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Research on Volatility of Silver Futures Market Based on GARCH Model

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Abstract: Taking the daily closing data of Shanghai and Silver Banks from May 27, 2014 to June 11, 2018 as samples, the GARCH model was used to conduct an empirical analysis to check the price fluctuations and leverage effect during this period of time. The results show that there is a leverage effect and volatility clustering characteristics in the silver futures market.

Keywords: Silver, GARCH model, Eviews, Leverage effect

1. Introduction

Silver has played the same currency as gold for a long time in history. With the reform of the monetary system and the emergence of credit currencies, silver coins have gradually withdrawn from circulation, and because silver has good conductive thermal conductivity, good flexibility, ductility, reflective and so on, the industrial application of silver and the function of decorating and beautifying life continue to play, making its application in most industries irreplaceable. At present, China is the world's largest silver producer and one of the world's leading silver exporters. Domestic silver futures have been listed on the Shanghai Futures Exchange on May 10, 2012, thus ending the history of China as a major producer and consumer of silver, but it has not had a say for prices for a long time.

Although China's futures market has been developed for more than a decade now, it still belongs to the emerging field, and its theoretical research is relatively lacking. Engel (1982) proposed the ARCH model and Bollerslev (1986) proposed the GARCH model. The GARCH family model can simulate some of the dynamic characteristics of the futures market, such as fluctuation aggregation, peak tail, asymmetry, and long memory and the positive correlation between risk and return. Therefore, in this paper we use the GARCH model to analyze the futures price volatility and its leverage effect.

2. Literature Review

Many scholars at home and abroad have studied the volatility of the futures market. In foreign countries, Clark (1973) first studied the price relationship in the futures market. Karpoff (1988) considered that there was no relationship between trading volume and earnings in the futures market through inspection of agricultural products, gold, and interest rate futures markets. Foster (1995) used the GARCH (1,1) model and the GMM to study the relationship between trading volume and price fluctuations in the crude oil futures market, and found that the trading volume and price fluctuations in the same period were positively correlated. Ragunathan and Peker (1997) conducted empirical research on the relationship among the price volatility, volume, and volume of four financial futures varieties on the Sydney Futures Exchange in Australia. It is concluded that the trading volume and the amount of open interest have a significant impact on futures price volatility. In China, Hua Renhai et al. (2004) conducted an empirical analysis of the relationship between the positions held by five futures trading products and their price returns. Since the Shanghai silver futures market has only been listed for more than six years, there has been little research on the volatility of the silver futures market.

3. Model Introduction

Engle (1982) proposed an autoregressive conditional heteroskedasticity (ARCH) model in the study of the inflation rate of the UK inflation, which provided a new way to solve the heteroskedasticity problem. Bollerslev (1986) proposed a generalized autoregressive conditional heteroskedasticity GARCH model on this basis. Nelon (1991) found that the symmetric conditional variance function does not accurately describe the fluctuation of the return on assets, and the GARCH model cannot characterize the effects of fluctuation asymmetry in many financial time series. Therefore, an exponential GARCH model, namely the EGARCH model, is proposed. In order to obtain a good estimation effect in practical applications, the ARCH model generally requires a large number of models, which will increase the number of parameters to be estimated, and also cause other problems such as multiple collinearity of explanatory variables, and the GARCH model is very good solution to the problem of too many parameters. The EGARCH model can well describe the asymmetric effect of the securities market. Because the conditional variance is expressed as an exponential form, there are no restrictions on the parameters in the model. The GARCH model is particularly suitable for studying the relationship between the return of securities and fluctuations. The EGA RCH model concentrates the advantages of the two. This model can not only reflect the influence of the number of residuals on the fluctuations in the past, but also indicate whether the positive and negative residual effects on the fluctuations are symmetrical, so as to know whether there is a leverage effect.

We have chosen GARCH and EGARCH to analyze the closing price index of the Shanghai Futures Exchange's silver futures. The model that this article will use is as follows.

