White Wine Market Volatility Forecast--Take Guizhou Maotai Stock as an Example

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Abstract: The "Fourteenth Five-Year Plan" of China's wine industry development guidelines and other policies continue to encourage the innovative development of the liquor industry. Financial instruments ultimately work in the real economy. Among the six stocks listed in the liquor sector, Guizhou Maotai has the highest market capitalization, and the changes in its return volatility have long been concerned and discussed by investors. In this paper, we select the daily price and daily trading volume data of Guizhou Maotai stock (600519) from July 12, 2017 to March 15, 2022, and obtain the sample data by logarithmic processing. This paper first models Guizhou Maotai stock returns based on GARCH-like models, and then conducts forecasting studies on its volatility. Then, the logarithmically processed daily trading volume of Guizhou Maotai stock is used as an exogenous variable to study its impact on Guizhou Maotai stock return.

1. Introduction

Baijiu, also known as shochu, is a distilled spirit unique to China. On January 26, 2022, the State Council issued the "Opinions on Supporting Guizhou in Breaking New Ground in the West of the New Era"[1], proposing to build an important national liquor production base by taking advantage of the origin and main production area of the Chishui River basin for saucy liquor. On the same day, Guizhou Moutai Distillery Group Company also issued an announcement, decided to invest 4.11 billion yuan to implement the "Fourteenth Five-Year Plan" sauce wine Xishui with the first phase of the Minba construction project. The development of financial instruments ultimately works in the real economy, so the real economy is supported is seen as good news for Guizhou Maotai stocks.

The forecast of Guizhou Maotai's stock yield has been a matter of concern for investors and scholars. Investors use the discounted cash flow model, the discounted dividend model and the discounted residual income model to discount the expected cash flows of Guizhou Maotai's stock and get the valuation of the enterprise value at the present moment. Scholars use models such as AR-GARCH [2] and LSTM [3] to fit Guizhou Maotai stock time series data to fit the volatility trend of this time series and thus make forecasts of price fluctuations of Guizhou Maotai stock. When the price forecast is obtained, the return of the day can be obtained by making the difference between the log price of the day and the log price of the previous day.

2. Literature Review

2.1 Guizhou Maotai Stock Yield Study

Scholars' forecasts about Guizhou Maotai's stock can be divided into three categories according to the forecasting methods. The first category is modeled by using ARCH and GARCH models for financial time series. Hu Caijuan et al. (2018) successfully captured six large fluctuations in Guizhou Maotai stock from January 2017 to May 2018 by building an AR-GARCH model with 2-period continuously compounded log returns. The second category uses neural networks such as RNN and LSTM to forecast Guizhou Maotai stock prices. Mengmeng Cui (2019) chose variables such as opening price and closing price as input variables and used LSTM and RNN to predict Guizhou Maotai stock price, concluding that LSTM can predict liquor industry stock price with smaller error compared to RNN; Qianyu Zhang et al. (2021) combined deep learning and decomposition algorithm for stock price prediction model, introducing complete integrated empirical modalities of adaptive noise decomposition (CEEMDAN) algorithm to extract the features of stock price time series on time scale to predict stock prices of four domestic and foreign companies such as Apple and Guizhou Maotai and the SSE index, and the empirical results show that the model can effectively reduce the prediction error and improve the model fitting ability compared with RNN, LSTM and other models. The third category is the prediction of Guizhou Maotai stock price by genetic algorithm in evolutionary algorithm. Chen Shile et al. (2021) used a multi-factor stock prediction method based on GA-Transformer model, using genetic algorithm (GA) for feature selection and combined with Transformer model for stock prediction enhancement, and the empirical results showed that the prediction performance of GA-Transformer model on six stock datasets, including Construction Bank and Guizhou Maotai, was The empirical results show that the GA-Transfer model outperforms the mainstream stock forecasting models on six stock datasets including Construction Bank and Guizhou Maotai.

Most of the existing literature on Guizhou Maotai stock return forecasting data use direct data of Guizhou Maotai stock price, this paper uses GARCH model to model Guizhou Maotai stock return, and also uses GARCH-X model to consider the effect of daily trading volume on Guizhou Maotai stock return.

