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Forecast on Price of Agricultural Futures in China Based on ARIMA Model

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Abstract The forecast on price of agricultural futures is studied in this paper. We use the ARIMA model to estimate the price trends of agricultural futures, which can help the investors to optimize their investing plans. The soybean future contracts are taken as an example to simulate the forecast based on the auto-regression coefficient (p), differential times (d) and moving average coefficient (q). The results show that ARIMA model is better to simulate and forecast the trend of closing prices of soybean futures contract, and it is applicable to forecasting the price of agricultural futures.

Key words Price of agricultural futures, ARIMA model, Short-term forecast of price

1 Introduction

The agricultural commodity trading is linked closely with the futures market. And forecasting agricultural futures price is conductive to agricultural production and adjustment of agricultural structure. Price forecasting holds great significance to economic activities. In all kinds of forecasting methods, the time series forecasting method admits the continuity of the development of things, and at the same time, it considers the random factors that affect the development of things to eliminate the effect of stochastic volatilities. Beyond that, it uses historical data for statistical analysis, and it has better performance and forecasting accuracy. Now, most researches focus on the volatility of futures' price and the factors that affect the price of futures. For instance, Pang and Liu (2013) used discrete wavelet transform and GARCH model to find out if futures market can reduce the volatility of agricultural price. The factors that affect the price of soybean futures are based on multiple regression model, published by Xiong and Sun (2004). In the field of price of futures forecasting, most studies use the exponential smoothing method. Nevertheless, few of them apply ARIMA model to price level of agricultural futures. China's soybean oil future went public on the Dalian Commodity Exchange on January 9, 2006. Soybean oil is widely used in various fields and industries such as food production and medical product making. Soybean oil future also has characteristics like large trading volume, large price volatility, high commercial rate and different delivery methods. Hence it is extremely influential and plays a significant role in economic activities. In this paper, the closing prices of soybean activity futures contracts between January 4, 2016 and August 24, 2016 are selected as the research samples. We select prices of soybean activity future contracts as the research object. ARIMA model is used to test if it is suitable for forecasting price level of agricultural futures. Furthermore, the correlation test of the residual error is presented. Then, the price of next 30 trading days is forecasted. Finally, we find ARIMA (28, 1, 25) model is better to simulate and forecast the trend of price level of agricultural futures.

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2 ARIMA model

2.1 Description of ARIMA model ARIMA (Autoregressive Integrated Moving Average) model is a well-known time series forecasting method proposed by Box and Jenkins in the early 1970s. It is also called Box-Jenkins model or Box-Jenkins method. There are variables in ARIMA (p, d, q), in which p is the order of the autoregressive model, d is the degree of differencing, and q is the order of the moving average model. P order autoregressive model is denoted by AR (p), and it satisfies the following equation:

$$u_t = c + \phi_1 u_{t-1} + \phi_2 u_{t-2} + \cdots + \phi_p u_{t-p} + \varepsilon_t, t = 1, 2, \cdots, T$$

where c is a constant; ϕ_1, $\phi_2 \cdots \phi_p$ are autoregressive model coefficients; ε is white noise series with a mean value of zero and a variance of σ^2.

Q order of the moving average model is denoted by MA (q), it satisfies the following equation:

$$u_t = \mu + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{t-q}, \ t = 1, 2, \cdots, T$$

where μ is a constant; θ_1, θ_2, $\cdots \theta_q$ are coefficients of the moving average model; ε_t is white noise series with a mean value of zero and a variance of σ^2.

Then AR model and MA model are mixed. It is often recorded as ARMA model. The equation is:

$$u_t = c + \phi_1 u_{t-1} + \cdots + \phi_p u_{t-p} + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{t-q}, \ t = 1, 2, \cdots, T$$

When $p = 0$, $ARMA$ (0, q) = MA (q); when $q = 0$, $ARMA$ (p, 0) = AR (p). For non-stationary time series, there is an initial differencing step that can be used to reduce the non-stationarity. The stationary time series that influence differential operation are called integration series. The definition is as follows. If y_t series after d times differencing becomes a stationary series, and it is not stationary in $d - 1$ times differencing, then the y_t series is *called d* order integration series. It written as $y_t \sim I(d)$. This d is the degree of differencing in ARIMA model.

