Application of GARCH Model in Research on Price of Agricultural Products

HE Hai *

Guizhou University of Finance and Economics, Guiyang 550004, China

Abstract Taking the price of grain in Guizhou Province as an example, by establishing GARCH model, I calculate VAR of logarithm return of grain price index, in order to conduct research on the variation law of price of the agricultural products. The results show that VAR of grain in Guizhou has variation. After the year 2010, VAR value is gradually increasing, and the price variation risk of grain market tends to increase progressively. Based on the characteristics of grain price variation, a series of corresponding proposals are put forward to stabilize the grain price as follows: strengthen the agricultural infrastructure construction, and promote the agricultural overall production capacity; reinforce the market supervision on the circulation field of agricultural products, and maintain market order; improve regulation system of agricultural products, and stabilize the price of agricultural products; strengthen mobility regulation, and prevent a flood of speculative cash.

Key words Price of agricultural products, Price fluctuation, GARCH model, VAR, China

Fluctuation in prices of agricultural products is a barometer of market information, so the prediction and research on price fluctuation of agricultural products captures close attention, and tends to be very valuable. At present, the analysis and prediction on price fluctuation of agricultural products at home is to conduct qualitative judgment largely based on experience. Because many factors affect the prices of agricultural products, such as supply and demand, season, weather, emergency and government regulation and so on. These factors exert complex influence on the price[1]. Therefore, some scholars have tried to use multivariate analysis methods, such as linear and nonlinear regression model, gray model and other methods, but the fitting result is less effective. Moreover, in multivariate analysis, the influencing factors have high requirements on data, but it has poor availability, thus multivariate analysis has been largely restricted, and not very scientific. Some adopt input-output technique to draw the input-output table, to conduct influencing trend analysis on price of agricultural products, and conduct short-term trend prediction according to the relationship between price levels of commodities and price level of agricultural products[2]. This method mainly focuses on research on price of commodities, having certain prediction effect. Some use BP neural network to predict the price of agricultural products, but the prediction effect is not very satisfactory.

I integrate the current research methods regarding fluctuation prediction of price of agricultural products in China, and propose a set of prediction methods on price fluctuations, that is, introduce VAR model to conduct long-term or medium-term forecast analysis and research on fluctuations in the prices of agricultural products, thus to master the law of price fluctuations of agricultural products, know trends in prices of agricultural products, provide farmers with various timely and accurate dynamic information concerning price of agricultural products, conduct long-term or medium-term market forecast on future price of agricultural products, and stabilize prices of agricultural products.

1 Data source and research method

1.1 Data selection The object of the empirical research is grain price index in Guizhou Province . The base of the grain price index is the average price in 2003. By using the monthly price data in other years and this base, I calculate the corresponding index.

1.2 Model introduction First, I take logarithm of the time sequence, then conduct difference on the time sequence, to get the time sequence of logarithm return of grain price in Guizhou Province . The specific expression is as follows:

$$VAR = f(y_t) + \sigma^t \quad (1)$$

Where y_t is the time sequence of logarithm return of grain price in Guizhou Province; σ^t is conditional standard deviation.

We use X to stand for random variable of return; $-X$ to stand for opposite number; F to stand for distribution of $-X$. Then VAR value at confidence level of α can be expressed as α discrete distribution of F distribution, namely:

$$VAR(X) = \inf\{x \in R: F(x) \geqslant \alpha\} \quad (2)$$

On the premise of normal distribution, this formula is further simplified as follows:

$$VAR(X) = \sigma^{Z_\alpha} \quad (3)$$

Where Z_α is α discrete distribution of normal distribution. In formula (3), the standard deviation is constant, which cannot reflect time-variation characteristics of random variables[3]. In practical application, we can use GARCH model family (including GARCH model, TGARCH model, EGARCH model, PGARCH model), to express conditional standard deviation. It can reflect inconsistency of return along with fluctuations over

Received: July 18, 2011 Accepted: August 27, 2011

Supported by Guizhou Provincial Science and Technology Department Soft Science United Funds Research Program(2010LKC2005).

* Corresponding author. E-mail: hehai68@sina.com

time, realize dynamic measure on the risk of related variables, and more accurately grasp the changes in risk[4]. When using conditional standard deviation, there is need to change σ^t in formula (3) as σ. Formula (2) assumes that return *X* follows normal distribution, which is rational to some extent. Return is often the result of mass " micro effect". According to the central limit theory, it can be held that it follows Gaussian distribution. But in fact, a large number of empirical studies have shown that financial gain often assumes the " peak-tail" characteristic, which shows that direct assumption of return following normal distribution, is not in line with reality.

