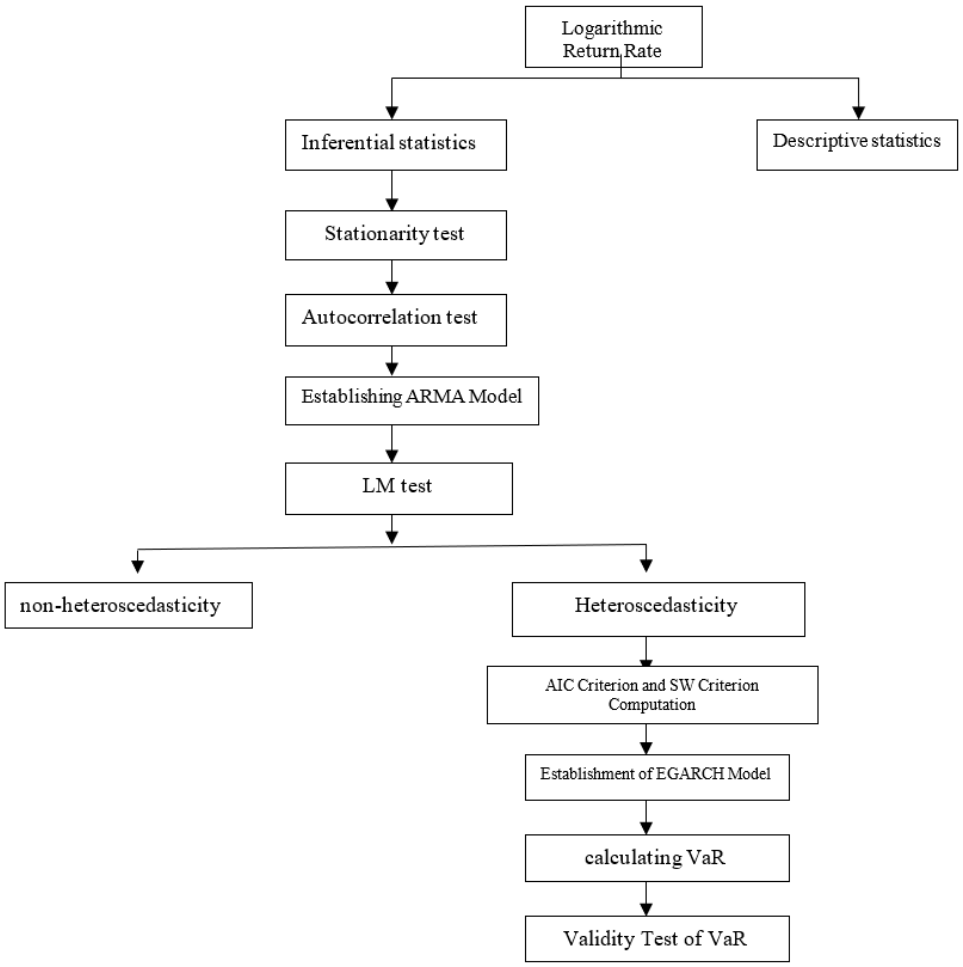


Fig. 4 Data processing flow chart

(4) ARCH Effect Test of Logarithmic Return Rate

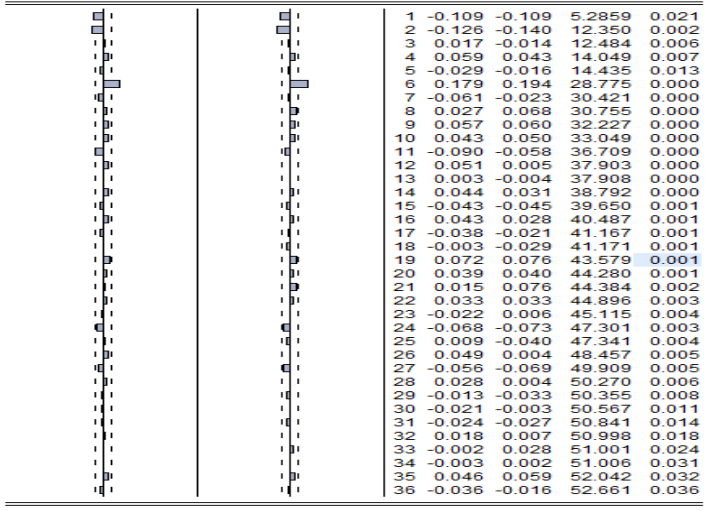
Through stationarity test (see table 2) and correlation test (see figure 5), we find that the new three-board exponential logarithmic return has stationarity and correlation. Through the test of autocorrelation function and partial autocorrelation function, we can establish the model of ARMA (3,3):

$$r_t = c_0 + \alpha_1 r_{t-1} + \alpha_2 r_{t-2} + \alpha_3 r_{t-3} + \beta_1 \varepsilon_{t-1} + \beta_2 \varepsilon_{t-2} + \beta_3 \varepsilon_{t-3} + \varepsilon_t \qquad (9)$$

Table 2 Stationality Test

Null Hypothesis: XSBR has a unit root				
Exogenous: Constant				
Lag Length: 1 (Automatic - based on SIC, maxlag=17)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-18.39065	0.0000
Test critical values:	1% level		-3.445093	
	5% level		-2.867934	
	10% level		-2.570240	
*MacKinnon (1996) one-sided p-values.				

Date: 08/24/16 Time: 11:14
Sample: 1 440
Included observations: 439



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.109	-0.109	5.2859	0.021
		2	-0.126	-0.140	12.350	0.002
		3	0.017	-0.014	12.484	0.006
		4	0.059	0.043	14.049	0.007