2.2 Basic procedures of ARIMA model (i) The time series' variance, trend and seasonal variations are tested, and the stability of time series is identified. The scatter plot is used for the plot of autocorrelation function and partial autocorrelation function and ADF test. Generally, the time series of futures price data are not stationary sequences. (ii) For non-stationary time series of stationary processing, the time series needs to be differentiated. If time series of data is non-stationary, it has the trend of growth or decline until the values of the autocorrelation function and partial autocorrelation function are not significantly different from zero. (iii) According to rules of identifying time series, if the partial autocorrelation function of stationary sequence is censored and the autocorrelation function is tailing, AR model is more suitable for this time series. In addition, if the partial autocorrelation function of stationary sequence is tailing and the autocorrelation function is then censored, MA model is more suitable for this time series. But if both autocorrelation function and partial autocorrelation are tailing or both censored, ARIMA model is needed to be used. (iv) The ARIMA model parameter is estimated and it is used to test if it has statistical significance. (v) The hypothesis testing is used for residual sequence to determine whether the sequence is white noise. (vi) The model which has been tested is used for forecasting.

2.3 The coefficient determination

2.3.1 The degree of differencing (d). Set closing prices of soybean activity future contracts as u series, and generate sequence diagram of u. This diagram shows that the time series of closing prices has the obvious trend of rising (see Fig. 1). After 1 time differencing, u series become stationary series (see Fig. 2). Then, set this integration series as u_t. This result shows that the difference coefficient (d) is 1. In other words, $u_t \sim I(1)$.

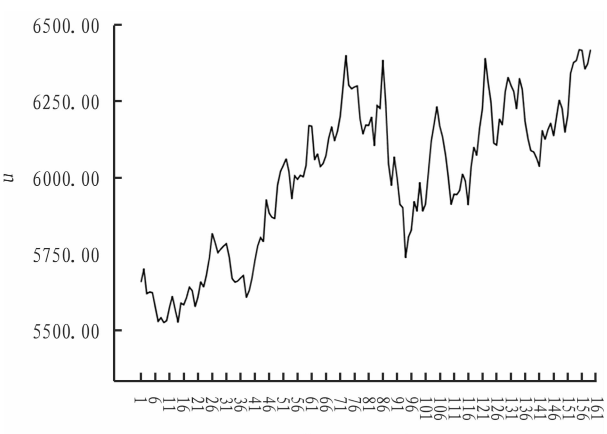

Fig. 1 Sequence diagram of *u*

2.3.2 Order of the autoregressive model (p). According to the calculation results of **2.3.1**, series is 1 order integration series. So, continue to calculate coefficient of partial autocorrelation faction of ut. Fig. 3 is drawn by the conclusion from Table 1. Fig. 3 shows the partial autocorrelation figure of ut series. In the autoregressive model, the 28th order is out of confidence interval. The coefficient is −0.187. So, the order of the autoregressive model is 28 ($p=28$).

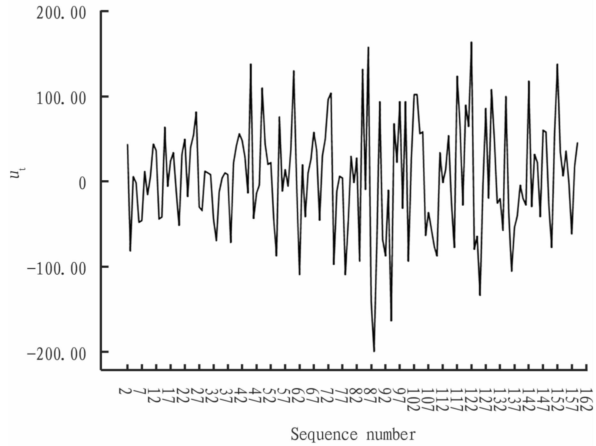

Fig. 2 Sequence diagram of u_t

Table 1 Partial autocorrelation of u_t Series: u_t

Lag	Partial Autocorrelation	Std. Error
1	0.051	0.080
2	−0.068	0.080
3	−0.115	0.080
4	0.035	0.080
5	−0.030	0.080
6	−0.033	0.080
7	−0.036	0.080
8	−0.107	0.080
9	−0.009	0.080
10	−0.037	0.080
11	−0.122	0.080
12	−0.054	0.080
13	0.105	0.080
14	−0.115	0.080
15	0.034	0.080
16	−0.041	0.080
17	−0.034	0.080
18	0.095	0.080
19	−0.080	0.080
20	−0.027	0.080
21	0.009	0.080
22	−0.134	0.080
23	−0.034	0.080
24	0.030	0.080
25	0.119	0.080
26	−0.023	0.080
27	0.065	0.080
28	−0.187	0.080
29	−0.045	0.080
30	0.089	0.080
31	0.083	0.080
32	0.100	0.080
33	−0.094	0.080
34	−0.029	0.080
35	−0.013	0.080
36	−0.042	0.080