2 Results and analysis

2.1 Description of statistical characteristics I use formula (1) to process the original data, to get distribution figure of the time sequence of logarithm return of grain price in Guizhou Province (Fig. 1).

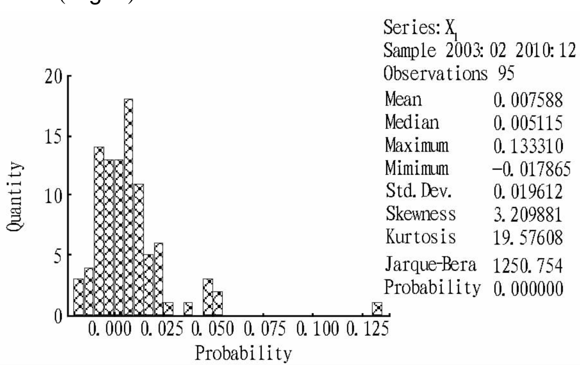

Fig. 1 Time series distribution of logarithm return of grain price in Guizhou Province

Fig. 1 reports that measure of skewness coefficient of the time sequence of logarithm return of grain price in Guizhou Province is 3.209 8, bigger than 0; in terms of distribution, the right tail is long, and it is right skew distribution; peak coefficient is 19.576, greater than peak value (3) of normal distribution. In terms of distribution, it is peak, and the distribution density curve is steeper than normal distribution in the neighbourhood of peak value; J-B statistic after test of normality is 1 250.754, bigger than the critical value of 5.991 of JB at confidence level of 0.05, indicating that at significance level of 5%, the time sequence of logarithm return of grain price in Guizhou Province , is conspicuously different from normal distribution.

2.2 Stationarity test I conduct ADF test on the time sequence of logarithm return of grain price, and the test result is −9.567 930. The critical value of unit root at significance level of 1% is −3.503 1; the critical value of unit root at significance level of 5% is −2.893 2; the critical value of unit root at significance level of 10% is 2.583 4. This absolute value is smaller than the absolute value of *ADF* statistic, indicating that the time sequence of logarithm return of grain price in Guizhou Province from 2003 to 2010 has no unit root, and the time sequence of logarithm return of grain price passes *ADF* test, so the sequence is stationary sequence.

2.3 Heteroscedasticity test I conduct fitting by using least square method on the time sequence of logarithm return of grain price, to test whether it has heteroscedasticity, and the specific fitting result can be seen in Table 1.

From the output results in Table 2, we can obtain the following mean equation of grain price logarithm return:

$$y = 0.000\,367 - 0.009\,460 y_{t-1} + 0.027\,705 y_{t-2} + u_t \quad (4)$$

Where u_t is the estimation value of random error term.

Table 1 Fitting result of time series of logarithm return of grain price by using least square method

Variable	Coefficient value	*T* statistic	Probability
Constant	0.000 367	0.753 933	0.452 9
First-order-lag logarithm return of grain price y_{t-1}	−0.009 460	−0.262 110	0.593 8
Second-order-lag logarithm return of grain price y_{t-2}	0.027 705	2.014 300	0.047 0

Now we conduct conditional heteroscedasticity ARCHLM test on mean equation of grain price logarithm return(4), and the result shows that *F* statistic is 38.527 31, the corresponding probability of *F* statistic is 0, the probability of chi square test is also 0, *LM* statistic is 95.864 22, logarithm likelihood number is 463.804 3, AIC value is −4.409 770. The corresponding concomitant probability of *F* statistic and *LM* statistic is smaller than the significance level of 0.05, therefore, the residual quadratic series of mean equation of grain price logarithm return shows ARCH effect, namely GARCH effect.

2.4 GARCH model In order to more accurately measure out heteroscedasticity of them, I conduct GARCH model analysis on heteroscedasticity of the time sequence of logarithm return of grain price. As GARCH model can accurately describe and analyse, and dynamically delineate heteroscedasticity of return, I use GARCH(1.1) model in ARCH model to describe the time sequence.

2.4.1 Calculation of fluctuation rate of logarithm return of grain price in Guizhou Province on the basis of GARCH(1.1). The fitting result of GARCH(1.1) of time sequence of logarithm return of grain price in Guizhou Province can be seen in Table 2.

