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Forecasting of Common Paddy Prices in India

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Abstract

Paddy is an important food crop in India and second most in the world. About 35% of net cropped area under paddy and about 50% of the farmers cultivate paddy every year. Farmer's decision making on acreage under paddy depends on the future prices to be realized during harvest period. Hence this paper presents a methodology to forecast prices during harvest period and applied the method to forecast for the *kharif* 2017-18. The time series data on monthly average prices of paddy from January, 2006 to December, 2016 collected from AGMARK was used. ARIMA (Box-Jenkins) model was employed to predict the future prices of paddy. Model parameters were estimated using the R programming software. The performance of fitted model was examined by computing various measures of goodness of fit *viz.*, AIC, BIC and MAPE. The ARIMA model was the most representative model for the price forecast of paddy in overall India. In *kharif* season the paddy is harvested during September – November. The forecast shows that market prices of paddy, would be ruling in the range of Rs. 1,600 – 2,200 per quintal in *kharif* harvesting season, 2017-18.

Keywords: ACF, ARIMA, Box and Jenkins, Forecasting, Moving Average and PACF *etc.*

Introduction

Paddy is one of the most important food crops of India and is second in importance throughout the world. It feeds more than 50 per cent of the world's population. It is the staple food of most of the people in South-East Asia. Asia accounts for about 90 per cent of the world's paddy cultivation and production (Rani *et al.*, 2014). Among the paddy growing countries, India has the largest area under cultivation, though in terms of volume of output, it is second to China. Productivity in India is much lower than in Egypt, Japan, China, Vietnam, USA and Indonesia and even below the world's average (Reddy, 2007; Reddy, 2015). It makes up 42 per cent of India's total food grain production and 45 per cent of the total cereal produced in the country. Each part of the plant has various uses. It is also used in medicine. Paddy bran oil is used for its medicinal properties and is also used as cooking oil. Paddy becomes rice after the removal of husk by threshing. Therefore, rice is a part of paddy.

In India, rice is the most preferred staple food for about 65 per cent of the population. It continues to play a vital role in the country's exports constituting nearly 25 per cent of the total agricultural exports from the country. One-third of the world's paddy cultivation area, is in India. It is grown in almost all the states of India but is mostly concentrated in the river valleys, deltas and low-lying coastal areas of north eastern and southern India. The paddy producing states are Assam, West Bengal, Punjab, Bihar, Madhya Pradesh, Orissa, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Maharashtra, Gujarat, Uttar Pradesh and Jammu and Kashmir, which together contribute over 95 per cent of the country's crop. As a result of very good rainfall during monsoon 2016 and various policy initiatives taken by the government, the country has witnessed record food grain production in the current year. As per the forth advance estimates for 2016-17, the total production of Rice is estimated at record 110.15 million tonnes which is also a new record. Production of rice has increased significantly by 4.74 million tonnes (4.54%) than the production of 104.41 million tonnes during 2015-16.

Being a major paddy producing country in world, present study is aimed to forecast the prices of paddy of major producing states of India. As the prices of paddy keep changing from time to time, it creates risks to producers, traders and consumers involved in production, marketing and consumption of paddy. Thus, it is important to forecast the paddy prices. Paddy is grown in both summer and winter seasons. But much of the paddy output comes from the *kharif* crop, sowing of which normally begins with the onset of the Southwest Monsoon. The government fixed the minimum support price (MSP) of paddy at Rs. 1,550 for 2017-18.