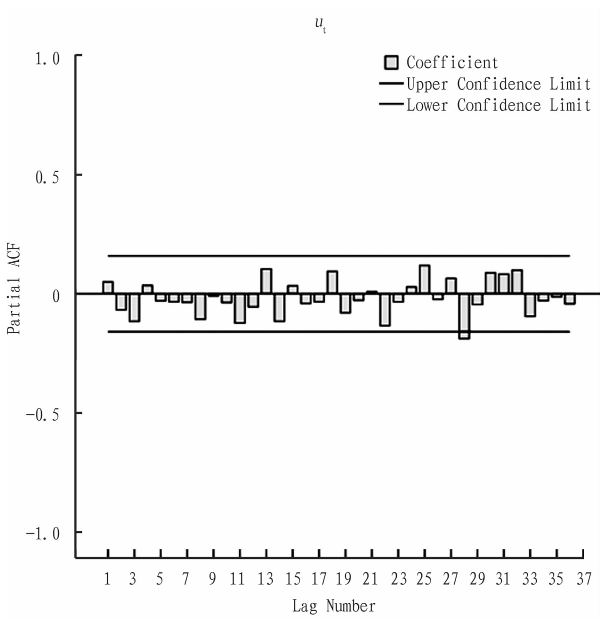

Fig. 3 Partial autocorrelation faction of u_t

2.3.3 Order of the moving average model (q). According to the calculation results of **2.3.1**, the autocorrelation coefficient of u_t is shown in Table 2. Fig. 4 is drawn by the conclusions from Table 2. Fig. 4 shows the autocorrelation figure of u_t series. From Fig. 4, in the moving average model, the 25th order is out of confidence interval. The coefficient is 0.154. Therefore the order of the moving average model is 25 ($q = 25$). The autocorrelation function is censored in the 25th order. The partial autocorrelation faction is censored in the 28th order, and ut series is 1 order integration series. Thus we establish ARIMA (28, 1, 25) model.

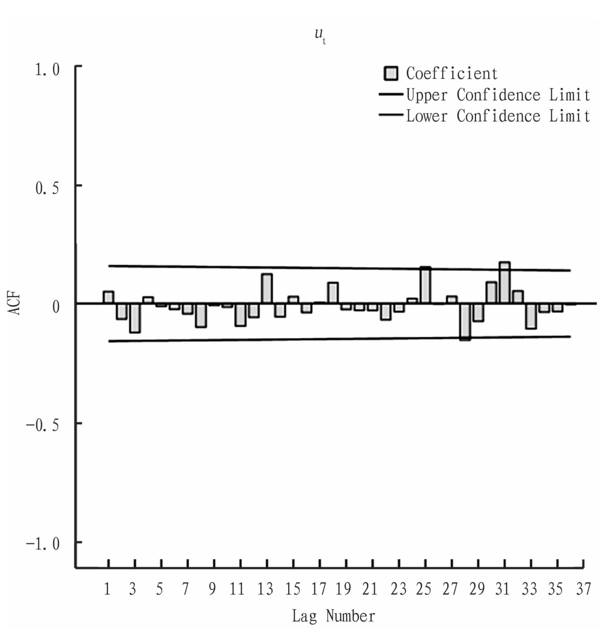

Fig. 4 The autocorrelation faction of u_t

2.4 Hypothesis test of residuals All lags of data in the confidence interval show that they are not obvious and not zero. From this conclusion, the residual of ARIMA (28, 1, 25) model of series has no serial correlation. This model passes the test, and it can be used in forecasting.