		5	-0.029	-0.016	14.435	0.013
		6	0.179	0.194	28.775	0.000
		7	-0.061	-0.023	30.421	0.000
		8	0.027	0.068	30.755	0.000
		9	0.057	0.060	32.227	0.000
		10	0.043	0.050	33.049	0.000
		11	-0.090	-0.058	36.709	0.000
		12	0.051	0.005	37.903	0.000
		13	0.003	-0.004	37.908	0.000
		14	0.044	0.031	38.792	0.000
		15	-0.043	-0.045	39.650	0.001
		16	0.043	0.028	40.487	0.001
		17	-0.038	-0.021	41.167	0.001
		18	-0.003	-0.029	41.171	0.001
		19	0.072	0.076	43.579	0.001
		20	0.039	0.040	44.280	0.001
		21	0.015	0.076	44.384	0.002
		22	0.033	0.033	44.896	0.003
		23	-0.022	0.006	45.115	0.004
		24	-0.068	-0.073	47.301	0.003
		25	0.009	-0.040	47.341	0.004
		26	0.049	0.004	48.457	0.005
		27	-0.056	-0.069	49.909	0.005
		28	0.028	0.004	50.270	0.006
		29	-0.013	-0.033	50.355	0.008
		30	-0.021	-0.003	50.567	0.011
		31	-0.024	-0.027	50.841	0.014
		32	0.018	0.007	50.998	0.018
		33	-0.002	0.028	51.001	0.024
		34	-0.003	0.002	51.006	0.031
		35	0.046	0.059	52.042	0.032
		36	-0.036	-0.016	52.661	0.036

Fig. 5 Autocorrelation test

Through LM test (table 3), it is found that there is Heteroscedasticity in the new three-board index return, and there is autocorrelation in the residual square. Therefore, we should choose to establish GARCH family model.

