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Predictive analysis of coconut prices in Odisha: An ARIMA approach

Utkal Keshari Sahoo, RV Chavan and SV Bharati

Abstract
Coconut is animportant fruit in India and ranked third in the world. The present study was carried out to forecast prices of coconut in APMC Sakhigopal market at Puri district of Odisha. ARIMA method was used for modelling and forecasting the prices of coconut in Sakhigopal market. The results indicated that ARIMA (1, 1, 1) model was the most adequate and efficient model for forecasting the prices of coconut. It also showed that the predicted midpoint price of coconut would be in the range of ₹11,805.21 to 11,825.27 per 1000nuts in Sakhigopal market at Puri district of Odisha for the period January 2021 to December 2022. The forecasted price will also help to fetch the highest sell price, ultimately resulting in the upliftment of the socio-economic status of farmers. It can also be applicable to the Government, NGOs and research institutions to take appropriate measures to ensure the benefits of end-users of the coconut.

Keywords: ACF, ADF, ARIMA, Box-Jenkins, coconut, forecast, PACF, stationary

Introduction
Coconut (*Cocos nucifera* L.) is a plantation crop predominantly cultivated worldwide. The coconut palm is widely planted in the tropics for ornamental purposes as well as for its numerous culinary and non-culinary applications; practically every portion of the coconut palm may be utilized by humans in some way and has great economic worth. Coconuts are known for their adaptability, which is occasionally reflected in their names. It is called *kalpavriksha* in Sanskrit ("the tree which provides all the necessities of life").
India has good productivity of more than 10,000 nuts per hectare. Coconut is produced in more than fifteen states, including the union territories in India. Among all coconut producing states, Tamil Nadu with a share of more than 31 per cent the stands on the top of the total coconut production in India. It was observed that Tamil Nadu, Kerala, Karnataka, Andhra Pradesh and Odisha are the leading coconut producing states of India. As such these states account for more than 90 percent of the total coconut produced in the country (indiastat.com and Horticulture Division, Department of Agriculture & Cooperation, Ministry of Agriculture and Govt. of India- 2018-19). Odisha is one of the major coconut producing states in India, with the production of 2996.54 lakh nuts in 2019-20 (third advance estimates). Coconut is grown in a large area with more than 43731.4 ha was covered under coconut plantation.
The present study was undertaken to forecast the price of coconut because forecasting price is a crucial part of trading a commodity. At present, the price is determined by the forces of both the domestic and international markets. It prompts to accelerate price volatility making it crucial to examine the trends in price by using accurate statistical modelling tools. It will help the policymakers to formulate policies. Agricultural economists have done various researches to forecast many special agriculture commodity prices. However, there are very less studies has been carried out that focus on predicting coconut prices so present study will be an efficient step towards prediction price of coconut which will helpful for farmer to take quality decision regarding cultivation of coconut. The objective is to forecast future prices of coconut by taking into account past trends and fluctuations in the prices.

Materials and Methods
The study was based on the prices of coconut in APMC Sakhigopal, so APMC Sakhigopal was selected purposively. Only coconut was selected for the present study as coconut was the main arrival to APMC, Sakhigopal. The data required for the investigation were collected from official records of APMC, Sakhigopal, and Puri. Annual reports of APMC, District statistical abstract and handbook of basic statistics of Odisha state. The month-wise data (2001-2020) in

respect of arrival and prices of coconut were collected from the records maintained by APMC, Sakhigopal.

The prices of coconut were forecasted for the short future in the Sakhigopal market of Puri area of Odisha state using univariate time series models. Agricultural price modelling differs from non-farm commodities and services price modelling due to the unique characteristics of agricultural product marketplaces. Seasonality of production derived nature of demand, and price-inelastic demand and supply functions are some of the unique features of crops. The biological nature of crop production influences agricultural product price behaviour.