2.2 Garch Family Model Development

Engle (1982) proposed the autoregressive conditional heteroskedasticity (ARCH) model to describe the heteroskedasticity of financial time series. the ARCH model can accurately characterize the volatility aggregation of financial time series. However, in the ARCH model, since volatility depends on the square of past "disturbances", the ARCH model assumes that positive "disturbances" and negative "disturbances" have the same effect on volatility. The ARCH model assumes that positive and negative "disturbances" have the same effect on volatility. However, it is clear that financial asset prices respond differently to positive and negative perturbations. In addition, the ARCH(q) model requires a higher order of q in order to obtain a better fit in practice. The increase in the parameters to be estimated not only increases the computational effort, but also brings about problems such as multicollinearity of the explanatory variables; Bollerslev (1986) further modeled the error term and proposed the generalized autoregressive conditional heteroskedasticity model (GARCH), which effectively improves the problem of more parameters to be estimated in the ARCH model and can fit the peak-thick-tail characteristics and conditional heteroskedasticity that often occur in financial time series Zakoian (1994) proposed a threshold autoregressive model (TGARCH) to measure the asymmetry of return volatility, i.e., the impact of negative and positive shocks on returns to different degrees; Lee (1994) developed the GARCH-X model based on cointegration theory to enhance the fitting ability of volatility models by adding exogenous regression variables to the volatility model.

Domestic scholars have embodied the GARCH model in predicting stock index returns and analyzing spillover effects. Yanhua Wei et al. (2004) used a Copula-GARCH model to analyze the conditional correlation among the index return series of each sector of the Shanghai stock market by establishing a Copula-GARCH model, and found that the index return series of different sectors have different marginal distributions and positive correlation among the series; Xiuliang Dong et al. (2009) used a multivariate GARCH model for the U.S., Japan, Hong Kong and Shanghai (2009) used a multivariate GARCH model to study the stock markets of the U.S., Japan, Hong Kong and Shanghai, and concluded that only the Hong Kong stock market has a significant volatility spillover to the Shanghai market, while the volatility spillover of the U.S. and Japanese stock markets to the Shanghai market is not significant; Li Congwen et al. (2015) measured the overall as well as local dynamic risk spillover effects of each type of shadow banks on commercial banks based on a GARCH time-varying Copula-CoVaR model with skewed t-distribution from the characteristics of shadow banks themselves.

3. Data Selection and Processing

The data for the empirical tests in this paper include the daily price of Guizhou Maotai stock (600519), the daily price of liquor index and the daily price of high-quality strong futures wheat. The sample time span is from July 12, 2017 to March 15, 2022. The Guizhou Maotai stock and liquor index were obtained from the Wind database, and the data on high-quality strong futures wheat were obtained from the Choice financial terminal. The data obtained were filtered according to public time, and a total of 1,120 trading days of data were obtained.

The treatment of Maotai returns in this paper is:

$$Y_{maotai}(t) = \log P_t - \log P_{t-1}, 1 \le t \le N \quad (1)$$

The treatment of the current day's volume is:

$$Y_{volumn}(t) = \log P_t - \log P_{t-1}, 1 \le t \le N \quad (2)$$

The descriptive statistics of the final data are:

Table 1 Descriptive statistics of the sample data

	Sample	Min(M)	Max(X)	Mean(E)	SD	Skewness	Kurtosis
Y_{maotai}(t)	1120	-0.045757491	0.03943058	0.000468168	0.009128334	-0.048	1.712
$Y_{volunmn}$(t)	1120	-4.6918438	5.9000882	0.01113636	0.43997838	1.04	57.546

Table 1 gives the descriptive statistics of the logarithmically processed Maotai returns, and same-day volume over the sample period. The results show that the maximum value of same-day volume is 5.9, the minimum value is -4.69, and the mean value is 0.01; the standard error of Maotai yield is 0.009, which indicates that the data of Maotai yield is more concentrated. This paper does ADF unit root test on these two indicators data, the p-value is 0. The results show that these two indicators are smooth data at 5% level of significance, so the GARCH class model can be used for empirical analysis.

