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Forecasting the Prices of Indian Natural Rubber using ARIMA Model

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ABSTRACT

In this paper, an attempt is made to forecast the prices of natural rubber in India by using monthly data for the period from January 1980 to December 2016. ARIMA (4, 1, 4) model was found best by identification, parameter estimation, diagnostic checking and validation. So, forecasting of prices was attempted for six months i.e., January 2017 to December 2017. Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), Root Mean Square Error (RMSE) were used as the selection criteria to determine the best forecasting model. The forecasting method for prices of natural rubber in India, as shown in this paper, can be a very useful tool for the farmers to decide upon their production.

Key words: *Natural rubber, ARIMA, forecasting.*

INTRODUCTION

Natural rubber (NR) is the major plantation crop in India, also in Kerala. Every year, the price fluctuations in NR were increasing. Since farmers have made a huge investment in the initial period, switching to other crops in the middle of the economic life of their plantation would involve huge losses. So, price forecasting helps the farmers to decide upon their production by the expected prices. This results in the requirement for statistical techniques to provide accurate and timely price forecast by taking into account the local information to the farmers, traders and policymakers so that they may make production, marketing and policy decisions well in advance.

For forecasting the prices, Auto Regressive Integrated Moving Average (ARIMA) models are extensively used[2] to study market fluctuations. The main advantage of this class is that model lies in its ability to quantify random variations present in any economic time series[1]. Hence, the data on prices of domestic NR were subjected to ARIMA analysis to quantify the variation and also to predict the future prices of NR.

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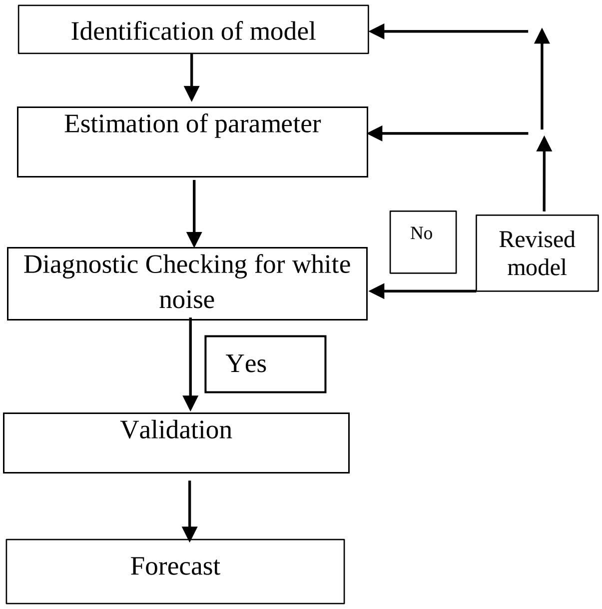
MATERIAL AND METHODS

The time series data on monthly price of NR collected from Rubber Board from the year 1980-2016. An ARIMA model developed by Box and Jenkins[2] was employed for analysis of the data. There are different steps for ARIMA procedure as follows:



RESULTS

The foremost step in the process of modelling is to check the stationarity of the series because if the variables are non-stationary, there is every possibility of misleading results. Augumented Dickey Fuller (ADF) test was conducted to check the stationarity of the data. Table 1 gives the results of Zero difference and First difference of the prices. Null hypothesis i.e., presence of unit root was rejected resulting stationarity for first difference. For further steps to dealt, ARIMA model considers first differences, as they were stationary. Menon *et al.*[6], also obtained stationarity by ADF test for forecasting the monthly prices of cardamom.

One or more models were tentatively chosen that seem to provide statistically adequate representations of the available data. Different ARIMA models like ARIMA (1,1,0), ARIMA (2,1,2), ARIMA (3,1,4) and ARIMA(4,1,4) have been tried for estimating best model for analysis. One way to accomplish this is through the analysis of residuals. It has been found that it is effective to measure the overall adequacy of the chosen model by examining a quantity Q known as Box-Pierce or Ljung-Box statistic. For model to be adequate, p-value associated with Q statistics should be large (p-value> α)[1]. Out of above models, ARIMA (4,1,4) was found to be proved best by the diagnostic checking like ljung-box Q statistic, Akaike information criterion and Bayesian information criterion (Table 2). Ljung box Q statistic revealed that errors are not white noise in the obtained model. AIC and BIC values were also less in the selected model because lesser values indicates the best model. A similar result was obtained by Adanacioglu and Yercan[1] regarding diagnostic checking in his study for forecasting the monthly prices of tomato. Thus, ARIMA (4,1,4) model for domestic rubber is