AR-GARCH（2，2）:

$$r_t = \omega_0 + \omega_1 r_{t-1} + \omega_2 r_{t-2} + \ldots + \omega_k r_{t-k} + \mu_t$$
$$\mu_t = \sigma_t v_t, \quad v_t \sim i.i.d(0,1)$$
$$\sigma_t^{\,2} = \alpha_0 + \alpha_1 \varepsilon_{t-1}^{\,2} + \alpha_2 \varepsilon_{t-2}^{\,2} + \beta_1 \sigma_{t-1}^{\,2} + \beta_2 \sigma_{t-2}^{\,2}$$

AR-EGARCH（1，1）:

$$r_t = \omega_0 + \omega_1 r_{t-1} + \omega_2 r_{t-2} + \ldots + \omega_k r_{t-k} + \mu_t$$
$$\mu_t = \sigma_t v_t, \quad v_t \sim i.i.d(0,1)$$
$$Ln\sigma_t^{\,2} = \alpha_0 + \alpha_1 \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \gamma_1 \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \beta_1 Ln\sigma_{t-1}^{\,2}$$

4. Empirical Analysis

The following analysis of data from the Shanghai Silver Bank continuous data range from May 27, 2014 to June 14, 2018, data capacity of 987.

4.1 Statistical description of data

First convert the data to the form of logarithmic returns, that is:

$$r = 100 * (\log(p / p(-1)))$$

Using Eviews software to get the linear graph of futures yield series:

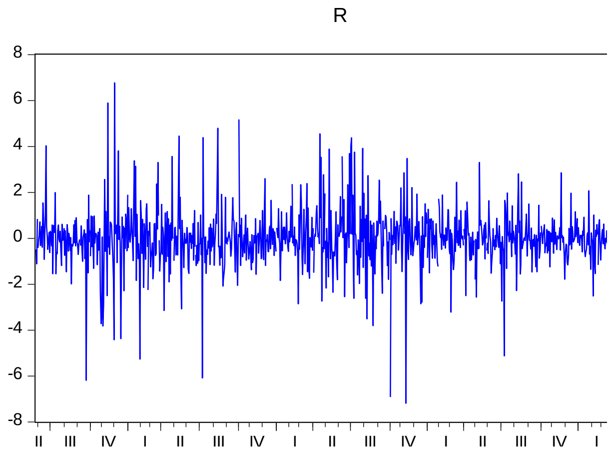


Figure 1: Linear graph

From the figure we can see that the sequence of futures yields has a clear aggregation, with a high rate of return followed by a higher rate of return, and a low rate of return followed by a lower rate of return. The following data is obtained from the bar chart of the logarithmic yield:

Table 1: Statistics Table

Mean	Maximum	Minimum	Standard deviation	Skewness	Kurtosis	J-B test value	P-value
-0.00709	6.76500	-7.18455	1.25569	-0.05692	9.26137	1611.196	0

As it can be seen from the data in the table, the skewness of the yield is a negative skewness, so the tail of the distribution is dragged slightly to the left, and the probability of surface profit is less than the probability of loss. The kurtosis value is larger than 3, which indicates that the distribution of the returns has the characteristics of sharp peaks and thick tails. The J-B test value is 1611.196, with a P value of zero, rejecting the assumption that the logarithmic return sequence obeys the normal distribution.

4.2 Test sequence stationarity

Table2. Test the stationarity of the data series:

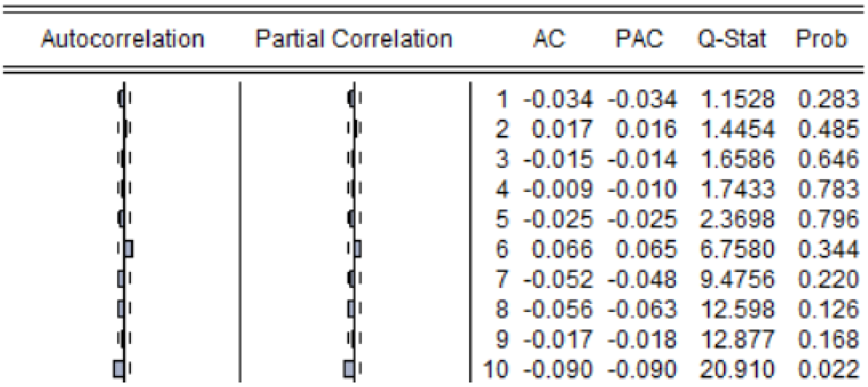
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-32.44235	0.0000
Test critical values:	1% level	-3.436769	
	5% level	-2.864263	
	10% level	-2.568272	

*MacKinnon (1996) one-sided p-values.

