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Risk Analysis of Pork Market Price in China based on ARIMA Model

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Abstract

Since 2019, pork prices have remained high. Affected by the new coronavirus epidemic, pork prices in various regions have fluctuated to varying degrees. ARIMA model is widely used in analyzing stationary random sequence and non-stationary random sequence, and has high prediction accuracy. In this paper, ARIMA model will be used to analyze the pork price in the wholesale market of Shanghai Agricultural Products Center at the beginning of 2020, and ARIMA (4,1,5) model is established. Through the white noise test of residuals, it is concluded that this model is suitable and has high fitting degree.

Keywords

ARIMA Model; Time Series; Pork Price.

1. Introduction

The sudden change of pork price in 2019 has a great impact on the development of pig industry and the level of residents ' consumption. The price of pork has been at a high level since the rise. In 2020, affected by the new coronavirus epidemic, more unstable factors have been brought to the pork price in China. Therefore, it is of practical significance to analyze the pork price fluctuation model. Based on the pork price in the wholesale market of Shanghai Agricultural Products Center in early 2020, this paper establishes an ARIMA model and obtains a better fitting model, which provides a reference for predicting the fluctuation of pork price.

Box-Jenkins method is a set of time series, prediction and control methods proposed by American scholar GPBox and British scholar GMJenkins in the 1970 s, also known as the traditional time series modeling method. Box-Jenkins method is widely used in various fields. It belongs to the regression analysis method and is the basic method of time series analysis and prediction, also known as the ARIMA (Autoregressive Integrated Moving Average) model. ARIMA belongs to the linear model and can describe the stationary random series and non-stationary random series. In this section, AR, MA, ARMA, ARIMA models and the extended ARFIMA model are introduced in turn, and realized with R language.

2. Arima Model

ARIMA model (Autoregressive Integrated Moving Average model) is all known as the differential autoregressive moving average model. This model is a set of methods about time series, prediction and control proposed by American scholar GPBox and British scholar GMJenkins in the 1970s. Therefore, it is also known as the Box-Jenkins method, which is a more effective model to predict the development trend of time series and is widely used in various fields. ARIMA belongs to linear model, which can describe stationary random sequence and non-stationary random sequence.

ARIMA modeling method is to transform the existing time series into a stable time series by difference processing, and then the lag term and random error of the variable are regressed by ARMA model. So we construct the model:

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$$\Phi(L)\nabla^d x_t = \Theta(L)\varepsilon_t$$

Where x_t denotes the time series, ∇^d denotes the difference of the sequence, ε_t is Gaussian white noise, $E(\varepsilon_t) = 0, Var(\varepsilon_t) = \sigma^2$, otherwise for any s ≠ t.

$$\Phi(L) = 1 - \varphi_1 L - \varphi_2 L^2 - \varphi_3 L^3 - \cdots - \varphi_p L^p$$
$$\Theta(L) = 1 - \theta_1 L - \theta_2 L^2 - \theta_3 L^3 - \cdots - \theta_q L^q$$

For the known data is ($x_1, x_2, \ldots, x_t$), the parameters to be estimated are $p, d, q, \varphi_i (i = 1,2, \ldots, p)$, $\theta_j (j = 1,2, \ldots, q)$. If $y_t = \nabla^d x_t$, the ARIMA(p, d, q) model is transformed into ARMA(p, q) model.

In general, we require that y _ t be a stationary non-white noise sequence. For any t and t – s, if the time series satisfies:

$$E(y_t) = E(y_{t-s}) = \mu$$
$$\text{var}(y_t) = \text{var}(y_{t-s}) = \sigma_y^2$$
$$\text{cov}(y_t, y_{t-s}) = \text{var}(y_{t-j}, y_{t-j-s}) = \gamma_s$$

Where $\mu, \sigma_y^2, \gamma_s$ are constants, then y_t is stationary.

Secondly, we need to test whether y _ t is white noise. Box-pierce uses sample autocorrelation function to construct Q statistic :

$$\text{Q} = \text{T}\sum_{k=1}^{s} r_k^2$$

where r_k is the sample autocorrelation coefficient

$$r_k = \frac{\sum_{t=s+1}^{T}(y_t - \bar{y})(y_{t-s} - \bar{y})}{\sum_{t=1}^{T}(y_t - \bar{y})^2}$$

Under the assumption that all r_k values are zero, Q approximately obeys the χ^2 distribution with degree of freedom s. Ljung-Box proposes a better modified Q statistic for small samples:

$$\text{Q} = \text{T}(\text{T} + 2)\sum_{k=1}^{s} r_k^2 /(\text{T} - k)$$

If the calculated Q value is greater than the critical value in the χ^2 distribution table, we reject the assumption that there is no obvious autocorrelation coefficient, that is, at least one autocorrelation function is not zero, and then ARMA model can be used to model.