Table 2 GARCH(1.1) fitting result of time series of logarithm return of grain price in Guizhou Province

Variable	Coefficient value	*Z* statistic	Probability
Mean equation constant	0.000 853	2.164 513	0.031 9
First-order-lag logarithm return of grain price y_{t-1}	0.001 642	0.069 340	0.863 05
Second-order-lag logarithm return of grain price y_{t-2}	0.018 674	0.936 482	0.359 02
Variance equation constant	1.682 300	4.523 345	0
First-order-lag residual quadratic term μ_{t-1}^2	0.032 417	6.231 914	0
First-order-lag conditional variance term σ_{t-1}^2	0.836 280	233.458 700	0

From Table 2, we can get the mean equation and variance equation of the time sequence of grain price logarithm return.

Mean equation: $y_t = 0.000\,853 + 0.001\,642 y_{t-1} + 0.018\,674 y_{t-2} + \mu_t$ (5)

Variance equation: $\sigma_t = 1.682\,300 + 0.032\,417 \mu_{t-1}^2 + 0.836\,280 \sigma_{t-1}^2$ (6)

I conduct conditional variance ACHLM test on mean equation (5), and the result shows that F statistic is 0.136 235, the corresponding probability of F statistic is 0.872 817, the probability of chi square test is also 0.869 053, LM statistic is 0.680 703, logarithm likelihood number is 469.460 3, AIC value is −4.834 982.

At this time, the corresponding concomitant probability of ARCHLM test 0.872 817, therefore, the residual series of mean equation of grain price logarithm return shows no ARCH effect, indicating that using GARCH(1.1) model eliminates the conditional heteroskedasticity of residual series of fitting mean equation based on the least-squares method. In GARCH(1.1) model, the logarithm likelihood number is bigger than the fitting result of the least-squares method, and AIC value is relatively small as against the fitting result of the least-squares method, so GARCH model can better fit the data.

2.4.2 Estimation of *VAR*. In practical calculation, we often adopt the calculation through estimating the quantile fractile of cumulative density function of residual series experience. According to mean equation (5) of grain price return fitted by GARCH(1.1) model in the foregoing and variance equation (6), we substitute them into expression (1), we can get the calculation formula of *VAR* of the time sequence of grain price return as follows:

$$VAR = 0.000\,853 + 0.001\,642 y_{t-1} + 0.018\,674 y_{t-2} + \sigma_t \quad (7)$$

$$\sigma_t = 1.682\,300 + 0.032\,417 \mu_{t-1}^2 + 0.836\,280 \sigma_{t-1}^2 \quad (8)$$

We select 95% as the confidence level, and the corresponding quantile fractile is 1.645, then we can calculate out *VAR* at the confidence level of 95%. According to the calculation result, we get Fig. 2.

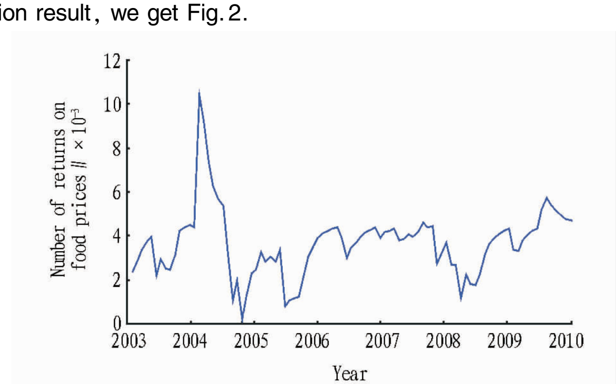

Fig. 2 *VAR* result of GARCH model of logarithm return of grain price at confidence level of 95% from 2003 to 2010

I use Kupiec likelihood ratio test method to conduct effectiveness test on the model, LR statistic follows distribution whose degree of freedom is 1. At confidence level of 95%, the critical value is 3.841. If LR statistic calculated at confidence level of 95% is bigger than 3.841, it rejects this model; if LR statistic calculated at confidence level of 95% is smaller than 3.841, it accepts this model. On the basis of the aforesaid estimation results of *VAR*, we get that $LR = 0.011\,8$, smaller than the critical value of 3.841, so it accepts this model. At confidence level of 95%, it has reliability in measuring *VAR* by using GARCH model.

