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An Empirical Study on Forecasting Potato Prices in Tamil Nadu

D. Murugananthi[1], K.M. Shivakumar[2] and A.Rohini[3]

ABSTRACT: *The present study aimed at predicting the price of potato to be prevailed in Tamil Nadu during December, 2015to January, 2016.The time series data on 23 years of potato prices prevailed in Nilgiris Co-operative Marketing Society (NCMS), Mettupalayam, a major market for potato in Tamil Nadu were analyzed. Seasonal index on potato price revealed that potato farmers will get above annual average price during the month of May to December and below the annual average price in January to April. Auto Regressive Integrated Moving Average model (ARIMA) was used to predict the price of potato in Tamil Nadu. Model selection was based on Minimum Absolute Percentage Error (MAPE) criterion. ARIMA (110) was selected as the best fit model. The results revealed that farm gate prices of good quality potato would be around Rs. 19 to Rs. 21 per kg in December' 2015–January' 2016. The farmers are recommended to take sowing decisions accordingly.*

Keywords: *time series forecasting- commodity prices- market intelligence*

INTRODUCTION

India ranks second position in potato production after China at the world level. Fresh potatoes are exported to Sri Lanka, UAE, Mauritius, Nepal, Singapore, Maldives and Kuwait etc. India exports less quantity of potato, since the domestic demand is much more and the world prices are not competitive for Indian potatoes.

India produced 449 lakhs tonnes of potato from an area of 20.60 lakh hectares in 2014-15, which was Eight percent higher in production and Four percent in cultivated area when compared to 2013-14. Uttar Pradesh, Gujarat, Madhya Pradesh, Punjab, West Bengal, Assam and Bihar accounted for 85 per cent share in total area and 90 percent of the total production in 2014-15 in India. In the current year, potato cultivation area in Gujarat has increased as replacement to wheat crop. India has exported about 12.56 lakh tonnes of potato in 2014-2015, which is 47 per cent higher compared to last year.

In Tamil Nadu, the area under potato was 5000 hectares and production was 1.27 lakh tonnes in 2014-15, which was Five per cent higher in area and Nine percent increase in production compared with the year 2013-14. Potato grown in the Nilgiris fetches higher prices due to longer shelf-life without refrigeration compared to those grown in other states. In Tamil Nadu, potato is grown in the hilly regions of Dindigul, Nilgiris, Krishnagiri and Erode districts.

Domestic and Export Market Intelligence Cell (DEMIC) functioning in the Directorate of Centre for Agricultural and Rural Development Studies, Tamil Nadu Agricultural University, Coimbatore has more than a decadal experience in generating commodity price forecasts and market advisories and disseminating the same to millions of farmers well in time so that they can take well informed decisions in sowing/selling/storing of the major agricultural and horticultural crops. The dissemination of the market intelligence advisory is done through mass, print, electronic and social media.

Potato is sown in the months of September and October and harvested in December and January.

[1] Assistant Professor(ARM), Department of Social Sciences, Agricultural College and Research Institute, Killikulam. *E-mail : murugananthi@gmail.com*

[2] Associate Professor (Agrl.Economics), Department of Agricultural Economics, Centre for Agricultural and Rural Development Studies, Tamil Nadu Agricultural University, Coimbatore. *E-mail : shivanomics@gmail.com*

[3] Assistant Professor (ARM), Department of Agricultural and Rural Management, Centre for Agricultural and Rural Development Studies, Tamil Nadu Agricultural University, Coimbatore.

There are two major varieties, viz., KufriJyoti, and Jalandhar grown in Nilgiri district. Potatoes arriving from other States like Gujarat, Karnataka and Uttar Pradesh are stored in cold storages mainly for seed purpose.

METHODOLOGY

The time series data were collected from NCMS, Mettupalyam for the period of January, 2000-November, 2015. The analytical tools used for price forecasting were seasonal indices and Auto Regressive Integrated Moving Average model (ARIMA) model.