Table 2 Autocorrelation of u_t Series: u_t

Lag	Autocorrelation		Box-Ljung Statistic		
			Value	*df*	
1	0.051	0.079	0.414	1	0.520
2	-0.065	0.079	1.105	2	0.576
3	-0.121	0.078	3.506	3	0.320
4	0.027	0.078	3.628	4	0.459
5	-0.012	0.078	3.649	5	0.601
6	-0.024	0.078	3.749	6	0.711
7	-0.043	0.077	4.062	7	0.773
8	-0.099	0.077	5.713	8	0.679
9	-0.008	0.077	5.723	9	0.767
10	-0.015	0.077	5.761	10	0.835
11	-0.094	0.076	7.283	11	0.776
12	-0.058	0.076	7.865	12	0.796
13	0.124	0.076	10.549	13	0.649
14	-0.056	0.075	11.092	14	0.679
15	0.029	0.075	11.244	15	0.735
16	-0.038	0.075	11.498	16	0.778
17	0.005	0.075	11.503	17	0.829
18	0.088	0.074	12.909	18	0.797
19	-0.025	0.074	13.025	19	0.837
20	-0.028	0.074	13.173	20	0.870
21	-0.029	0.074	13.332	21	0.897
22	-0.068	0.073	14.198	22	0.894
23	-0.035	0.073	14.423	23	0.914
24	0.021	0.073	14.509	24	0.934
25	0.154	0.073	19.045	25	0.795
26	-0.002	0.072	19.046	26	0.834
27	0.030	0.072	19.221	27	0.862
28	-0.153	0.072	23.778	28	0.693
29	-0.075	0.071	24.869	29	0.685
30	0.090	0.071	26.479	30	0.650
31	0.174	0.071	32.495	31	0.393
32	0.053	0.071	33.049	32	0.416
33	-0.106	0.070	35.307	33	0.360
34	-0.036	0.070	35.569	34	0.394
35	-0.033	0.070	35.796	35	0.431
36	-0.004	0.069	35.799	36	0.478

Note: The underlying process assumed is independent (white noise) based on the asymptotic chi-square approximation.

3 Application and discussion

3.1 Accuracy test of forecasting This paper uses ARIMA (28, 1, 25) model to fit the closing prices of soybean activity future contracts from January 4, 2016 to August 24, 2016, and draws the comparative line chart (see Fig. 6). From Fig. 6, we can see that this model highly fits the closing price of soybean oil active futures contract. Table 3 shows that determinant coefficient R-squared is 0.950, explaining many data. The data that can not be explained is only 0.05. And the value of *MAE* and *MAPE* is 43.397 and 0.72, respectively. It shows that the model has few errors and good accuracy in application. Thus, ARIMA (28, 1, 25) model is feasible for short-term forecasting of futures.

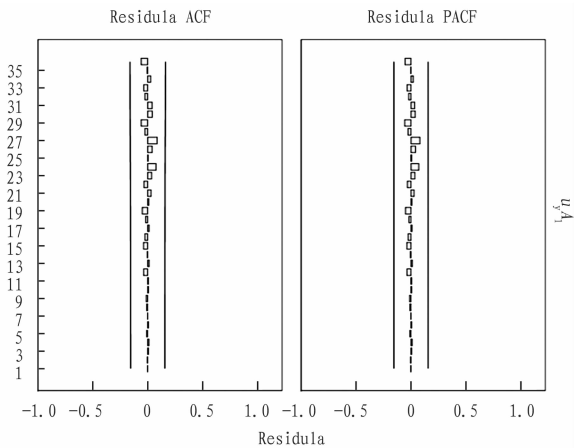

Fig. 5 Residual correlation of ARIMA (28, 1, 25) model series

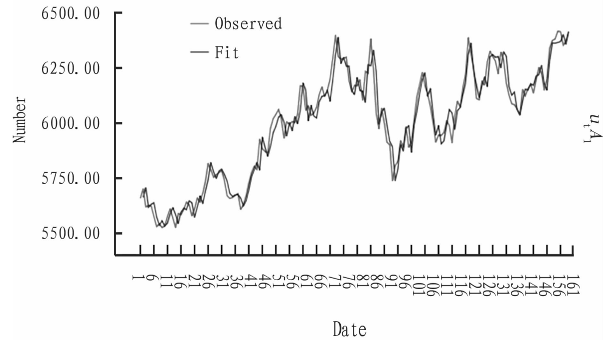

Fig. 6 The fitting value and observation value of u series

3.2 Forecasting of the price of futures We use the established ARIMA (28, 1, 25) model to forecast series in next 30 lags. The results are shown in Table 4. Fig. 6 and Table 4 are combined together (Fig. 7).