Table 3 Heteroscedasticity test (LM test)

Breusch-Godfrey Serial Correlation LM Test:			
4.518892	Prob. F(2,427)		0.0114
9.036978	Prob. Chi-Square(2)		0.0109

(5) Estimated Value of EGARCH(1,1) Model and Calculation of VaR for New Three-Board Index Logarithmic Return Rate, through the calculation of AIC criterion and SW criterion, we model EGARCH (1,1). The specific models are as follows:

$$r_t = c_0 + \alpha_1 r_{t-1} + \alpha_2 r_{t-2} + \alpha_3 r_{t-3} + \beta_1 \varepsilon_{t-1} + \beta_2 \varepsilon_{t-2} + \beta_3 \varepsilon_{t-3} + \varepsilon_t \tag{10}$$

$$\varepsilon_t = \sqrt{\sigma_t^2} * z_t \tag{11}$$

$$\ln \sigma_t^2 = \alpha_0 + \alpha_1 \left| \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} \right| + \gamma_1 \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \beta_1 \ln(\sigma_t^2) \tag{12}$$

Table 4. Assuming Normal Distribution

	c	ar(1)	ar(2)	ar(3)	ma(1)	ma(2)	ma(3)	α_0	α_1	β_1	γ_1
EGARCH-N	0.00049 (0.848)	-1.673 (-30.6*)	-1.524 (-17.4*)	-0.752 (-13.3*)	1.708 (27.3*)	1.514 (15.3*)	0.711 (10.7*)	-1.516 (-4.9*)	0.614 (6.8*)	0.867 (26.5*)	-0.024 (20.5*)

Table 5. Assuming T-distribution

	c	ar(1)	ar(2)	ar(3)	ma(1)	ma(2)	ma(3)	α_0	α_1	β_1	γ_1
EGARCH-t	-0.00014 (-0.142)	1.359 (31.4*)	-0.643 (-10.9*)	0.246 (5.48*)	-1.441 (-136.2*)	0.690 (29.8*)	-0.189 (-6.3*)	-1.367 (-4.3*)	0.786 (3.68*)	0.885 (23.7*)	-0.053 (20.6*)

Estimation results show that no matter the normal distribution or t distribution, the influence of each parameter is significant, and there are persistence and leverage effects of volatility. However, the heteroscedasticity LM test of the estimated residual will find that there is no significant heteroscedasticity anymore, so the above model can better characterize the logarithmic return heteroscedasticity of the new three-board market.

Table 6. VaR value and validity test results

Model	confidence level (%)	mean value	standard deviation	skewness	kurtosis	test interval	failure days	Failure rate (%)	rejection of the original hypothesis
EGARCH-N	95	-0.022	0.007	-0.556	2.627	100	5	5	f
	99	-0.032	0.009	-0.557	2.600	100	2	2	t
EGARCH-t	95	-0.022	0.006	-0.476	2.356	100	5	5	f
	99	-0.042	0.012	-0.468	2.317	100	0	0	f

Mean deviation (%) kurtosis (%) test interval (%) failure days (%) rejection of the original hypothesis

From the results, based on the VaR values calculated by EGARCH (1,1) under t distribution, the LR statistics proposed by Kupeic (1995) can not reject the original hypothesis at 5% (or 1%) significant level. However, under the normal distribution hypothesis, when the confidence level is 99%, the original hypothesis is rejected and the prediction fails. Therefore, the prediction of VaR value based on EGARCH (1,1) - t is more accurate.

Through the J-B normal test of sample data, the results verify that the logarithmic return distribution of China's new third board market index is not normal distribution, showing the non-normality of the thick tail peak, which also verifies that the selection of t distribution is more practical.

4. Analysis of Leverage Effect in New Third Board Market

In the EGARCH-t model, the valuation of alphaα1 is 0.786, the valuation of asymmetric term γ1 is -0.053; whenεt-1>0, the impact of "good news" is (0.786-0.053 = 0.733) times, and whenεt-1< 0, the impact of "bad news" is (0.786 + 0.053 = 0.839) times, which indicates that there is asymmetry in the new third board Market of China, that is leverage effect in the new third board market, and "negative news" is eliminated. The impact of interest rate on the new three-board stock index is stronger than the "good news", which is consistent with the conclusion drawn by developed and

mature western markets. It is different from the "anti-leverage effect" of stock market volatility in China's main board market.