ESTIMATION OF SEASONAL INDICES OF MONTHLY DATA

Construction of Seasonal Index

Seasonal Index of a period indicates how much this period typically deviates from the annual average. The base or denominator for the index is generally the average for the time period being examined (365 days, 52 weeks or 12 months). Each time period's price is expressed as a percentage of the season's average and will have a value equal to, greater than or less than 100. Most indices of this type use a base value of 100 percent. This method dampens the variability that may occur from combining data from years with high annual prices with periods of low annual prices, because what it focuses on is the relative movement of prices within the season (Jadhav *et al.*, 2013). This result is supported by Kumar *et al.* (2012), who developed seasonal indices in price and arrivals of wheat in major markets of Karnataka.

Auto Regressive Integrated Moving Average Model (ARIMA)

A brief description of Auto Regressive Integrated Moving Average (ARIMA) processes are given in the following sections as described by Gujarati (2003). Price forecast models based on Auto Regressive Integrated Moving Average (ARIMA) model are applied for a wide range of contexts. The popularity of ARIMA model is due to its statistical properties as well as use of well-known Box-Jenkins methodology in the model building process (Jha and Sinha, 2013).

The ARIMA is an extrapolation method, which requires historical time series data of underlying variable. The methodology refers to the set of procedures for identifying, fitting, and checking ARIMA models with time series data.

In an Auto-Regressive Integrated Moving Average (ARIMA) model, time series variable is assumed to be a linear function of the previous actual values and random shocks. In general, an ARIMA model is characterized by the notation ARIMA (p, d, q), where p, d and q denote orders of Auto-Regression (AR), Integration (differencing) and Moving Average (MA), respectively.

A p^th^-order Auto-Regressive model: AR(p), which has the general form:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \alpha_3 y_{t-3} ...... + \alpha_p y_{t-p} + \varepsilon_t \quad ...1$$

y_t = potato price at time t

$y_{t-1}, y_{t-2}, y_{t-3} .... y_{t-p}$ = Potato price at time lags $t-1, t-2, ..., t-p$, respectively

$\alpha_0, \alpha_1, \alpha_2, ..., \alpha_p$ = coefficients to be estimated,

ε_t = Error term at time t

A q^th^-order Moving Average model: MA(q), which has the general form:

$$y_t = \mu + \varepsilon_t - \varphi_1 \varepsilon_{t-1} - \varphi_2 \varepsilon_{t-2} - ..... - \varphi_q \varepsilon_{t-q} \quad ...2$$

y_t = potato price at time t

μ = constant mean

$\phi_1, \phi_2, ..., \phi_q$ = Coefficients to be estimated

ε_t = Error term at time t

$\varepsilon_{t-1}, \varepsilon_{t-2}, ... \varepsilon_{t-q}$ = Errors in previous time periods that are incorporated in Y_t.

Auto Regressive Moving Average Model: ARMA(p,q), which has general form:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \alpha_3 y_{t-3} ...... + \alpha_p y_{t-p} + \varepsilon$$
$$-\varphi_1 \varepsilon_{t-1} - \varphi_2 \varepsilon_{t-2} - ... - \varphi_q \varepsilon_{t-q}$$

y_t = Potato price at time t

$\alpha_0, \alpha_1, \alpha_2, ... \alpha_p, \phi_1, \phi_2 ... \phi_q$ = Coefficients to be estimated

ε_t = Error term at time t

$\varepsilon_{t-1}, \varepsilon_{t-2}, ... \varepsilon_{t-q}$ = Errors in previous time periods that are incorporated in Y_t.