Table 3 Model fitting

Fit Statistic	Mean	Minimum	Maximum	Percentile						
				5	10	25	50	75	90	95
Stationary R-squared	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280
R-squared	0.950	0.950	0.950	0.950	0.950	0.950	0.950	0.950	0.950	0.950
RMSE	68.020	68.020	68.020	68.020	68.020	68.020	68.020	68.020	68.020	68.020
MAPE	0.721	0.721	0.721	0.721	0.721	0.721	0.721	0.721	0.721	0.721
Max APE	3.188	3.188	3.188	3.188	3.188	3.188	3.188	3.188	3.188	3.188
MAE	43.397	43.397	43.397	43.397	43.397	43.397	43.397	43.397	43.397	43.397
Max AE	192.680	192.680	192.680	192.680	192.680	192.680	192.680	192.680	192.680	192.680
Normalized BIC	10.170	10.170	10.170	10.170	10.170	10.170	10.170	10.170	10.170	10.170

Table 4 Forecast of the closing price of soybean oil active futures contract in next 30 trading days

Day	Number	Day	Number
1	6433.88	16	6439.57
2	6437.55	17	6447.62
3	6405.49	18	6493.77
4	6399.22	19	6510.70
5	6453.55	20	6515.62
6	6475.74	21	6486.55
7	6462.20	22	6447.56
8	6450.26	23	6436.94
9	6414.25	24	6449.87
10	6418.81	25	6471.53
11	6423.57	26	6481.34
12	6438.73	27	6485.80
13	6431.85	28	6457.22
14	6446.15	29	6450.63
15	6470.04	30	6506.34

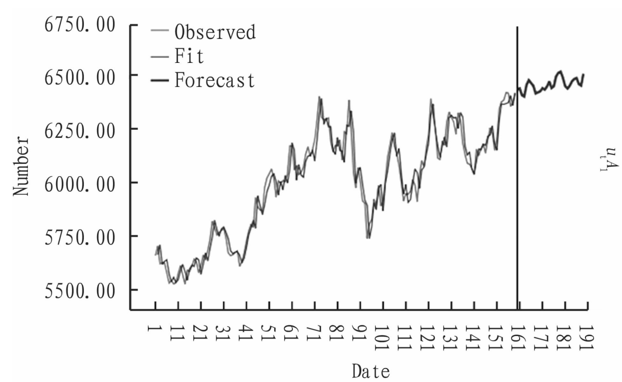

Fig. 7 Line chart of forecasting and historical data

4 Conclusions and discussions

The key to the forecast of the closing price of futures with ARIMA model is to use the historical closing price of futures of T period to speculate on the futures price of $T+1$ period. Now ARIMA model is widely used in a variety of areas for pricing prediction because of its excellent ability of short-term forecasting. Whether the time series is non-stationary or stationary, both can be predicted by ARIMA. In general, the most economic series are non-stationary series. If we use ARIMA model to predict, the effect of trend does not matter and can be ignored. However, ARIMA model also has its deficiencies, that is, ARIMA model can only be used in short-term prediction. With increase in time, the variance of data will increase, and the error of prediction will also increase. As a result, there will be a large deviation between the predictive value

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mountains, but they are all high-input, high-output technologies. Through the economic benefit analysis of integrated application for several years, it is found that simplified cultivation technology is an integrated technology suitable for the longan orchard in Maoming's hills and mountains, and the one-time investment is high, but it can produce long-term sustainable economic benefit and ecological benefit. In the context of increasingly scarce high-quality labor resources for agriculture, the industrial upgrading and transformation is a necessary way to break the obstacles to industrial development[17]. The simplified cultivation technology changes the traditional agricultural production model heavily dependent on chemical fertilizers, pesticides and cheap labor to the efficient agricultural production model with organic fertilizer as the basis and simplified technology as the support, and it is the agricultural technology and idea that should be fully promoted and used in the future.

References

[1] WANG Y,WU YB. Economic benefit analysis of several water-saving irrigation techniques [J]. Journal of Economics of Water Resources, 2002, 20(6):35 −40. (in Chinese).

[2] ZHENG J, ZHOU SF, WU DF. Economics benefit analysis of the crop under the condition of water saving irrigation [J]. Drainage and Irrigation Machinery, 2005, 23(3): 39 −41. (in Chinese).

[3] LI L, WANG JY, PENG LZ, *et al*. On the lightweight cultivation techniques of fruit trees [M]. Beijing: China Agriculture Press, 2011. (in Chinese).

[4] DENG ZQ, SHAO GS, HE GH. Practice and thought of shade control of Longan thick planting orchard in Maoming [J]. Fujian Fruits, 2008(4): 30 −33. (in Chinese).

[5] PAN XW, LI JG, LI R, *et al*. On the bounce back clip test of Longan Thick Planting Orchard [J]. South China Fruits, 2000, 29(2): 23 −24. (in Chinese).

[6] LI JG, YUAN PY, GUO DL, *et al*. On the crwon renovation mode of Longan Thick Planting Orchard [J]. China Tropical Agriculture, 2012 (6):52 −54. (in Chinese).