3. Empirical Analysis

The trend chart of pork prices in Shanghai Agricultural Products Center wholesale market in the first half of 2020 is as follows:

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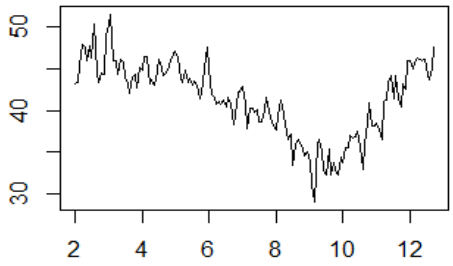

Figure 1. Pork price trend chart of Shanghai Agricultural Products Center wholesale market

It is not difficult to see that there is no small fluctuation in pork prices. After a brief correction, pork quickly returns to a higher price. Therefore, the difference of time series is carried out and the stability test is carried out by ADF. Table 1 shows the results of ADF test.

Table 1. ADF test table

difference order	DF	p
0	-0.0319	0.6706
1	-10.4187	<0.01

As we expected, the original time series is non-stationary time series, and the stationary sequence is obtained by first-order difference.

Use Ljung-Box to test whether the difference sequence is white noise. Q statistic results as table 2:

Table 2. Difference Sequence Q Statistics

Symbol	Q value	P value
Q(4)	14.085	0.00703
Q(8)	21.395	0.006168
Q(16)	27.695	0.03438

It is not difficult to see that the difference sequence is stationary non-white noise sequence, so ARMA(p,q)model is used to fit. We preliminarily determine the autoregressive order p and the average moving order q by analyzing ACF and PACF. ACF and PACF of differential sequences are shown in Figure 2:

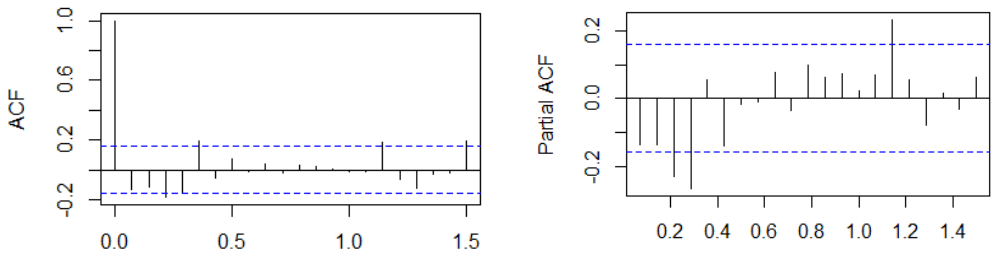

Figure 2. Difference sequences ACF (left) and PACF (right)

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The possible candidate models of the sequence are ARMA (4, 5), ARMA (4, 6), ARMA (5, 5) and ARMA (5, 6). We fit the above models and calculate the AIC and Log Likelihood of each model. The results are as follows:

Table 3. Comparison of ARMA (p, q) Model Results

Model	Log Likelihood	AIC
ARMA (4,5)	-288.38	598.76
ARMA (4,6)	-287.84	599.67
ARMA (5,5)	-286.56	597.12
ARMA (5,6)	-287.42	600.85

The above table shows that ARMA (4,5) is the most suitable model under the AIC criterion. In order to further verify the model, we test the residuals of the model by Ljung-Box white noise test. The results are as follows:

Table 4. Model residual Q statistic

Symbol	Q value	P value
Q(8)	0.45159	0.9999
Q(16)	5.5238	0.9925
Q(32)	23.613	0.8581

From table 4, we can conclude that the model residual is a white noise, so the ARMA (4,5) model fits well with the sequence after first order difference. So far we get a better description of Shanghai Agricultural Products Center wholesale market pork price trend model that ARIMA (4,1,5) model, its parameters as shown in table 5.

Table 5. Parameter table of ARIMA (4,1,5) model

Term	Symbol	Value
constant term	c	0.0210
	φ_1	0.1669
	φ_2	0.4895
AR parameter	φ_3	-0.0164
	φ_4	-0.1202
	θ_1	-0.4556
	θ_2	-0.6781
MA parameter	θ_3	-0.0265
	θ_4	0.1218
	θ_5	0.3715

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4. Conclusion

ARIMA model has broad application prospects in various fields, especially in the economic field. Appropriate models can have important reference value for understanding economic trends and predicting economic development. In the context of the new coronavirus epidemic, this paper explores the trend of pork prices in the wholesale market of Shanghai Agricultural Products Center in the first half of 2020. After the first-order difference stabilization, ARIMA (4, 1, 5) is established by using the AIC quasi-selection model and parameter estimation. The residuals of the model are tested by white noise, and a model with high fitting degree is obtained, which provides an effective model for people to understand the trend of pork prices under the epidemic.

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