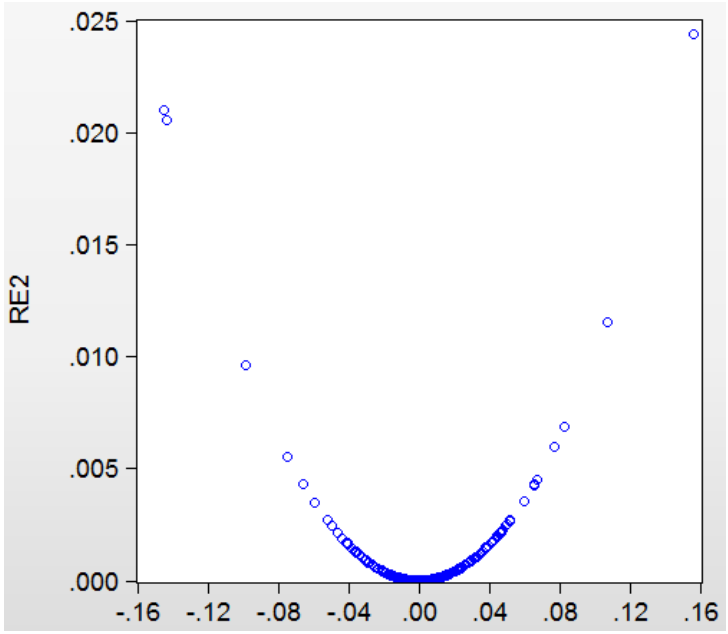


Fig. 6 Information Shock Curve of New Third Board Market

5. Conclusion

(1) Through statistical analysis of the daily return rate of China's new third-board market index, the logarithmic return rate of the new third-board market index is sTable and suiTable for the establishment of ARMA (3,3) model.

(2) By statistical analysis of the daily return rate of China's new third board market index, we can conclude that it has the characteristics of peak and heavy tail, heteroscedasticity and obvious volatility clustering, and non-normal distribution, which is suiTable for the selection of GARCH family model. Through the calculation of AIC criterion and SW criterion, we model EGARCH (1,1).

(3) Through empirical analysis, the VaR value based on EGARCH (1,1) - t prediction is accurate; therefore, the model of the new third board market index yield in China is EGARCH (1,1) - t model.

(4) Through the empirical analysis of EGARCH, we find that the value γ is less than zero and significant, which indicates that the new third board market has leverage effect and is more sensitive to negative news. Once the market has bad news, the stock price of the new third board market fluctuates greatly.

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References

[1] Lin Shu. VaR Risk Management Technology and Its Application in Stock Market, Development Research [J], 2006 (12)

[2] Tian Juanjuan, Xing Tiancai. Liquidity Risk of New Third Board Market after Expansion, Financial Forum [J], 2014 (11)

[3] Tang Yifan. Current Situation and Prospect Analysis of China's New Third Board Market, Brand [J], 2015 (5)

[4] Shen Hongmei. The validity test of VaR based on GARCH family model and its improvement, Master's Degree Thesis of Lanzhou University, 2007 (6)

[5] Lei Jun. Asymmetric Analysis of Stock Price Fluctuation in Shanghai Stock Market, Research on Financial Development [J], 2008 (03)

[6] Xu Fei. Study on the Contagion and Asymmetry of Stock Market Crash of Listed Companies --- Based on the Empirical Test of A Shares in Shanghai and Shenzhen, Enterprise Economy [J], 2017 (11)

[7] Liu Qinglei, Zhou Chengyuan. Asymmetric Effects of Chinese Stock Market, Journal of Systems Engineering [J], 2012 (27)05

[8] Zhanjie. Present situation, problems and suggestions of the new third board market in China, contemporary economy [J], 2017 (02)