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Garch and Egarch Models for Analyzing the Influence of CSI 300 Index Futures on Stock Market Fluctuation

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Abstract: This article focus on the influence of SCI 300 index futures on fluctuation of stock market in China by examining date of recently six months' closing prices in 30 min of Shanghai-Shenzhen 300 index. And due to the residual cluster characteristics of financial time series, GARCH test and ARCH effect test are adopted, the GARCH model and EGARCH model are building. Research results show that the index future plays a role that slows down the fluctuation of stock market but the effect is not obvious. Innovation of this study includes that the 30 min of high-frequency data and a variety of model test are adopted mutually, which have guaranteed the accuracy of result. In addition, it's not long since the introduction of Shanghai-Shenzhen 300 index future, so this article can make researches in the related fields more comprehensive.

Key words: Shanghai-Shenzhen 300 index futures, fluctuation of stock market, GARCH model, EGARCH model

INTRODUCTION

Much significant research in the finance literature has been done to study the influence of index future on fluctuation of stock market. But a unified conclusion has not been reached yet. Some scholars pointed out that the index future is stabilizing in the sense that it leads to stabilize the stock prices. For example, Lee and Ohk's inner relationship research on the HSI index future and HSI stock index (Lee and Ohk, 1992); Bessembinder and Seguin's research on S and P500 index (Bessembinder and Seguin, 1992); Xie L. and Wang Y.CH.'s research on HSI index future in Hong Kong (Xie and Wang, 2010), all of these researches get the similar result. On the contrary, some other scholars believe that the index future may be destabilizing, in that the asymmetric information prevailing in the financial derivative market may increase the fluctuation of the stock market. Harris and Lawrence's analysis on S and P500 index (Lawrence, 1989), Antonious and Holmes's study on the FTSE100 index future in UK (Antoniou and Holmes 1995) and Ryoo, Hyum-Jung, Smith and Graham's research on KOSP200 index future in Korea (Ryoo and Smith, 2004) are strong supporting evidences.

In addition, the past researches paid more attention to the mature market in developed country and lacked of the understanding on emerging market in Asia-Pacific region. In April 16, 2010, China had officially introduced a new index future: Shanghai-Shenzhen 300 index future. Then what kind of influence of the new financial instrument has upon the fluctuation of stock market? Unfortunately, the researches on it are quite deficient.

So in this article, date of recently six months' closing prices in 30 min of Shanghai-Shenzhen 300 index are used. And due to the residual cluster characteristics of financial time series, the Generalized Auto-regressive Conditional Heteroskedasticity Model (GARCH) and the Exponential Generalized Auto-regressive Conditional Heteroskedasticity Model (EGARCH) are established, so as to analyze the influence of the Shanghai-Shenzhen 300 index futures on the fluctuation of stock market.

THEORETICAL BACKGROUND

GARCH model: Compared with ARCH model, GARCH model overcomes the disadvantages of various parameters and limited conditions. Because of this, people are not required to estimate large quantities of parameters, which can contribute to time saving. For this reason, GARCH model is widely prevalent. In GARCH model, consideration shall be given to conditional mean and conditional variance.

The generalized GARCH (1, 1) model is defined as:

$$y_t = x_t \gamma + u_t \tag{1}$$

$$\sigma_t^2 = \omega + \alpha u_{t-1}^2 + \beta \sigma_{t-1}^2 \tag{2}$$

In Eq. 1, x_t is $1\times(k+1)$ dimensional exogenous variable vector and γ is $(k+1)\times 1$ dimensional coefficient vector.

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EGARCH model: In capital market, it is common that capital downward movement often goes with upward movement that is stronger. To explain this phenomenon, Engle and Ng have drawn the asymmetric information curve for "bullish news" and "bearish news" to demonstrate that the shock of capital market is often embodied as an asymmetric effect, which is called leverage effect. The EGARCH model presented by Nelson can explain and analyze asymmetric shock in an effective way.

EGARCH model, which also consists of mean equation and variance equation, has a more complicated variance equation compared with GARCH model:

$$\ln(\sigma_t^2) = \omega + \alpha\left|\frac{u_{t-1}}{\sigma_{t-1}}\right| + \beta\ln(\sigma_{t-1}^2) + \gamma\frac{u_{t-1}}{\sigma_{t-1}} \quad (3)$$

EMPIRICAL ANALYSIS

GARCH test and ARCH effect test: Before making empirical study based on GARCH Model, it is necessary to test whether GARCH model is applicable. The ARCH LM test is adopted. Firstly, an autoregressive mean equation is constructed, which can be expressed as below:

$$\text{In}\,(Y_t) = 0.0623 + 0.9921\ \text{In}(T_{t+4}) + u_t \quad (4)$$

The p value for the $\text{In}(T_{t+4})$ is 0.0000, which proves that the model is reliable.

