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Forecasting of Tomato Wholesale Price Using Auto Regressive Integrated Moving Average (ARIMA) Model in Chittoor, Andhra Pradesh

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ABSTRACT

Price forecasting is more sensitive and difficult in vegetable crops due to their seasonality. In addition, to improve domestic market potential for producers, who are the biggest suppliers in the market and in line with Government Agricultural sector. Prices forecasting is vegetables essential. This paper attempted to predict the Tomato wholesale prices of Chittoor district by using ARIMA models using a period of 67 months (January 2010-July 2015) secondary data. The best model has been selected based on the maximum R^2 and minimum Bayesian Information Criterion (BIC) values. It has been found that ARIMA (2, 0, 7) Model the best as the coefficient of determination is 0.79 and Maximum Absolute Percentage (MAPE) is 24.19%. It was observed that the Tomato prices an highest in the month of August and lowest in the month of November every year.

Key words : ARIMA, Prediction model, Time series, Tomato prices.

Time series is the collection of observations made sequentially over time and methods of analyzing this data of time series constitute an important area of statistics (Chatfield, C., 2005). Vegetable prices play a major role in crops domestic prices and annual growth of the country. Hence, modeling of their prices will be useful to producers, consumers, processors rural development planners and other people involved in the vegetable market. Dieng, A., (2008) investigates the performance of parametric models in forecasting selected vegetable prices in Senegal and makes recommendations to potential users.

Generally, vegetables are seasonal commodity and there is a lead time between the demand and supply. The harvesting judgments are based on knowledge and experience rather than market demand. This is due to the lack of accepted forecasting model. Due to these conditions farmers are force to sell the Vegetables to the consolidators at a very low price. This is more so in the developing countries especially in India where around 98% of the vegetables are sold in local markets. Therefore, there exists a need to forecast the demand of vegetables in the wholesale market to avoid wastage of vegetables and to increase the profits of the entire stake holders.

MATERIALS AND METHODS

Data was taken from the website of Agricultural Marketing Information Network-AGMARKET (http://www.agmarket.nic.in), Government of India. In Chittoor market, Tomato is one of the leading crop. The ARIMA model was applied on the data for a period of 67 months (Jan 2010 to July 2016). The majority of time series data normally used forecasting models like linear and non linear growth models.

But, in this study Box-Jenkins's methodology was used to fit ARIMA models to identify the significant parameters using Box-Jenken's methodology. The ARIMA (p d q) model is churn of Auto Regressive (AR) and Moving Average (MA) models shows that there is relation between observed value and expected value and residuals respectively. To identify the best ARIMA models and their residual analysis MAPE criteria was used. For evaluating the adequacy of AR, MA and ARIMA models, various measures like R^2, Stationary R^2 , Root Mean Square Error (RMSE) and Bayesian Information Criterion (BIC) were used. SPSS 20.0 version was used for the study to identify best model and to forecast the Tomato prices.

Table 1. Model of fit statistics.

Model of fit statistics (Tomato wholesale prices data)	
Stationary R-squared	0.8417
R-squared	0.7929**
Mean Absolute Percentage Error (MAPE) (%)	24.1875
Normalized BIC	12.0843
Ljung-Box Q-Statistics	15.2374

Note: ** Significant at 0.01 levels

Table 2. ARIMA (2, 0, 7) Model parameters – Tomato wholesale.

ARIMA Model Parameters (After log transformations)

	Estimate	Standard Error	(SE)t-value
Constant	6.4636	0.0337	191.7850**
AR1	1.0476	0.0710	14.6340**
AR2	-0.7988	0.0727	10.9860**
MA7	0.6720	0.1023	6.5680**

Note: ** Significant at 0.01 levels

The forecasted model was Y_t = 6.4636+1.0476 Y_{t-1} -0.79882 Y_{t-2} - 0.67203 ϵ_{t-7}

Table3. Forecasted Tomato wholesale prices obtained from ARIMA (2, 0, 7) model.