For a given time series data the ARIMA model was used to quantify and forecast future prices. An ARIMA could model predicts a value in a response time series as a linear combination of its past values. The forecasting models are often written in shorthand as ARIMA (p, d, q), where ‘p’ describes the ‘AR’ part, ‘d’ describes the ‘I’ part, and ‘q’ describes the ‘MA’ part. ARIMA model was used, which required a sufficiently large data set, and model parameters were estimated using R programming software to fit the ARIMA models.

The ARIMA approach was first propounded by Box and Jenkins (1976). The ARIMA models are also referred to as Box-Jenkins models. The analysis performed by ARIMA was divided into four stages for the present investigation.

Box–Jenkins method: Box and Jenkins 1976 describe the entire model-building and forecasting process. In summary, they recommend four essential steps: (i) Model-identification, (ii) Model parameter estimation, (iii) Model diagnostic checking, and (iv) Model forecasting. Below are the details of the estimating and forecasting procedure.

Box–Jenkins Method

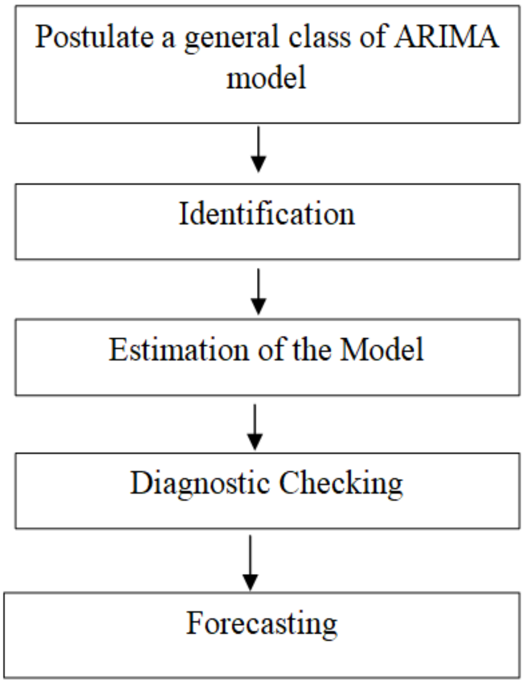

Fig 1: Stages of building optimal ARIMA model

Identification of model: The stationary check of time series data is performed by applying Augmented Dickey-Fuller (ADF) test. The ADF test is to test for the unit root in a time series. The number of non-zero coefficients in ACF determines the order of MA terms, and the number of non-zero coefficients in PACF plots determines the order of AR terms. Among several ARIMA models, the best-fitted model was used to forecast the coconut prices using the data from January 2001 to December 2020. ARIMA models were identified by estimating the initial values for the orders of non-seasonal parameters “p” and “q”. These were based on autocorrelation and partial auto correlation functions with significant spikes. As such one or more models were ultimately chosen at the identification stage, that provided statistically adequate representations of the available data. At the next stage the precise estimates of parameters of the model were obtained by least squares.

Estimation of parameters: After tentative identification of a suitable model, the next step is to obtain the Least Square Estimates of the parameters such that the error sum of squares is minimum. On the whole there are fundamentally two ways of getting estimates for such parameters.

i) Trial and error ii) Iteractive method

The Iteractive method was used in the analysis for estimating the parameters.

Diagnostic checking: It is necessary to do diagnostic checking to verify that the model is adequate after estimation of the parameters of a tentatively identified ARIMA model.

Examining ACF and PACF of residuals may show adequacy or inadequacy of the model. The minimum Akaike Information Coefficient (AIC) criteria were used to determine the differencing order (d, D) required to attain stationarity and the appropriate number of AR and MA parameters.

Forecasting: After satisfying the adequacy of the fitted model, it can be used for forecasting. R programming software was used for time series analysis, developing ARIMA models, and forecasting coconut prices. Originally ARIMA models were studied extensively by George Box and Gwilym Jenkins during 1970, and their names were frequently been used synonymously with the general ARIMA process applied to time series analysis, forecasting and control. Ansari and Ahamed (2001) [1] applied ARIMA modelling for time series analysis of world tea prices and industrialized countries' export prices. Pravin (2005) [9] applied Box-Jenkins Approach for Forecasting Copra wholesale price series. Shankar & Prabhakaran (2012) used the ARIMA model to forecast milk production in Tamil Nadu. Chaudhari and Tingre (2013) [2] found that ARIMA (1,1,0) was the best-fitted model for forecasting green gram prices in Maharashtra.