Then test the ARCH effect of residual term. The test result is shown as in Table 1.

Since P-values (probability) of F statistic and chi-squared statistic are smaller than 0.05, it can be inferred that original series has ARCH effect.

Specification of GARCH model order: Akaike Information Criterion (AIC) and Schwarz Criterion (SC) are applied to making comparisons so as to determinate lag orders of ARCH and GARCH of GARCH model. From Table 2, it can be seen that the sum of AIC and SC values is smallest in GARCH (1, 1) model. Therefore, both the lag orders of ARCH and GARCH are 1.

Table 1: Sixth-order ARCH LM test of residual term

Heteroskedasticity test: ARCH			
F-statistic	135.7192	Prob. F (6,961)	0.0000
Obs*R-squared	444.0097	Prob. Chi-Square (6)	0.0000

Table 2: Comparison table for AIC and SC of different GARCH models

Models	AIC	SC
GARCH (1,1)	-7.0481	-7.0230
GARCH (1,2)	-7.0497	-7.0196
GARCH (2,1)	-7.0468	-7.0167
GARCH (2,2)	-7.0452	-7.0102

Estimation results of GARCH model: Parameter estimation result of GARCH (1, 1) model is shown in the Table 3. The result in Table 3 shows that in mean equation, the probability of the test statistic of constant term is not less than the significance level of 5%, while those of other terms are less than the significance level of 5%. Thus, the constant term is 0, while other parameters are not. According to the estimation result of variance equation, corresponding probabilities of all parameters approach zero, which is smaller than the significance level of 5%. Therefore, the hypothesis that the orders of ARCH and GARCH are 1 is true.

Based on the result above, GARCH (1, 1) model for 30 min closing prices of Shanghai-Shenzhen 300 index is determined as below:

$$\text{In}\,(Y_t) = 1.005\ \text{In}(Y_{t+4}) + u_t \quad (5)$$

$$\sigma_t^2 = 1.83\times10^{-5} + 0.6578u_{t-1}^2 + 0.1252\sigma_{t-1}^2 \quad (6)$$

Estimation results of the GARCH model with dummy variables: In order to explain the influence of stock index futures on stock market volatility, this study introduces a (0, 1) dummy variable series into GARCH model with a view to interpreting if stock index futures influence the normal volatility of stock market in one-day trading. Dummy variable is set as below: when the mean value for the turnover of stock index futures among the whole sample data is taken as benchmark, if the turnover in a certain period is higher than mean value, then the stock index futures trading can be considered active and the value of dummy variable can be assumed to be 1; if the turnover in a certain period is lower than mean value, then the stock index futures trading can be considered weak and the value of dummy variable can be assumed to be 0. The estimation results are described in Table 4.

According to the output result of Table 4, a new set of mean equation and variance equation can be obtained:

Table 3: Estimation result of GARCH model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.038776	0.023217	-1.670207	0.0949
L (-4)	1.004931	0.002975	337.817900	0.0000
Variance Equation				
C	1.83E-05	2.13E-06	8.589173	0.0000
RESID (-1)^2	0.657807	0.076920	8.551799	0.0000
GARCH (-1)	0.125195	0.036478	3.432041	0.0006
R-squared	0.985206	Mean dependent var	7.800184	
Adjusted R-squared	0.985191	S.D. dependent var	0.074013	
S.E. of regression	0.009007	Akaike info criterion	-7.048075	
Sum squared resid	0.078853	Schwarz criterion	-7.023016	
Log likelihood	3437.413	Hannan-Quinn criter.	-7.038539	
F-statistic	16182.33	Durbin-Watson stat	0.451285	
Prob (F-statistic)	0.000000			

GARCH = C (3) + C (4)*RESID (-1)^2 + C (5)*GARCH (-1)

