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Empirical Analysis of Logarithmic Return Rate of China's Financial Stocks—based on the ARMA-GARCH Model

Yang Ding
College of Computer Science, Sichuan University, Chengdu 610207, China
2235912354@qq.com

Abstract. This paper studies the predicted average prices of financial stocks of 90 Chinese A-share listed financial companies. By analyzing the average daily closing prices from April 3rd, 1991 to July 23rd, 2018, it finds that they are consistent with the GARCH model of time series. Therefore, the model is adopted for data prediction, and the prediction results obtained indicate that the average prices of China's financial stocks will rise in the future.

Keywords: Time series, logarithmic return rate of China's financial stocks, ARMA-GARCH model.

1. Introduction

Stock prices fluctuate from time to time, which disrupts the production and consumption of enterprises and residents and thus has gradually attracted the attention of society and scholars. This paper forecasts the average stock prices of A-share financial companies listed on Shanghai Stock Exchange, enriching the research on all of such stocks. At the same time, it compares the effect of GARCH model in prediction. The practical significance of this study lies in that it provides managerial countermeasures for risks caused by fluctuations in financial stocks so as to enhance their ability to deal with fluctuation risks and promote the sustainable development of the financial industry. The research ideas and methods of this paper are closely related to the realities and can be directly applied to the financial industry, thus worth of extending.

2. Literature Review

As for financial time series, the ARMA model and the GARCH model are often used to simulate the price trend of financial products, and the return series of financial products are used to measure their fluctuations. Securities trading started early among western developed countries where the theoretical research on and quantitative analysis of financial time series are more systematic.

In 1963, Mandlebrot was the first to discover that the stock return series possessed a volatility clustering effect [1]. In 1982, Engle proposed an autoregressive conditional heteroscedasticity model to fit the residuals of the stock return series, further describing the volatility clustering effect [2]. In 1986, based on the ARCH model, Boiler-slev introduced the generalized autoregressive conditional heteroscedasticity model, namely the GARCH model, making the measurement of financial time series and risks more accurate [3]. Since the 1990s, the Western theoretical circle has applied the GARCH model widely in the financial field, fitting the factors influencing the volatility of stock returns and the influencing degree. The TGARCH model proposed by Zakoiao, Glosten, Jagannathan, and Runkle was used to conduct a long-term analysis of the factors affecting stock returns, clearly demonstrating that a leverage effect existed in the western stock market. The EGARCH model can fit the volatility of the impact on stock returns, indicating that the volatility of stock returns is asymmetric.

Based on the western modern financial econometric models, the domestic theoretical circle has done a lot of research on the securities market in China. In 1999, Ding Hua introduced the concept and test method of the ARCH (P) model, and used the SSE A-share composite indexes from 1994 to 1997 for empirical analysis which showed that the returns of SSE stocks also demonstrated heteroscedasticity [4]. In 2001, Yue Chaolong established a GARCH cluster model to analyze the returns of stocks listed on Shanghai Stock Exchange and found that the Shanghai Stock Exchange possessed a leverage effect [5]. In 2002, Liu Jinquan and Cui Chang conducted a comparative analysis of the return series of the Shanghai and Shenzhen stock markets and concluded that the two cities demonstrated different short-term fluctuation patterns but both of them kept a long-term equilibrium [6]. In 2010, Hui Jun and Zhu Cui used the ARMA model to first fit the stable return rate of China's fund market and then the residual series of the return rates, which helped facilitate the time series modeling of volatile returns under the condition that the variance varied frequently and describe the characteristics of the fund series [7].

3. Methodology

By analyzing the average daily closing prices from April 3rd, 1991 to July 23rd, 2018, this paper finds that they are consistent with the GARCH model of time series. Therefore, the GARCH model is used for data prediction and achieves the prediction results that indicate the average price of China's financial stocks will rise in the future.