This paper applies Autoregressive Integrated Moving Average (ARIMA) forecasting model, the most popular and widely used forecasting model for time series data. Applying ARIMA model Hossain *et al.*, (2006) forecasted three different varieties of pulse prices namely motor, mash and mung in Bangladesh with monthly data from Jan 1998 to Dec 2000; Wankhede *et al*., (2010) forecasted pigeon pea production in India with annual data from 1950-1951 to 2007-2008; Mandal (2005) forecasted sugarcane production in India; Iqbal *et al.*, (2005) forecasted area and production of wheat in Pakistan; Khin *et al.*, (2008) forecasted natural rubber price in world market; Shukla and Jharkharia (2011) forecasted wholesale vegetable market in Ahmedabad; Darekar *et al*., (2015) forecasted onion prices in Lasalgaon and Pimpalgaon market; Assis *et al*., (2010) forecasted cocoa bean prices in Malaysia along with other competing models; Nochai and Nochai (2006) forecasted palm oil prices in Thailand; Masuda and Goldsmith (2009) forecasted world Soybean productions; Cooray (2006) forecasted Sri Lanka's monthly total production of tea and paddy beyond Sept 1988 using monthly data from January 1988 to September 2004. Burark and Sharma (2012) confirmed the suitability of Box-Jenkins univariate ARIMA models in agricultural price forecasting. Paul and as (2010) have attempted forecasting of inland fish production in India by using ARIMA approach.

Methodology and Data:

Data collection

The monthly average price data of paddy for 11 years (from January, 2006 to December, 2016) for Punjab, West Bengal, Uttar Pradesh, Andhra Pradesh and Tamil Nadu has been used for forecasting the prices. As per availability the time series data related to monthly average prices of paddy was collected from AGMARKNET website. Using the data paddy prices were forecasted for harvesting months.

The ARIMA model analyzes and forecasts equally spaced univariate time series data. An ARIMA model predicts a value in a response time series as a linear combination of its own past values. The ARIMA approach was first popularized by Box and Jenkins (1976), and ARIMA models are often referred to as Box-Jenkins models. In this study, the analysis performed by ARIMA is divided into four stages.

Identification Stage: The stationary check of time series data was performed, which revealed that the paddy prices were nonstationary. The nonstationary time series data were made stationary by first order differencing and best fit ARIMA models were developed using the data from January 2006 to December 2016 and used to forecast the prices during harvesting season. Candidate ARIMA models were identified by finding the initial values for the orders of non-seasonal parameters "p"and "q." They were obtained by looking for significant spikes in autocorrelation and partial autocorrelation functions. At the identification stage, one or more models were tentatively chosen which seem to provide statistically adequate representations of the available data. Then precise estimates of parameters of the model were obtained by least squares.

Estimation Stage: ARIMA models are fitted and accuracy of the model was tested on the basis of diagnostics statistics.

Diagnostic Checking: The best model was selected based on the following diagnostics.

(i) Low Akaike Information Criteria (AIC): AIC is estimated by AIC = $(-2\log L + 2m)$, where $m = p + q$ and L is the likelihood function.

(i) Low Bayesian Information Criteria (BIC): Sometimes, Bayesian Information Criteria (BIC) is also used and estimated by BIC = $\log \sigma 2 + (m \log n)/n$.

(ii) The Mean Absolute Percent Error (MAPE) was used as a measure of accuracy of the models

Forecasting Stage: Future values of the time series are forecasted. R programming software was used for time series analysis and developing ARIMA models and forecasting paddy prices. These methods have also been useful in many types of situations which involve the building of models for discrete time series and dynamic systems. (Granger and Newbold 1970). Originally ARIMA models have been studied extensively by George Box and Gwilym Jenkins during 1968 and their names have frequently been used synonymously with general ARIMA process applied to time series analysis, forecasting and control.

Ansari and Ahamed (2001) applied ARIMA modeling for time series analysis of world tea prices and industrialized countries export prices. Prawin Arya *et.al* (2005) applied Box-Jenkins Approach for Forecasting Copra Wholesale Price Series. Nochai and Titida (2006) used ARIMA model for forecasting oil palm prices. Punitha (2007) used ARIMA model to forecast the arrivals and prices of maize and ground nut in Hubli and Devangere markets in Karnataka state. Moghaddsi and Bita (2008) applied econometric model for wheat price forecasting in Iran. Rabbani *et.al.* (2009) forecasted wheat prices in Bangladesh. Shankar & Prabhakaran (2012) used the ARIMA model for forecasting the milk production in Tamil Nadu. Chaudhari & Tingre (2013) found that ARIMA (1,1,0) was the best fitted model for forecasting of milk production in India.