4. Modeling and Forecasting Guizhou Maotai Stock Returns Based on Garch Family Model

4.1 Autocorrelation Test of Residuals and Lm Test of Heteroskedasticity

Table 2 Correlation of the squared residuals before fitting the GARCH(1,1) model

Self-Related	Partial Self-Related	Lagging order	AC	PAC	Q-Stat	Prob
|* |	|* |	1	0.08	0.08	7.1362	0.008
|* |	|* |	2	0.084	0.078	15.075	0.001
| |	| |	3	0.036	0.024	16.525	0.001
|* |	|* |	4	0.175	0.166	51.053	0
| |	| |	5	0.058	0.031	54.822	0
| |	| |	6	0.046	0.015	57.176	0
|* |	| |	7	0.079	0.064	64.222	0
| |	| |	8	0.049	0.006	66.906	0
| |	| |	9	0.016	-0.012	67.202	0
|* |	| |	10	0.077	0.063	73.84	0
| |	| |	11	0.053	0.019	77.002	0
| |	| |	12	0.002	-0.027	77.006	0
| |	| |	13	0.04	0.033	78.833	0
| |	| |	14	0.009	-0.023	78.916	0
|* |	|* |	15	0.094	0.075	88.986	0
| |	| |	16	0.009	-0.001	89.089	0
| |	| |	17	-0.01	-0.043	89.2	0
| |	| |	18	-0.011	-0.016	89.341	0
| |	| |	19	0.013	-0.008	89.542	0
| |	| |	20	-0.002	-0.015	89.545	0

In the calculated results as in Table 2, the correlations of the residual squares tested to the 20th order lag are all significant at a 5% confidence level of significance, i.e., there is a significant autocorrelation of the original series residual squares [7].

Engle (1982) proposed the LM test for the ARCH process, which can test the GARCH effect of the time series [7], and the calculation results are shown in Table 3:

Table 3 Heteroskedasticity test: ARCH

Variables	Coefficient	SD	t	Probability
Constant	7.66E-05	5.38E-06	14.23504	0
Residual squared lag term	0.080702	0.030006	2.689545	0.0073
R2	0.006434	Mean value of the explanatory variables		8.33E-05
Adjusted R2	0.005545	Standard deviation of the explanatory variables		0.00016
Regression standard error	0.00016	Bare pool information criterion		-14.64347
Residual sum of squares	2.85E-05	Schwartz criterion		-14.6345
Log-likelihood estimates	8195.024	H Q information criterion		-14.64008
F-statistic	7.233655	DW statistic		2.001307
The probability corresponding to the F-statistic	0.007262			

The results show that the p-value of the residual squared after fitting the GARCH(1,1) model is 0.0073, which is less than 0.05. Therefore, the lagged term of the residual squared is significant at the 5% confidence level, and the original series can be considered to have ARCH effect.

In summary, the residual squared series of Guizhou Maotai stock return has obvious autocorrelation and heteroskedasticity, and it is reasonable to use GARCH(1,1) model to fit it.

4.2 Garch(1,1) Modeling of Guizhou Maotai Stock Data

Table 4 GARCH(1,1) modeling based on Guizhou Maotai stock data

Variables	Coefficient	SD	z	p
C	0.000643	0.00026	2.475088	0.0133
C	4.06E-06	1.29E-06	3.140925	0.0017
RESID(-1)^2	0.060839	0.012639	4.81349	0
GARCH(-1)	0.892166	0.023024	38.74987	0
R^2	-0.000365	Mean value of the explanatory variables		0.000468
Adjusted R^2	-0.000365	Standard deviation of the explanatory variables		0.009128
Standard error of the regression	0.00913	Akuchi Information Guidelines		-6.596708
Residual sum of squares	0.093276	Schwartz Criteria		-6.578776
Log-likelihood estimates	3698.157	H Q information criterion		-6.58993
DW statistic	2.017351			

As shown in Table 4, all coefficients of the GARCH(1,1) model estimation results are positive, which meets the restriction that the coefficients of the GARCH model are set non-negative. In addition, the sum of the squares of the residual lag term and the coefficients of the GARCH term is less than 1, which satisfies the volatility convergence requirement of the GARCH model. Since the estimated p-value of the constant coefficient of the mean equation is 0.0133; the estimated p-values of the constant, residual term, and GARCH term coefficients of the conditional variance equation are 0.0017, 0, and 0, respectively, which are less than 0.05. Thus, the coefficients are significant at the 5% level of significance. In summary, the mean equation and variance equation after GARCH(1,1) modeling can be written as shown in Equation (3).

$$y_t = 0.000643 + \varepsilon_t$$

$$\sigma_t^2 = 4.06*10^{-6} + 0.060839\varepsilon_{t-1}^2 + 0.892166\sigma_{t-j}^2$$

4.3 Garch(1,1) Model Validity Test

After obtaining the estimated model, this paper performs residual tests on the fitted results of the

GARCH(1,1) model to verify the validity of the estimation. As shown in Table 5.