$$(1-\phi_1B-\phi_2B^2-\phi_3B^3-\phi_4B^4)\ (1-B)\ y_t = (1-\theta_1B-\theta_2B^2-\theta_3B^3-\theta_4B^4)\ \varepsilon_t$$

$$(1.0.37B-0.25\ B^2-0.47\ B^3-0.63\ B^4)\ y_t = (1-0.65B-0.14\ B^2-0.53\ B^3-0.84\ B^4)\ \varepsilon_t$$

Parameter estimates for ARIMA (4,1,4) were significant (Table 3). Model fit statistics of ARIMA (4,1,4) (Table 4) concluded that 94% of the variation in the data explained by the past values. RMSE, MAE and MAPE indicated that model chosen was fit. By residual ACF and PACF plots (Fig 1), it was clearly evident that majority of the spikes in ACF and PACF plots were within the critical values indicating that there was no serial dependencies. This proves additionally, the adequacy of ARIMA (4, 1,4) model for domestic rubber.

The validation period was taken for 6 months. The forecasts were generated for the validation period i.e., from July 2016 to December 2016, where all the observations are within the limits (upper and lower limits) shown in the table 5 and given in the figure 1. From the table, it was observed that the actual values were within the confidence limits of the expected values. By this, it can be proved that the model assumed ARIMA (4,1,4) was realistic. Manasa[5] arrived at similar conclusion regarding validation of ARIMA modeling in her study on the pigeon pea price. As predicted prices in the validation period held good, forecasting was taken into consideration for next 6 months i.e., January 2017 to July 2017 (Table 6 and figure 2). The prices were expected to be high i.e., 14345.6 per 100 kg in the month of March and low i.e., 13844.32 per 100 kg in the month of June. Vinayak and Patil[7] also tried a similar forecasting process to predict the onion prices in Hubli market, Karnataka.

Table 1: ADF test for domestic rubber prices

	ADF test statistic	Probability
Zero difference	-0.06	0.66
First difference	-3.48	0.00

Table 2: Diagnostic checking for model parameters of domestic rubber

Diagnostic checking				
Models	BIC	AIC	Ljungbox Q-statistic	p-value for Q-statistic
ARIMA(1,1,0)	6816.838	6804.557	31.50	0.00
ARIMA(2,1,2)	6833.491	6808.930	30.85	0.00
ARIMA(3,1,4)	6832.115	6795.273	22.58	0.00
ARIMA(4,1,4)	6814.727	6773.792	7.56	0.11

Table 3: Parameter estimates of ARIMA (4,1,4) model for domestic rubber

Parameters	Coefficient	Z	p-value
Non-seasonal difference	1		
phi_1	0.37	5.40	0.00**
phi_2	0.25	3.47	0.00**
phi_3	0.47	5.20	0.00**
phi_4	0.63	9.61	0.00**
theta_1	0.65	11.09	0.00**
theta_2	0.14	2.18	0.00**
theta_3	0.53	6.63	0.00**
theta_4	0.84	14	0.00**

** indicates significance at 5 per cent level.

Table 4: Model fit statistics of ARIMA (4,1,4) model for domestic rubber

Model fit Statistics				
ARIMA(4,1,4)	R2	RMSE	MAE	MAPE
	0.94	493.75	276.73	4.3229

Table 5: Validation test for the model ARIMA (4,1,4) from 2016 July to 2016 December

Year and Month	Actual values (per 100 kg)	Predicted values (per 100 kg)	difference	95% limit
2016:07	14177	13525.66	651.34	12567.15-14484.16
2016:08	13850	13348.05	501.95	11796.5-14899.57
2016:09	12142	13047.11	-905.11	11070.81-15023.41
2016:10	11692	12930.35	-1238.3	10536.57-15324.14
2016:11	12214	13959.98	-1745.9	10195.46-1572.50
2016:12	13370	13277.09	92.91	10199.36-16254.83