3 Conclusion and suggestions

3.1 Conclusion First, the risk of the grain market price fluctuation in Guizhou Province is relatively high. When conducting the normality test on the logarithmic return time sequence of the grain price in Guizhou Province, it is found that the coefficient of peak is 19.576 0, and it's in leptokurtic distribution. The J-B statistic resulted from a J-B normality test is less than 5% of the level of significance. The logarithmic return time series of the grain price in Guizhou Province evidently differs from the normal distribution and the logarithmic return rate time sequence of the grain price in Guizhou Province clearly has the " leptokurtosis and fat-tail" phenomenon. Hence, the possibility of having extreme incidents in the grain market is much higher than that in the normal distribution. In order to reduce the influence resulted from excessive fluctuation of the grain price, the market supervisor and investor should not only do well in prediction, but also get prepared for taking emergency measures for extreme incidents.

Second, ever since the sharp rise in grain price in 1997, the value-at-risk of grain price in Guizhou Province became the extreme in April 2004, it was the final period for fighting against SARS. The drastic fluctuation of grain price in that period was due to the relevant economic policy formulated by the government), and then began to decline gradually. In January 2005, the value-at-risk fell into the lowest. It was a complete process of fluctuation in the period from January 2005 to November 2008. Starting from 2009, the value-at-risk of grain price in Guizhou Province appeared to move upwards continuously and tended to expand ceaselessly[5]. It is predicted that grain price in Guizhou Province will still be in high risk in 2011, which requires related enterprises and administrative departments in Guizhou Province to lay stress on the grain price problem, to actively pay attention to the fluctuation of grain price, and to get prepared for forecasting measures in advance to avoid the possible undesirable influence caused by drastic fluctuation of grain price.

3.2 Suggestions for stabilizing price of agricultural products

3.2.1 Strengthen the agricultural infrastructure construction and promote the agricultural overall production capacity. The key to basically stabilizing the price of agricultural products is to possess agricultural products with steady quantity and adequate supply. The government is required to strengthen the agricultural infrastructure construction, to invest more in the development of agricultural science and technology, and to steadily improve the quantity and quality of agricultural products. What's more, the government needs to scientifically guide farmers to adjust planting structure, to reasonably arrange the planting area and to maintain the balance between supply and demand.

3.2.2 Reinforce the market supervision on the circulation field of agricultural products and maintain market order. Efforts should be made to set up an agricultural product market which

(To page 22)