Table 5 Residual squared correlation after GARCH(1,1) model fit

Self-Related	Partial self-relation	Lagging order	AC	PAC	Q-Stat	Prob*
| |	| |	1	0.008	0.008	0.0758	0.783
| |	| |	2	-0.013	-0.013	0.2554	0.88
| |	| |	3	-0.028	-0.028	1.1218	0.772
| |	| |	4	0.045	0.045	3.39	0.495
| |	| |	5	-0.001	-0.003	3.3922	0.64
| |	| |	6	-0.025	-0.025	4.11	0.662
| |	| |	7	0.032	0.035	5.298	0.624
| |	| |	8	-0.018	-0.021	5.6614	0.685
| |	| |	9	-0.028	-0.029	6.5664	0.682
| |	| |	10	0.045	0.05	8.8685	0.545
| |	| |	11	0.006	0	8.915	0.63
| |	| |	12	-0.025	-0.025	9.6433	0.647
| |	| |	13	0.008	0.016	9.7077	0.718
| |	| |	14	0	-0.007	9.7077	0.783
| |	| |	15	0.05	0.049	12.537	0.638
| |	| |	16	-0.011	-0.005	12.674	0.696
| |	| |	17	-0.026	-0.031	13.44	0.706
| |	| |	18	-0.034	-0.03	14.721	0.681
| |	| |	19	-0.014	-0.014	14.96	0.725
| |	| |	20	-0.01	-0.016	15.085	0.772

From the calculation results in Table 5, it can be seen that the correlation of the squared residuals tested to the 20th order lag is not significant at the 5% confidence level, so it can be judged that the sample series of the squared residuals of Guizhou Maotai stock returns after the GARCH(1,1) model is fitted no longer has autocorrelation.

In this paper, ARCH effect test is done on the squared residuals of the GARCH(1,1) model after fitting. From Table 6, we can see that the p-value of the squared residuals after GARCH(1,1) model fitting is 0.7827, so the lagged term of the squared residuals is not significant at the 5% confidence level, so there is no ARCH effect in the Guizhou Maotai stock return series after GARCH(1,1) model fitting.

Table 6 Heteroskedasticity test after GARCH(1,1) fit: ARCH

Variables	Coefficient	SD	t	Probability
C	0.99095	0.061748	16.0483	0
Lagged term of the squared residuals	0.008289	0.030053	0.275817	0.7827
R^2	0.000068	Mean value of the explanatory variables		0.999188
Adjusted R^2	-0.000827	Standard deviation of the explanatory variables		1.807064
Standard error of the regression	1.807811	Bare pool information criterion		4.023896
Residual sum of squares	3650.557	Schwartz criterion		4.032869
Log-likelihood estimates	-2249.37	H Q information criterion		4.027288
F-statistic	0.076075	DW statistic		1.990877
Probability corresponding to the F-statistic	0.78274			

From the above analysis, it can be seen that there is autocorrelation and ARCH effect in the squared series of residuals of Guizhou Maotai stock returns before the GARCH(1,1) model is fitted; after the GARCH(1,1) model is fitted, there is no autocorrelation and ARCH effect in the squared series of residuals of Guizhou Maotai stock returns. Therefore, the GARCH(1,1) model models the residuals of the Guizhou Maotai stock sample data completely and fits the Guizhou Maotai stock return series well.

4.4 Prediction Based on Garch(1,1) Model

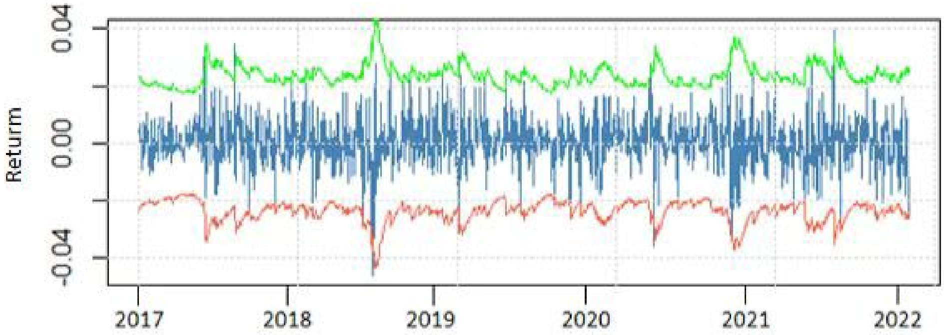

Figure 1 Var Prediction Series of Garch(1,1) for Guizhou Maotai Stock Return At 99% Confidence Level