The T-statistic value is -32.44235, which is lower than the T-statistic value at significant levels of 10%, 5%, and 1%, and the p-value is zero. Therefore, the unit root is rejected in the original hypothesis sequence, and the data is stable.

4.3 Sequence autocorrelation and partial autocorrelation test

After checking the stationarity, identify the model of the data:



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.034	-0.034	1.1528	0.283
		2	0.017	0.016	1.4454	0.485
		3	-0.015	-0.014	1.6586	0.646
		4	-0.009	-0.010	1.7433	0.783
		5	-0.025	-0.025	2.3698	0.796
		6	0.066	0.065	6.7580	0.344
		7	-0.052	-0.048	9.4756	0.220
		8	-0.056	-0.063	12.598	0.126
		9	-0.017	-0.018	12.877	0.168
		10	-0.090	-0.090	20.910	0.022

Figure2: Correlation test

From the sequence of the autocorrelation coefficient (AC) and partial autocorrelation coefficient (PAC)analysis results can be seen, the futures rate of return sequence in the 10th-order autocorrelation phenomenon weakened, the sequence of the lag period of 10 ARCH-LM test.

Table3 Heteroskedasticity Test: ARCH

F-statistic	6.379383	Prob. F(1,973)	0.0117
Obs*R-squared	6.350857	Prob. Chi-Square(1)	0.0117

The P value is very small (0.0117),so the original hypothesis is rejected, ARCH effect is considered in the rate series, and the P value is still small from the 10th-order ARCH-LM test result, ie, the residual has a high-order ARCH effect, so the GARCH model is continued to be established.

4.4 Establishing a GARCH Model

Use the above AR(10) directly as the mean value equation and build a GARCH model on this basis.

Table 5: Comparison of models

	GARCH（1，1）	GARCH（1，2）	EGARCH（1，1）
α_0	0.2637	0.3083	-0.0442
α_1	0.113	0.132	0.0686
γ_1			-0.0258

β_1	0.7273	0.3117	0.9937
β_2		0.096	
AIC	3.2492	3.251	3.2181
SC	3.2691	3.276	3.2431
LM	0.8890	0.7186	0.4561

We have established the GARCH(1,1), GARCH(1,2), GARCH(2,1), GARCH(2,2), and EGARCH(1,1) models respectively, of which only the following three models passed the test.
According to the AIC and SC criteria, the EGARCH(1,1) model is optimal, and it can be seen that there is no ARCH effect at this time, indicating that the EGARCH model can better fit the volatility of yield. All parameters passed the test, indicating that there is a leverage effect in silver futures, and γ_1 is less than zero, that is, the investor's response to negative price fluctuations is significantly higher than the impact of the same degree of positive price fluctuations. The parameter is very close to 1 and statistically significant, indicating that there is a clear persistence and aggregation of the yield volatility in the silver futures market.

5. The Conclusion

This paper uses the AR-GARCH and AR-EGARCH model to analyze the volatility and fluctuation asymmetry of the silver futures price return. Through analysis, basically the following conclusions can be drawn:

Firstly, there is a clear aggregation phenomenon on the time series chart of the price returns of silver futures. The price fluctuation range is quite the same in a period of time. The histogram of the yield rate also has a “spike”, and does not obey the normal distribution.

Secondly, there is a clear GARCH effect on the price returns of silver futures, and after modeling and regression of GARCH models, the heteroscedasticity of residuals can be eliminated, indicating that GARCH family models are feasible for the analysis of volatility of futures price returns.

Thirdly, in the EGARCH(1,1) model, the parameter tends to 1, indicating that as long as there is a large fluctuation, it is difficult to eliminate its influence in a short time. Therefore, investors should consider when conducting futures trading, both to consider the current and future factors, but also to consider the impact of historical fluctuations.

At last, there is a leverage effect and volatility clustering characteristics of the silver futures price return, and the good news has a smaller impact on the yield than a spread message of the same size.

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