Table 4: Output result of GARCH model with dummy variable

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.039418	0.023252	-1.695240	0.0900
L (-4)	1.005014	0.002980	337.2994	0.0000
Variance equation				
C	1.94E-05	2.64E-06	7.366009	0.0000
RESID (-1)^2	0.655962	0.077765	8.435207	0.0000
GARCH (-1)	0.129502	0.038323	3.379206	0.0007
DUMMY	-2.33E-06	2.44E-06	-0.952117	0.3410
R-squared	0.985205	Mean dependent var		7.800184
Adjusted R-squared	0.985190	S.D. dependent var		0.074013
S.E. of regression	0.009007	Akaike info criterion		-7.046609
Sum squared resid	0.078857	Schwarz criterion		-7.016539
Log likelihood	3437.699	Hannan-Quinn criter.		-7.035166
F-statistic	12945.20	Durbin-Watson stat		0.451300
Prob (F-statistic)	0.000000			

GARCH = C (3)+C (4)*RESID (-1)^2+C (5)*GARCH (-1)+C (6)*DUMMY

Table 5: Estimation result of EGARCH model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
L (-1)	1.000011	1.70E-05	58882.15	0.0000
Variance equation				
C (2)	-4.549152	1.055409	-4.310322	0.0000
C (3)	0.222300	0.045137	4.924981	0.0000
C (4)	0.115128	0.029666	3.880785	0.0001
C (5)	0.597286	0.094773	6.302280	0.0000
R-squared	0.996510	Mean dependent var		7.800015
Adjusted R-squared	0.996510	S.D. dependent var		0.073962
S.E. of regression	0.004370	Akaike info criterion		-8.048067
Sum squared resid	0.018636	Schwarz criterion		-8.023070
Log likelihood	3936.481	Hannan-Quinn criter.		-8.038556
Durbin-Watson stat	2.004446			

LOG (GARCH) = C (2)+C (3)*ABS (RESID (-1)/at SQRT (GARCH (-1)))+C (4)*RESID (-1)/@SQRT (GARCH (-1)) + C (5)*LOG (GARCH (-1))

$$\sigma_t^2 = 1.94\times10^{-5} + 0.6560u_{t-1}^2 + 0.1295\sigma_{t-1}^2\text{-}2.33\times10^{-5}\,\text{dummy} \quad (7)$$

It can be seen that dummy coefficient is negative and meanwhile insignificant at the statistical significance level. This implies that stock index futures play a role in mitigating market volatility, which, however, is not considerably significant.

Estimation results of EGARCH model: The source data here are not stationary, which, however, become stationary after first difference. This can satisfy not only the first-order integration process but also the application condition of EGARCH model. The computational result of Eviews is shown as in Table 5.

New variance equation is obtained under EGARCH model:

$$\ln(\sigma_t^2) = -4.5492 + 0.2223\left|\frac{u_{t-1}}{\sigma_{t-1}}\right| + 0.5973\ln(\sigma_{t-1}^2) + 0.1151\frac{u_{t-1}}{\sigma_{t-1}} \quad (8)$$

The table and equation above show that $\gamma = 0.1151>0$ and the test statistic is smaller than the significance level of 5%. Thus, it can be considered that shock effect is asymmetric. Meanwhile, volatility is positively correlated with the index, which suggests that stock market has leverage effect. The stock price volatility triggered by bullish news exceeds that caused by bearish news, which has partly alleviated stock market volatility. This result happens to coincide with that of GARCH model.

CONCLUSION

This study is based on the GARCH-based model and collected closing price of Shanghai-Shenzhen 300 index from October 17, 2012 at 14: 30 to April 19, 2013 at 15: 00 every 30 min. We use unit root inspection, co-integration test, ARCH LM test and GARCH models to analysis the influence to the fluctuation of Shanghai-Shenzhen 300 index future in the last six months. The result shows that the Shanghai-Shenzhen 300 index future retard the fluctuation of the stock market in the last six months but the effect is not very clear. In addition, we can confirmed that the stock index future retard the fluctuation of the stock market by the non-symmetry of the market.

Regarding these issues in our country, the volatility declines not too much may be caused by these reasons below: First, the stock future runs a very short time in our country. Second, the financial agency is not fully mature and it may take a longer time to proper operate. The immature market and the sheep-flock effect of the market investors in China lead to a result that increasing the fluctuation of market or counteract the role of stabilizator by establish the stock index future at the beginning by the coherence and abnormalities behavior. At the same time, the expiration effect will be enlarged among the investors in our country. And it is the reason why the effect of stock index future decline obviously.

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