Using R software, this paper makes the VaR prediction series of GARCH(1,1) on Guizhou Maotai stock return at 99% confidence level as shown in Figure 1. VaR (Value at risk) means the maximum loss of a certain financial asset or portfolio of securities under normal market volatility. From Figure 1, it can be seen that Guizhou Maotai stock return can be predicted at 99% confidence level [8].

4.5 Extension of Garch Model: Tgarch Model

In reality, investors' reaction to negative news is different from that of positive news: generally speaking, the "disturbance" brought by negative news is greater than that brought by positive news, i.e., there is a leverage effect. Due to the limitation of GARCH model, the estimation of GARCH model is only influenced by the absolute value of "disturbance" and not its sign, so this paper fits the TGARCH model to the Guizhou Maotai stock return data which can reflect the leverage effect. The fitting results are shown in Tables 7:

Table 7 TGARCH model fitting results for Guizhou Maotai stock return sample data

Variables	Coefficient	SD	z	Probability
C	0.000653	0.000263	2.484956	0.013
C	3.88E-06	1.27E-06	3.056067	0.0022
RESID(-1)^2	0.063704	0.015278	4.169565	0
RESID(-1)^2*(RESID(-1)<0)	-0.006787	0.016811	-0.403722	0.6864
GARCH(-1)	0.894934	0.022438	39.88526	0
R^2	-0.000411	Mean value of the explanatory variables		0.000468
Adjusted R^2	-0.000411	Standard deviation of the explanatory variables		0.009128
Standard error of the regression	0.00913	Akachi Information Guidelines		-6.595013
Residual sum of squares	0.093281	Schwartz criterion		-6.572597
Log-likelihood estimates	3698.207	H Q information criterion		-6.58654
DW statistic	2.017259			

From Tables 7, it can be seen that the p-value of the residual squared lagged term of the fitted GARCH model is 0, which is less than 0.05, and the p-value of the residual squared lagged term of the TGARCH model is 0.6864, which is greater than 0.05. It can be judged that at the 5% level of significance, the GARCH term of Guizhou Maotai stock return data is significant and the TGARCH term is not significant, therefore Guizhou Maotai stock return There is no leverage effect in the sample data [9].

5. The Effect of Guizhou Maotai Stock's Same-Day Trading Volume on Maotai's Yield

5.1 Garch-X Based Model Estimation

In this section, the "daily trading volume" of Guizhou Maotai stock is regarded as an exogenous variable X. The sample data of Guizhou Maotai stock return is fitted by GARCH-X model. The fitted results are shown in Table 8:

Table 8 Estimation results of GARCH-X model with same-day trading volume as an exogenous variable

	Estimates	SD	t	Probability
mxreg1	0.001062	0.00047	22.82603	0
omega	0	0.000001	0.12552	0.90011
alpha1	0.10162	0.000127	798.5462	0
betal1	0.898295	0.000182	4934.07427	0
vxreg1	0.000191	0	4416.82867	0

Where mxreg is an abbreviation for mean x regression, which represents the regression coefficient of the exogenous variable X in the conditional mean equation, and vxreg is an abbreviation for variance x regression, which represents the regression coefficient of the exogenous variable X in the conditional variance equation, in the calculated results in Table 8 [10]

Table 8 Estimation results of GARCH-X model with same-day trading volume as exogenous variable in mxreg1 and vxreg1 estimated p-value is 0, which is less than 0.05, at 5% level of significance, the same-day trading volume of Guizhou Maotai stock has a significant effect on the mean equation and conditional variance equation of Guizhou Maotai stock return. In summary, the conditional variance equation after modeling GARCH-X with same-day trading volume as the exogenous variable can be written as shown in Equation (4).

$$\sigma_t^2 = 0.10162 + 0.892166\sigma_{t-j}^2 + 0.000191x_{t-l}^2 (4)$$

5.2 Garch-X Fit with "Day Trading Volume" as an Exogenous Variable

In this paper, LB tests are performed on the residuals, squared residuals, after fitting the GARCH-X model with same-day trading volume as an exogenous variable.