3.1 Theoretical Models

GARCH (p, q) Model

In order to describe the tail features of time series more accurately, Bollerslev proposed a generalized ARCH model in 1986, namely the GARCH (Generalized ARCH) model. He added a hysteretic term ht to the equation of conditional variance, which can reflect more flexible hysteretic structure. The term ht is defined as follows:

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j h_{t-j} \tag{1}$$

Where $\alpha_0 > 0, \alpha_i > 0, \beta_j > 0$, $\sum_{i=1}^{q} \alpha_i + \sum_{j=1}^{p} \beta_j < 1$.

The GARCH (p, q) model regards the variance of the rate of return as being predictable. Besides, it assumes that the conditional variance depends not only on latest information, but also on previous conditional variance.

4. Empirical Analysis

4.1 Data Selection and Descriptive Statistics

Considering the availability of relevant data, the sample spacing of this paper includes the daily closing price data of all 90 A-share financial companies listed on the Shanghai Stock Exchange from April 3, 1991 to July 23, 2018. In addition, the closing prices of the Shanghai (securities) composite index of the same period are selected for comparison (Date is collected from the Wind Financial Database). As for data pre-processing, the stock prices of 90 listed financial companies are first processed to obtain the average price of Chinese financial stocks. And then the stock price series is converted into return series to obtain better prediction results and more stable fluctuation rate and range, which helps obtain the time series data of A-share financial stocks of the Shanghai Stock Exchange. As shown in Table 1, the average return rate of financial stocks is 1.804074e-06, the median is 0.00055, the maximum is 0.1178, the minimum is negative 0.1773, and the standard deviation is 0.018642016, which indicate that the return rate of China's financial stocks does not follow the normal distribution. In general, the return rate of China's financial stocks is obviously gregarious and can be estimated by use of the ARMA-GARCH model.

Table 1. Descriptive Statistics

Mean	Median	Maximum	Minimum	Std.Dev.
1.84074e-06	0.00055	0.1178	-0.1773	0.018642016

Source: Collected from Wind

4.2 Empirical Analysis of GARCH Model

4.2.1 Unit Root Test

Considering that the GARCH model requires the time series data used to be stationary, the first step is to verify the stationarity of all-time series data before we apply this model to conduct empirical analysis. This paper adopts the ADF test to test the return rate data of China's financial stocks, and finds that the data is stationary after the first-order difference. The test results are shown in Figure 1:

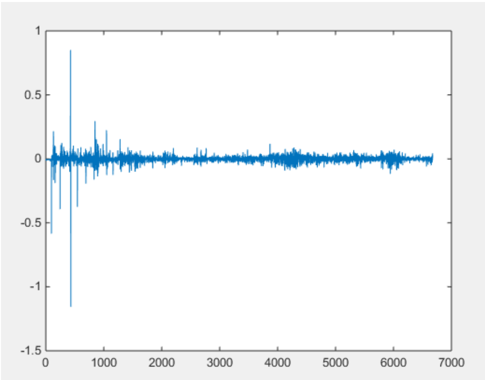

Figure 1. ADF Test Results

4.2.2 Test of the ARCH Effect

In this paper, matarch's archtest function is used to test the residual series of the return rate to see if it possesses the arch effect, which helps obtain the following results: The P-Value is 0.4313, the CV value is 3.8415 and the Stat value is 0.6192. Since the output result P-Value is not 0, it indicates that there exists autocorrelation in the residual square of average return rate of China's financial stocks and that the residual term itself does not have autocorrelation, which proves the existence of the arch effect.