Results and Discussion

The analysis of the present study revealed that the time series data was stationary for the coconut prices. Among several ARIMA models, based on the lowest AIC and BIC, the ARIMA model (1, 1, 1) was the best-fitted model to forecast the coconut prices using the data from January 2001 to December 2020. Similar model was used by Darekar and Reddy (2017), Darekar and Yadav (2016) and Jalikatti and Patil (2015) [3, 7, 6] to forecast the prices and arrivals of agricultural commodities. The results of the coconut ADF tests are depicted in Table 1, and the ACF and PACF are plotted in Figure 1.

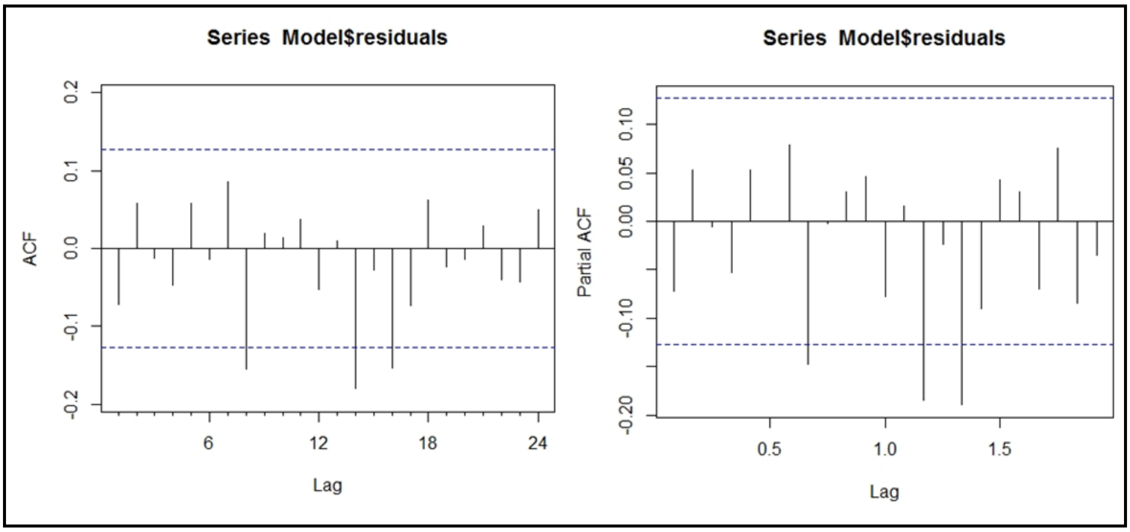

Fig 1: Autocorrelation function (ACF) and Partial autocorrelation function (PACF) of residuals of fitted ARIMA

Table 1: ADF test values and best fitted ARIMA models for the coconut in APMC, Sakhigopal

Particulars	Coconut
ADF values at the level	-4.0044
p-value	0.01
Best fit ARIMA model	$(1,1,1)_{12}$

From Table 1 it observed that the time series of coconut was stationary and will generate accurate results for forecasting future prices. For forecasting, the future prices of the coconut ARIMA model was $(1,1,1)_{12}$ used.

Forecasting future prices of coconut APMC, Sakhigopal

In the above stated ARIMA model, the future prices for 24 months for coconut had been predicted and depicted in following Table 2 and Figure 2, respectively. Table 2 contained the upper limit, lower limit, and midpoint value generated from the output of the ARIMA model, and the actual value prevailed in the market for eight months (January 2021 to August 2021).