Table 6: Forecast values using ARIMA (4,1,4) from 2017 January to 2017 June

Year/month	Predicted value (per 100 kg)	Standard error	95% Confidence limit
2017:01	13891.59	493.73	12923.88 - 14859.29
2017:02	14186.69	803.56	12611.73 - 15761.66
2017:03	14345.6	1024.63	12337.39 - 16353.81
2017:04	14271.89	1240.90	11839.76 - 16704.03
2017:05	13935.64	1432.82	11127.35 - 16743.93
2017:06	13844.32	1568.09	10770.92 - 16917.73

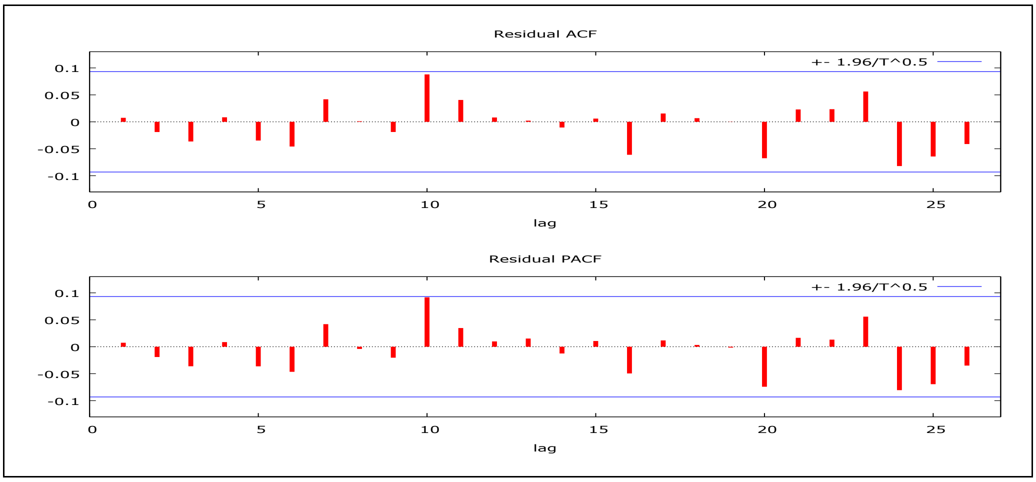


Fig. 1: Residual Correlogram showing the evidence of stationarity for ARIMA (4,1,4) model for domestic rubber prices

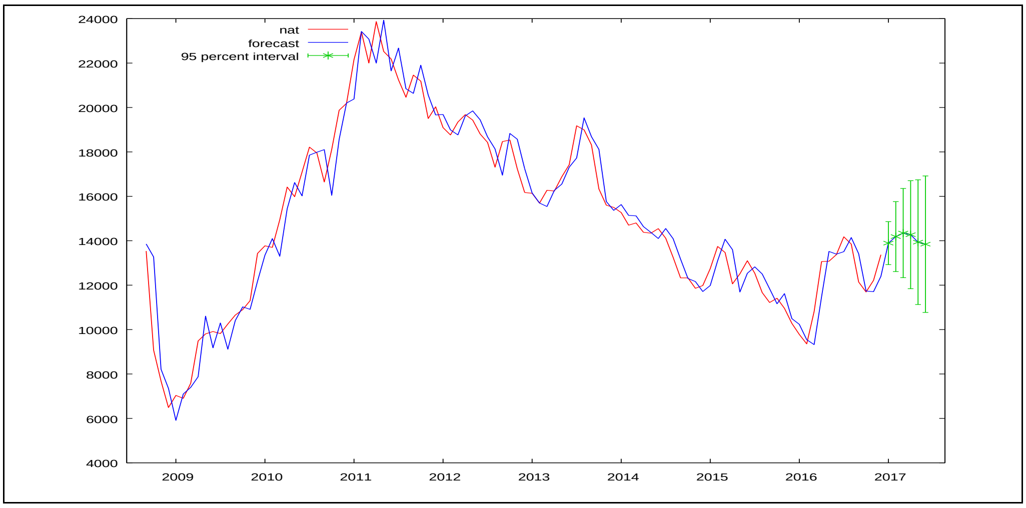


Fig. 2: Graph showing the forecast of domestic rubber by using ARIMA (4,1,4) model

CONCLUSION

Due to globalization and market integration, there is a huge price fluctuation where farmers cannot decide upon their farming practices. So, there is an increased need for price information at all levels of decision making. Time series model like ARIMA is vastly used for this purpose of model building and forecasting. ARIMA (4,1,4) was found to be best model to predict the future rubber prices by attaining the stationarity in the data and also by diagnostic checking.

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