Results and Discussion

1. Identification

Identification of the model was concerned with deciding the appropriate values of (p,d,q) (P,D,Q). It was done by observing Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) values. The Auto Correlation Function helps in choosing the appropriate values for ordering of moving average terms (MA) and Partial Auto-Correlation Function for those autoregressive terms (AR). The ACF and PACF suggest that there is no significant correlation to be captured by an ARMA model (Figure 1).

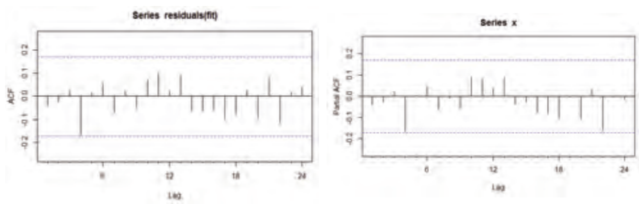

Figure 1:Autocorrelation function (ACF) and Partial autocorrelation function (PACF) of residuals of fitted ARIMA

2. Estimating the parameters

The number of non-zero coefficients in ACF determines order of MA terms and the number of non-zero coefficients in PACF plots determines order of AR terms. Based on the Akaike Information Coefficient (AIC) and Bayesian Information Criteria (BIC), the model ARIMA (1,1,1)(0,0,2), ARIMA (0,1,0), ARIMA (1,1,1)(0,0,1), ARIMA (2,1,1) ARIMA (0,1,0)(0,0,2) ARIMA (0, 1, 0) (0, 0, 2) model was the best fitted model for Punjab, West Bengal, Uttar Pradesh, Andhra Pradesh, Tamil Nadu and India respectively. The results of these coefficients are given in Table 1. ARIMA model was estimated after transforming the variables under study into stationary series through computation of either seasonal or non-seasonal or both, order of differencing. A careful examination of ACF and PACF up to 24 lags revealed the presence of seasonality in the data. However, the series was found to be stationary, since the coefficient dropped to zero after the second lag.

Table 1. Residual analysis of monthly prices of paddy in selected states

Sr. No.	State	ARIMA Model	MAPE	AIC	BIC
1	Punjab	(1,1,1) (0,0,2)	2.12	2019.72	2034.09
2	West Bengal	(0,1,0)	2.77	1365.60	1371.35
3	Uttar Pradesh	(1,1,1) (0,0,1)	5.99	1619.54	1631.04
4	Andhra Pradesh	(2,1,1)	3.86	1471.40	1485.78
5	Tamil Nadu	(0,1,0) (0,0,2)	6.14	1578.90	1587.53
6	India	(0,1,0) (0,0,2)	4.17	1489.66	1498.29

3. Diagnostic checking

Preceding 11 years (2006 - 2016) monthly prices data used for this model. Various methods and literature are studied to judge the appropriate model, the best model has been selected based on the MAPE, minimum AIC and BIC. It has been found that ARIMA (1,1,1)(0,0,2), (0,1,0), (1,1,1)(0,0,1), (2,1,1), (0,1,0)(0,0,2) and (0, 1, 0) (0, 0, 2) model is the best fit for the paddy price data of Punjab, West Bengal, Uttar Pradesh, Andhra Pradesh, Tamil Nadu and India respectively (Table:1).