References

[1] Inner Mongolia Autonomous Region Bureau of Statistics. Inner Mongolia Statistical Yearbook: 2010[M]. Beijing: China Statistics Press, 2010. (in Chinese).
[2] Guangxi Zhuang Autonomous Region Bureau of Statistics. Guangxi Statistical Yearbook: 2010 [M]. Beijing: China Statistics Press, 2010. (in Chinese).
[3] Chongqing Municipal Bureau of Statistics. Chongqing Statistical Yearbook: 2010[M]. Beijing: China Statistics Press, 2010. (in Chinese).
[4] Sichuan Bureau of Statistics. Sichuan Statistical Yearbook: 2010 [M]. Beijing: China Statistics Press, 2010. (in Chinese).
[5] Guizhou Bureau of Statistics. Guizhou Statistical Yearbook: 2010 [M]. Beijing: China Statistics Press, 2010. (in Chinese).
[6] Yunnan Bureau of Statistics. Statistical Yearbook: 2010[M]. Beijing: China Statistics Press, 2010. (in Chinese).
[7] Tibet Autonomous Region Bureau of Statistics. Tibet Statistical Yearbook: 2010 [M]. Beijing: China Statistics Press, 2010. (in Chinese).
[8] Shaanxi Bureau of Statistics. Statistical Yearbook: 2010[M]. Beijing: China Statistics Press, 2010. (in Chinese).
[9] Gansu Bureau of Statistics. Statistical Yearbook: 2010[M]. Beijing: China Statistics Press, 2010. (in Chinese).
[10] Qinghai Bureau of Statistics. Statistical Yearbook: 2010[M]. Beijing: China Statistics Press, 2010. (in Chinese).
[11] Ningxia Bureau of Statistics. Statistical Yearbook: 2010[M]. Beijing: China Statistics Press, 2010. (in Chinese).
[12] Xinjiang Uygur Autonomous Region Bureau of Statistics. Xinjiang Uygur Autonomous Region Statistical Yearbook: 2010[M]. Beijing: China Statistics Press, 2010. (in Chinese).
[13] National Bureau of Statistics of China. China Statistical Yearbook: 2010[M]. Beijing: China Statistics Press, 2010. (in Chinese).
[14] National Bureau of Statistics of China. China Energy Statistical Yearbook: 2010[M]. Beijing: China Statistics Press, 2011. (in Chinese).
[15] ZHANG XZ, CAO MM. Calculation and analysis of ecological footprint of Xi'an City[J]. Bulletin of Soil and Water Conservation, 2005, 25(2): 92-96. (in Chinese).
[16] MA XY. The study of excess population based on the theory of ecological footprints[J]. Social Sciences in Guangdong, 2007(5): 189-194. (in Chinese).
[17] CHEN Y, MAO CB, CHENG L. A study on eco-optimum population in different parts of China using theory of ecological footprint [J]. Ecology and Environmental Sciences, 2009, 18(2): 560-566. (in Chinese).
[18] XIAO L, ZHAO XG, YANG BC. Ecological footprint and ecological safety of Weinan City of China[J]. Chinese Journal of Eco-Agriculture 2007, 15(6): 139-142. (in Chinese).
[19] YANG HL, NING FS, YOU X. Ecological footprints method for quantitative measurement of sustainable development of small town [J]. Journal of Chongqing Technology and Business University: Natural Science Edition, 2005, 22(3): 253-256. (in Chinese).
[20] SONG X, DU LP. Analysis of ecological footprint and relative carrying capacity of economic resources in desertified areas-a case in Kerqinzuoyihouqi County[J]. Journal of Henan Agricultural University 2005, 39(1): 51-56. (in Chinese).
[21] XU ZM, CHEN DJ, ZHANG ZQ, *et al*. Calculation and analysis on ecological footprints of China[J]. Acta Pedologica Sinica, 2002, 39 (3): 441-445. (in Chinese).
[22] WANG XQ, LU Q. Natural capital accounting with the ecological footprint concept in Gonghe County as a Desertification Area, Qinghai Province[J]. Scientia Silvae Sinicae, 2005, 41(3): 13-18. (in Chinese).

(From page 17)
is safe, orderly and with fair competition, to reduce the circulation links of agricultural products and the intermediaries' price advance, to decrease the cost for circulation and to cut off the channel and chain of the hot money speculation for agricultural products. We should rectify and regulate the market order, severely crack down on speculation such as hoarding, cornering and collusive pricing.

3.2.3 Improve regulation system of agricultural products and stabilize the price of agricultural products. In order to control excessive price hikes of agricultural products, it is necessary to soundly improve the price regulation system of agricultural products. Except for taking temporary price intervention measures for agricultural products in special circumstances, the government should shift the focus of price regulation of agricultural products to maintaining the price order of the market, to severely cracking down on speculation like hoarding, cornering and price gouging. When there is an abnormal fluctuation of market price of agricultural products, it is necessary to stabilize the market price by underselling agricultural products reservation and other measures, and to eventually make the price back to normal.

3.2.4 Strengthen mobility regulation and prevent a flood of speculative cash. As for the rise in agricultural products price caused by excess liquidity, it is suggested to change the current easy monetary policy into a prudent one. The PBC should not only regulate and control the money supply and bank rate, but also regulate the newly increased credit scale, and strengthen the liquidity management by making comprehensive use of various monetary policy tools. In the meanwhile, it should strengthen the private capital management, make more efforts to control and crack down international hot money and maintain a reasonable level of money in circulation. Through all the above monetary policy regulations, we could finally stabilize the agricultural product prices.

References

[1] ZHANG LJ. Analysis and forecast of grain price[J]. China Price, 2009(5): 21-23. (in Chinese).
[2] HE QZ. Research on risk of price fluctuations of international agricultural products[J]. Finance and Trade Research, 2010(3): 63-68. (in Chinese).
[3] CHENG SZ, WU HY. The VAR method and its application for finance market risk measurement[J]. Commercial Research, 2002 (22): 109-111. (in Chinese).
[4] GU L. Analysis of the volatility of Shanghai stock market based on the GARCH model[J]. Economic Research Guide, 2007(2): 81-83. (in Chinese).
[5] ZHU XF. International food prices in 2008 and the trend judgment of the trend of 2009[J]. Grain Science and Technology and Economy, 2009(3): 9-11. (in Chinese).