The first step in the process of ARIMA modeling is to identify the model using Auto Correlation Functions (ACFs) and Partial Auto Correlation Functions (PACFs) to achieve stationary and tentatively identify patterns and model components. A series is regarded stationary if its statistical characteristics such as the mean and the autocorrelation structures are constant over time. Determine whether the series is stationary or not by considering the graph of ACF. If a graph of ACF of the time series values either cuts off fairly quickly or dies down fairly quickly, then the time series values should be considered stationary. If the original series is stationary, $d = 0$ and the ARIMA models reduce to the ARMA models. However, many economic time series are non-stationary, that is, they are integrated. If a time series is integrated with an order of 1, it implies that the first difference of the price is effective and it is denoted as $I(0)$. This implies that mean and covariance have attained stationarity. In general, if a time series integrated as $I(d)$, after differencing it d times we obtain a stationary $I(0)$ series. If a price series is non-stationary it is differentiated'd' times to make it stationary using ARIMA (p, d, q) model. The stochastic trend of the series is removed by differencing, multiple ARMA models are chosen on the basis of Auto-Correlation Function (ACF) and Partial Auto-Correlation Function (PACF) that closely fit the data.

The second step involves determining the coefficients and estimation is through maximum likelihood approach such that the overall measure of errors is minimized or the likelihood function is maximized. The third step involves diagnostics checking using ACFs and PACFs of residuals to verify whether the model is valid. In this step, model must be checked for adequacy by considering the properties of the residuals whether the residuals from an ARIMA model must has the normal distribution and should be random. Otherwise, the procedures are repeated for identification, estimation and diagnostics. The most suitable ARIMA model is selected using the smallest Akaike Information Criterion (AIC) or Schwarz-Bayesian Criterion (SBC) value and root mean square error and lowest Mean Absolute Percentage Error (MAPE) criterion.The MAPE calculates the forecast error as a percentage of actual value. MAPE is used as relative measure to compare forecasts for the same seriesacross different models.

The MAPE is calculated using the following formula

$$\text{MAPE} = \frac{\sum_{t=1}^{n} \left| \frac{y_t - \hat{y}_t}{y_t} \right|}{n} * 100$$

y_t = Actual value at time t

$\hat{y}_t$ = Predicted value at time t

n = Number of observations

The procedure for these tests is drawn from Makridokis and Wheelright (1978). The final step is forecasting simple statistics and confidence intervals to determine the validity of the forecast and track model performance to detect out of control situation. In this study, all estimations and forecasting of ARIMA model have been done using SPSS 16.

RESULTS AND DISCUSSION

Seasonal Index for Potato Price in Tamil Nadu

The seasonal index for potato price in Tamil Nadu was calculated and the results are discussed in the following paragraph.

The graph depicted that during the months of February, potato price ruled below 23 per cent than the annual average price. During the harvest months, potato price remained low when compared to annual average price which was clear from the seasonal indices during the months of February to April. During summer months, the index was at peak when compared to any other months. From the seasonal index values, producers and processors could make out their farm management decisions.

Results of ARIMA Model

The first step in building ARIMA model is the identification stage. This identification is done through plotting the autocorrelation values. Autocorrelations are numerical values that indicate how a data series is related to itself over time. These measures are most often evaluated through graphical