4.2.3 The Construction of GARCH Model

The order of the ARMA-GARCH model is to be determined before the ARCH effect test is carried out. According to the AIC, SC, and DW criteria, the stationary ARMA (0, 0)-GARCH (1, 1) model is selected, and the results are shown in Table 2:

Table 2. Order Determination of the ARMA—GARCH Model

ARMA (p, q)—GARCH (p, q)	R-squared	Log likelihood	D-W	AIC	SC
ARMA(0,0)—GARCH (1,1)	0.9997	14206.64	1.5207	-1486.9	-14.5814
ARMA(0,1)—GARCH (1,1)	0.9997	14298.96	1.9931	-1485.4	-14.66850
ARMA(1,0)—GARCH (1,1)	0.9997	14470.52	1.9288	-1485.4	-14.8409
ARMA(1,1)—GARCH (1,1)	0.9997	14477.88	1.9603	-1483.6	-14.8524

Bring the selected results of the ARMA (0, 0)-GARCH (1, 1) model into the following formula:

$$y_t = C + \sum_{i=1}^{R} \phi_i y_{t-i} + \varepsilon_t + \sum_{j=1}^{M} \theta_j \varepsilon_{t-j} + \sum_{k=1}^{N_x} \beta_k X(t,k) \tag{2}$$

The obtained conditional mean parameter is as follows:

$$y_t = 0.0008473 + \varepsilon_t \tag{3}$$

Bring the computing results into the conditional variance equation:

$$\sigma_t^2 = k + G_i\sigma_{t-i}^2 + A_j\varepsilon_{t-j}^2 \tag{4}$$

The obtained conditional variance parameter is as follows:

$$\sigma_t^2 = 0.000030067 + 0.88768\sigma_{t-i}^2 + 0.046328\varepsilon_{t-j}^2 \tag{5}$$

From the above analysis, it can be seen that the GARCH (1, 1) model can better analyze how the average return rate of China's stocks fluctuates.

4.2.4 The Analysis of Model Prediction and Result

In order to test the prediction effect of the GARCH (1, 1) model, the following 100 periods data from April to August 2018 is stimulated with the optimal model ARMA (0,0)-GARCH (1, 1), and its estimated coefficient as well as the garchsim function in MATLAB. This process helps get the price series with 1 as the initial price, which is used to make the price chart and compared with the original sample price series whose initial price is 1. The simulation results are shown in Figure 2, among which the red line represents the raw data and the blue line represents the actual data:

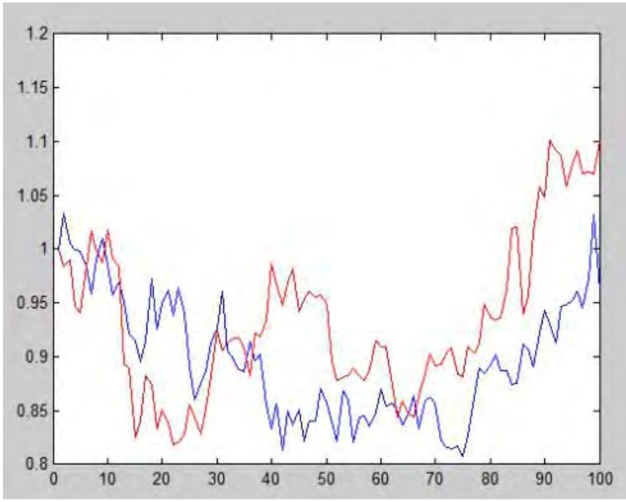

Figure 2. the simulation of the ARMA (0, 0)-GARCH (1, 1)

From the simulation figure above, it can be seen that this model can predict the general trend of the average financial stock price, but its prediction lacks accuracy. In other words, the predicted results deviate from the actual observed value to varying degrees and demonstrate a delay in translating the fluctuation of the average of the financial stock prices, which is in line with the actual situation. In real life, people often predict the future price changes through the current stock prices as well.

5. Conclusion

This paper firstly demonstrates the possibility of the GARCH model in predicting the average price of A-share financial stocks through the ARCH test, that is, the heterogeneity and autocorrelation of time series, and then establishes the GARCH (1, 1) model to predict the average price of those A-share financial stocks. According to the evaluation indicators of such prediction, this model is relatively successful in predicting the trend, reflecting the rising trend of the average price of A-share financial stocks. It can be seen from Figure 2 that the GARCH (1, 1) model conforms to the time series of the average price of the A-share financial stocks to a certain extent and possesses certain practicability in predicting the short-term price trend.

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