4. Forecasting

The results of forecast of prices of paddy are shown in the Table 2. The forecasts indicate that there are narrow variations in between the actual and forecasted values of prices of paddy in the selected states and the forecasted values of prices showed an increasing trend in the future months. In *Kharif* season the paddy crop is harvested during September – November. Forecast shows that market prices of paddy, would be ruling in the range of Rs. 1,600 – 2,200 per quintal in *kharif* harvesting season, 2017-18. This forecast is based on past data and model and that actual market price may not turn out to be the same as forecasted. The prices of paddy in the market during harvesting period would be high in Punjab, Uttar Pradesh and Tamil Nadu *i.e.* Rs. 2,000, 1,700 and 1,700 per q respectively. The prices would be low *i.e.* Rs. 1,600 per q in West Bengal and Andhra Pradesh respectively (Table:2). Forecast for the seasonally adjusted paddy prices by using best fit ARIMA model in R programing software shown in Figure 2.

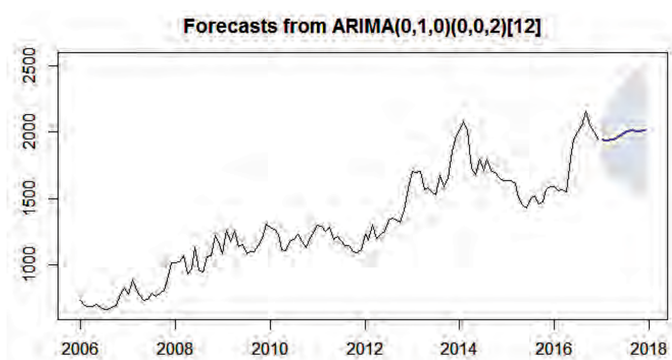

Figure 2: Forecast for the seasonally adjusted paddy prices in India

Table 2. Projected prices for paddy in major producing states during *kharif* harvesting season 2017-18 (Rs./q)

Sr. No.	State	Lower Limit	Mid-point	Upper Limit
1	Punjab	1,200	2,000	2,400
2	West Bengal	1,200	1,600	1,800
3	Uttar Pradesh	1,500	1,700	1,900
4	Andhra Pradesh	1,200	1,600	1,800
5	Tamil Nadu	1,200	1,700	2,000
6	India	**1,600**	**1,800**	**2,200**

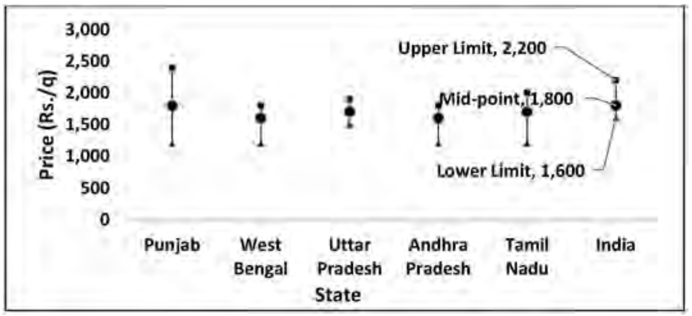

Figure 3. Forecasted paddy prices in India

Forecasted prices of paddy by using ARIMA (0,1,0) (0,0,2) model in India is shown in Figure 3. Thus, from foregoing discussion, it is clearly noted that, such forecasting of future paddy prices can help the farmers to decide the area allocation for paddy in next season and marketing. Besides this, the farmers can also take the decision of marketing of stored paddy immediately or after some months.

Conclusion

The paper forecasted paddy prices for the *kharif* 2017-18 by using historical monthly prices. The paper used ARIMA model to forecast prices. Just like any other method, this technique also does not guarantee perfect forecasts. Nevertheless the model is handy have been successfully used for forecasting in the future. Similar model was used by Almemaychu Amera (2002), Punitha (2007), Darekar *et al.*, (2016) and Jalikatti & Patil (2015) to forecast the prices and arrivals of agricultural commodities and drawn conclusions. ARIMA model is an extrapolation method that requires only the historical time series data on the variable under study. The ARIMA model forecasted prices revealed an increase in the prices of paddy in the future years and also demand for the crop. Hence, increase in the area of production of paddy and their sale in the suitable markets can be planned suitably. This forecast is based on past data and model and that actual market price may not turn out to be the same as forecasted.

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