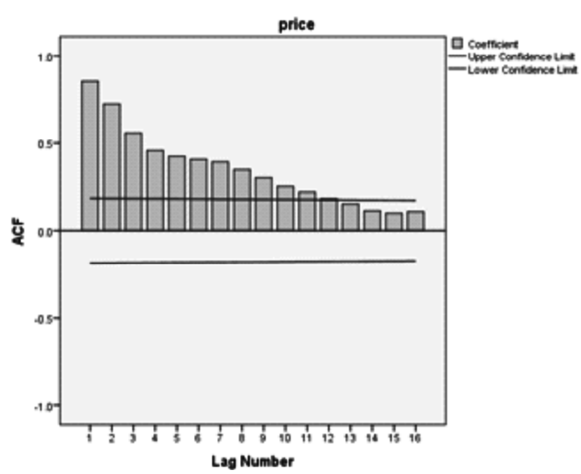

Figure 1(a): Auto Correlation Plot of Potato Price Series

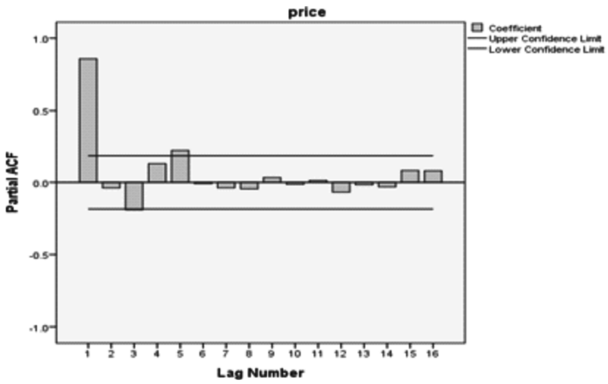

Figure 1(b): Partial Auto Correlation plot of potato price series

plots called "correlograms". A correlogram plots the auto-correlation values for a given series at different lags. This is referred to as the "autocorrelation function" and is very important in the ARIMA method.

If a graph of ACF of the time series values either cuts off fairly quickly or dies down fairly quickly, then the time series values should be considered stationary. In our graph since the values are not dies down quickly it could be considered for non stationrity of the series. Hence, differencing could be done to make the series stationary. The above graph on auto correlation plot of potato price series also showed an exponential decline with first two or many lags significant. The partial auto correlation plot indicated a single significant positive peak at lag 1. Both the pattern confirmed that the presence of AR(1) component.

Auto Correlation and Partial Auto Correlation Plot of Residuals of selected ARIMA (110) model

The ACF and PACF of the selected ARIMA (110) model is presented below in Figure 2.

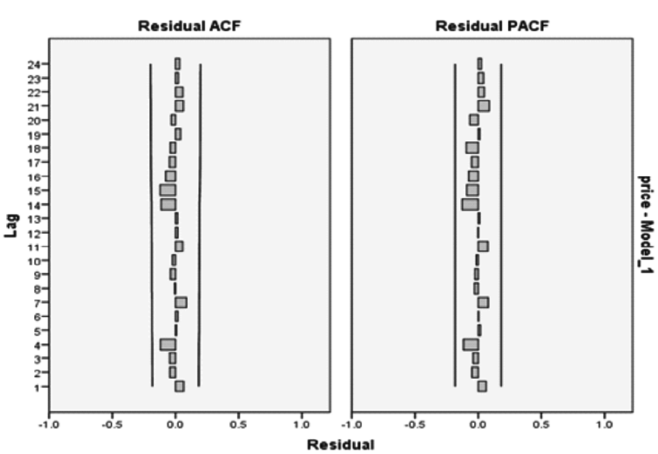

Figure 2

From the figure 2, it could be inferred that the residuals are white noise and adhering to OLS principles and hence, the fitted model is valid and used for generating short term forecasts.

Forecasted Price Using Different Models

The forecasted price for potato (Rs./kg) under various ARIMA model are analyzed and presented in Table 1.

Table 1
Forecasted price of Potato (Rs./kg)

ARIMA Model	*December, 2015*	*January, 2016*
100	21.13	21.38
110	19.87	20.91
111	20.00	20.11
101	17.49	15.71
011	19.78	15.02

Accuracy Performance Measures of Forecast

The mean absolute percentage error was calculated across the model. The results are presented in the below Table 2.

Table 2
MAPE under various ARIMA models

Model	*MAPE*
100	17.49
110	16.30
111	16.68
101	17.55
011	17.88

From the Table, it could be inferred that the model with the lowest MAPE is ARIMA (110) whereas other models showed a higher MAPE value. Hence for forecasting potato prices, ARIMA (110) is selected.

CONCLUSION

Based on the lowest MAPE value, ARIMA(110) model is chosen for forecasting potato price in Tamil Nadu. price for potato in December, 2015 and January, 2016. The forecasted price for per kg of potato is Rs. 19-21. The resultsare disseminated to the commodity chain participants to take appropriate farm business management decisions according to this market advisory. The prevailing spot market price for potato also confirmed this trend and supported by the likely fall in the prices of potato in the North Indian states.

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