Table 2: Projected prices for coconut for 2021-2022 (₹ per 1000 nuts)

Month	Lower limit	Midpoint	Upper limit	Actual value
January, 21	8616.41	11809.34	15002.64	17000
February, 21	8160.01	11812.63	15465.25	15000
March, 21	7851.03	11815.24	15779.45	15000
April, 21	7627.73	11821.32	16006.91	13000
May, 21	7458.52	11818.97	16179.42	9000
June, 21	7325.19	11820.28	16315.36	12000
July, 21	7216.53	11821.32	16426.11	10500
August, 21	7125.29	11822.15	16519.00	12000
September, 21	7046.63	11822.80	16598.98	-
October, 21	6977.23	11823.33	16669.42	-
November, 21	6914.75	11823.74	16732.73	-
December, 21	6857.53	11824.07	16790.61	-
January, 22	6804.35	11824.33	16844.32	-
February, 22	6754.52	11824.54	16894.76	-
March, 22	6706.77	11824.71	16942.65	-
April, 22	6661.19	11824.84	16988.48	-
May, 22	6617.21	11824.94	17032.68	-
June, 22	6574.52	11825.03	17075.53	-
July, 22	6532.90	11825.09	17117.28	-
August, 22	6492.17	11825.14	17158.12	-
September, 22	6452.20	11825.19	17198.18	-
October, 22	6412.86	11825.22	17237.58	-
November, 22	6374.09	11825.25	17276.40	-
December, 22	6335.80	11825.27	17314.74	-

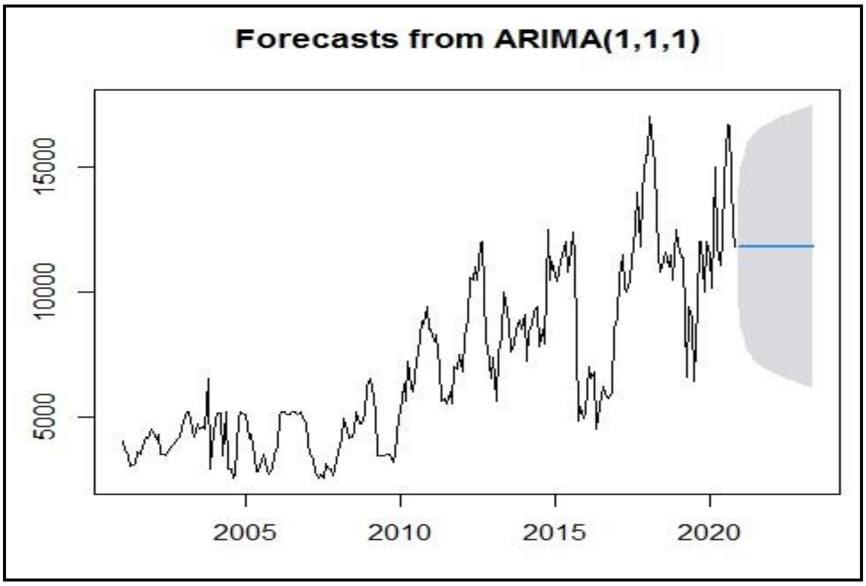

Fig 2: Forecasts of coconut prices in the Sakhigopal market

The perusal of Table 2 revealed that the lower limit, midpoint and upper limit of the predicted value of coconut had ranged between ₹6335.80 to 8616.41, ₹11809.34 to 11825.27 and ₹15002.64 to ₹17314.74 respectively per 1000 coconuts. The predicted price was compared with the actual price of coconut from January 2021 to August 2021, which revealed a minor deviation between the predicted and actual prices of coconut in the Sakhigopal market of Odisha.

Conclusions

There was a lower deviation when the forecasts were compared with the real-time price. Due to the high fluctuation in the price of coconut in the Sakhi gopal market, the future price behaviour will help the farmers take the suitable decision for marketing their product and deciding what to cultivate. The forecasted price will also help to fetch the highest sell price, ultimately resulting in the upliftment of the socio-economic status of farmers. It can also be applicable to the Government, NGOs and research institutions to take appropriate measures to ensure the benefits of end-users of the coconut.

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