Months	Predicted (Tomato Wholesale price)
Aug-15	1069.78
Sep-15	724.63
Oct-15	578.17
Nov-15	521.92
Dec-15	596.16
Jan-16	752.79
Feb-16	606.01
Mar-16	591.12
Apr-16	687.82
May-16	820.85

The general form of ARIMA (p d q) model is

$$\mathbf{Yt} = \theta_1 \mathbf{Y_{t-1}} + \theta_2 \mathbf{Y_{t-2}} + \ldots \theta_p \mathbf{Y_{t-p}} - \emptyset_1 \epsilon_{t-1} - \emptyset_2 \epsilon_{t-2} \ldots \emptyset_q \epsilon_{t-q} + \epsilon_t$$

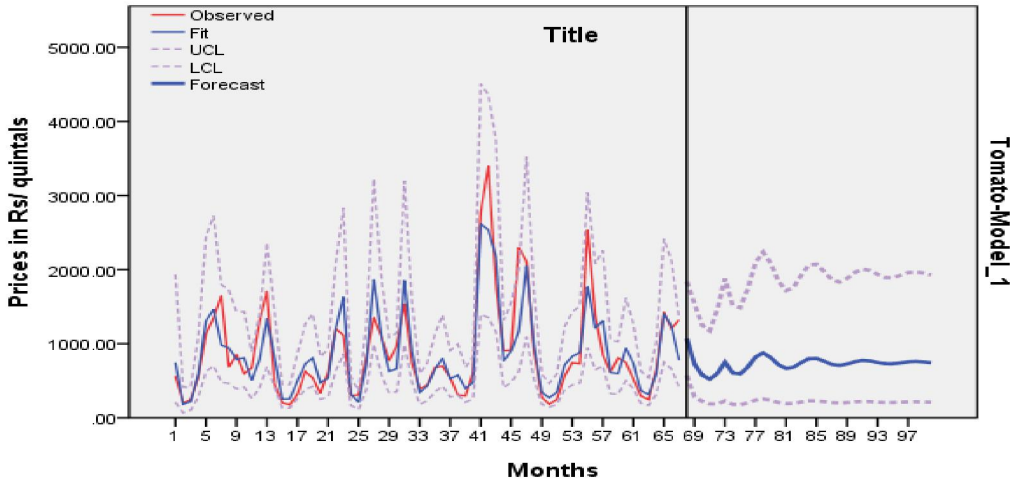
Diagnosis of the model

This model is diagnosed using the Ljung-Box Q statistics to check overall adequacy of the model. The Q statistics is

$$\mathbf{Q_n} = \mathbf{nr(nr+2)} \sum_{l=1}^{n} \frac{\mathbf{r1^2\,(e)}}{\mathbf{nr-l}},$$ where r1 (e) is the residual autocorrelation at lag l

nr is the number of residuals, n is the number of time lags includes in the test. For model accuracy, P-value associated with Q statistics should be large (p-value>α).

Figure 1. Trend values of Tomato wholesale prices (actual and forecasted) obtained from ARIMA model (2, 0, 7).



RESULTS AND DISCUSSION

Different time series models were fitted on Tomato wholesale prices of Chittoor District and the best model was identified by using R^2, MAPE, Normalized BIC criterion. The ARIMA (2, 0, 7) was identified as the best suited model based on criterion. Based on the selected model the wholesale tomato prices were forecasted up to August 2016.

The forecasting Tomato wholesale prices are presented in table: 2. the residual, actual and predicted data shows the consistency and the same were observed moving the same trend.

The model parameters of the ARIMA (2, 0, 7) shows that wholesale prices in the last two months period is highly influencing the wholesale prices of current period. It can be inferred that, the wholesale prices in the past periods affects the tomato demand in the current period, which is due to the lack of proper storage facilities and market information.

From the table: 3 it was observed that the prices of Tomato during the month August 2015 Rs 1069 which is highest during the year. Very lower speculations can be observed in Tomato wholesale prices i.e. between the months of September, 2015 to May2016. These forecasting models are very useful for farmers as well as market people for deciding the upcoming tomato prices. The accuracy of the proposed model is judged based on the MAPE value. The outcome of the tomato wholesale prices forecasting demand of accuracy is 24.19%. It is statistically highly significant at 0.01 levels. The R-squared value is 0.79; it means 79% of variation can be explained by the independent parameters.

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