Table 9 LB test for residuals and squared residuals after fitting the GARCH-X model with same-day trading volume as the exogenous variable

Residuals after fitting			Squared residuals after fitting		
	Statistical quantities	p		Statistical quantities	p
Lag[1]	0.3818	0.5367	Lag[1]	1.489	0.2224
Lag[2*(p+q)+(p+q)-1][2]	0.4483	0.7184	Lag[2*(p+q)+(p+q)-1][5]	2.083	0.5989
Lag[4*(p+q)+(p+q)-1][5]	1.1277	0.8302	Lag[4*(p+q)+(p+q)-1][9]	2.765	0.797
d.o.f=0			d.o.f=2		

The LB test is a statistical test for the presence of lagged correlation in a time series. It is based on a series of data to determine whether there is serial correlation or stochasticity in the aggregate. The results in Table 9 show that the p of the fitted residuals and the squared residuals of the GARCH-X model with the current day's trading volume as the exogenous variable are greater than 0.05. Therefore, the fitted residuals and the squared residuals of the GARCH-X model with the current day's trading volume as the exogenous variable are white noise series without autocorrelation at the 5% level of significance.

In addition, this paper also performs LM tests on the fitted residuals squared.

Table 10 ARCH LM test

	Statistical quantities	p
ARCH Lag[3]	0.5675	0.4512
ARCH Lag[5]	1.1499	0.689
ARCH Lag[7]	1.4985	0.8217

As can be seen from Table 10, the p-values of the residual squared in the LM test are 0.4512, 0.689 and 0.8217 at lags 3, 5 and 7, all of which are greater than 0.05. Therefore, at the 5% significance level, the residual squared 3rd, 5th and 7th order 1 lagged terms are not significant, and it can be concluded that there is no ARCH effect in the residual squared after the GARCH-X model is fitted, so it can be stated that The GARCH-X model with current day trading volume as the exogenous variable fits well.

6. Conclusion

This paper not only uses a GARCH-like model to model the Guizhou Maotai return time series and predict the volatility of Guizhou Maotai stock returns; it also uses a GARCH-X model to analyze the effect of same-day turnover on Guizhou Maotai returns.

The results of the model fitting and testing done are specified below:

1) Using GARCH(1,1) to model the change in Guizhou Maotai stock return itself

In this paper, GARCH(1,1) is used to model Guizhou Maotai stock returns. Through Eviews 10, the residuals are modeled and the final mean equation of the GARCH(1,1) fitting result of Guizhou Maotai stock return is obtained as $y_t = 0.000643 + \varepsilon_t$;The conditional variance equation is: $\sigma_t^2 = 4.06*10^{-6} + 0.060839\varepsilon_{t-1}^2 + 0.892166\sigma_{t-j}^2$.

For the established GARCH(1,1) model, the fitted residuals and squared residuals correlation test and the fitted heteroskedasticity ARCH effect test are made in this paper. The result is that the fitted series is white noise and there is no ARCH effect. Meanwhile, in order to further illustrate that there is no leverage effect in Guizhou Maotai stock sample data, TGARCH modeling is conducted on Guizhou Maotai sample data in this paper, and since the p-value of TGARCH term RESID(-1)^2*(RESID(-1)<0) is 0.6864, which is greater than 0.05, the TGARCH term is not significant at the 5% level of significance, and Guizhou Maotai There is no leverage effect in the sample data of stock returns.

2) Fitting the GARCH-X model with Guizhou Maotai stock daily trading volume as an exogenous variable

The paper is fitted with a GARCH-X model using current day trading volume as an exogenous variable. The results show that the mean and variance equations of the fitted GARCH-X model with the current day trading volume as the exogenous variable are significant, and the conditional variance equation is $\sigma_t^2 = 0.10162 + 0.892166\sigma_{t-j}^2 + 0.000191x_{t-l}^2$.

Next, we consider the fitting effect of the GARCH-X model for Guizhou Maotai stock. The residuals and residuals squared after model fitting are white noise series, and there is no ARCH effect on the residuals squared. Therefore, the GARCH-X fitted model with the current day's volume as the exogenous variable works well and models the residuals adequately.

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