[7] HE YM. A technological and economic analysis and evaluation on Litchi and Longan [J]. South China Fruits, 2013,42(2):68 −72. (in Chinese).

[8] NI JZ, XU JM, XIE ZM, *et al*. Effects of different organic manure on biologically active organic fractions of soil [J]. Plant Nutrition and Fertilizer Science,2004(5):12 −16. (in Chinese).

[9] WANG LG, LI WJ, QIU JJ, *et al*. Effect of biological organic fertilizer on crops growth,soil fertility and yield [J]. Soils and Fertilizers Sciences in China,2001,7(4):374 −378. (in Chinese).

[10] ZHANG P, JIA ZK, LU WT, *et al*. Effects of organic fertilization on soil nutrient, enzyme activity and crop productivity in semi-arid areas of southern Ningxia [J]. Plant Nutrition and Fertilizer Science, 2011,17 (5):1172 −1130. (in Chinese).

[11] LIU M, WANG YH, GAO Y, *et al*. Analysis on the application amount of organic fertilizerof farmers and its influencing factors [J]. Statistics and Decision, 2009(12):61 −63. (in Chinese).

[12] XU E. On the experiment of high efficient water-saving irrigation technique of the integration of water and fertilizer in the garden [J]. China Fruit and Vegetable, 2011(4):34 −37. (in Chinese).

[13] ZANG XP, MA WH, ZHOU ZX, *et al*. Technological rules of water fertilization mixture drip irrigation for banana cultivation [J]. Guangdong Agricultural Sciences, 2012, 39(14): 68 −70. (in Chinese).

[14] DENG LS, TU PF, ZHANG CL, *et al*. Application model of fertigation technology in hilly region [J]. Guangdong Agricultural Sciences, 2012, 39(9): 67 −69. (in Chinese).

[15] WANG FG, ZHANG DW, LIN CL, *et al*. Analysis on the construction of mechanical spraying pipe facilities in hillside orchard and its efficiency [J]. South China Fruits, 2005, 34(5): 73 −74. (in Chinese).

[16] LU YH, ZHANG DW, LIN CL, *et al*. Analysis of construction of piping chemical spray facilities and its return with plums orchard in mountainous region [J]. Northern Fruits, 2005(1):19 −20. (in Chinese).

[17] SHAO GS, WANG ZK, LIANG HW, *et al*. Practice and thinking on simplified efficient cultivation [J]. China Tropical Agriculture, 2010 (6):23 −27. (in Chinese).

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and the observed value. ARIMA model can not adjust uncertainty factors in the economic environment like good news in the market, market reaction to the news and the expectation of investors. Therefore, this model can only be used in short-term prediction, and it does not have good performance in long-term forecasting. In summary, although ARIMA model has shortcomings, it will acquire the precision data when it is used in short-term forecasting. This model provides an important method to predict price level of agricultural futures, and it will be of great significance to improving agricultural futures. This model can be used for the following aspects. First, it helps consumers to purchase agricultural products at lower price. This can reduce the non-necessary cost. The second one is that this model can show the arbitrage opportunities. Last but not least, it helps the investors who invest in futures market to receive the expected returns on investment, and it can make investors bear less loss in crisis or recession.

References

[1] XUE W. SPSS statistical analysis method and application [M]. Beijing: Publishing House of Electronics Industry, 2004: 402 −474.

[2] NARENDRA B, PALLAVIRAM S. Partitioning and interpolation based hybrid ARIMA − ANN model for time series forecasting[J]. Sadhana, 2016, 41(7): 695 −706.

[3] XU LP, LUO MZ. Short term analysis and prediction of gold price according to ARIMA model [J]. Finance & Economics, 2011(1): 26 − 34.

[4] ERNESTA G, EGLE B. Short − term wind speed forecasting using ARIMA model [J]. Energetika, 2016, 62(1/2): 45 −55.

[5] PANG ZY, LIU L. If futures market can reduce the volatility of agricultural price by Discrete wavelet transform and GARCH model[J]. Journal of Financial Research, 2013 (11): 130 −143.

[6] LIU F, WANG RJ, LI CX. Application of ARIMA model in forecasting agricultural product price [J]. Computer Engineering and Applications, 2009, 45(25): 238 −239.

[7] CHI QS. Analysis of the growth trend of China's oil consumption base on ARIMA model [J]. Resources Science, 2007, 29(5): 69 −73.

[8] XIONG Y, SUN YD. The factors that affect the price of soybean futures in China [J]. Journal of South − Central University, 2004, 23(2): 100 −102.