Price forecast models for coconut and coconut oil

By

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(2014-19-102)

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2016

DECLARATION

I, hereby declare that this thesis entitled **'Price forecast models for coconut and coconut oil'** is a bonafide record of the research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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Abbreviations

ACF	Autocorrelation Function
AIC	Akaike Information Criterion
ANN	Artificial Neural Network
ARIMA	Autoregressive Integrated Moving Average
BIC	Bayesian Information Criteria
CMA	Centered Moving Average
CV	Coefficient of variation
DES	Double Exponential Smoothing
HWMS	Holt Winters' Multiplicative Seasonal
LCL	Lower Confidence Limit
MA	Moving Average model
MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error
MSE	Mean Square Error
PACF	Partial Autocorrelation Function
$\mathbf{R^2}$	R-Square
RMSE	Root Mean Square Error
SARIMA	Seasonal Autoregressive Integrated Moving Average
SBC	Schwartz Bayesian Criterion
SES	Single Exponential Smoothing
TS	Time Series
UCL	Upper Confidence Limit

Introduction

1. INTRODUCTION

India ranks first in production and productivity of coconut among the coconut growing countries in the world, with 12.5 million hectare in area under coconut. Although Kerala is known as the 'land of Kera' (the coconut tree), the present scenario with respect to production and productivity of coconut is not promising. Among the four southern states of India viz., Kerala, Tamil Nadu, Karnataka and Andra Pradesh, Kerala had the largest area under coconut (37.43%) followed by Karnataka (26.07%), Tamil Nadu (23.54%) and Andra Pradesh (5.36%) in 2014-15. But, during the above period, Kerala was in the third position with respect to production and productivity, with Tamil Nadu in the first position and Karnataka in second position. Productivity of coconut was almost double in Tamil Nadu (14873 nuts/ha.) compared to Kerala (7535 nuts/ha.) in 2014-15.

The price behaviour of coconut and its products has profound influence on the rural economy of Kerala. Coconut is a perennial crop with production of nuts round the year. But large variation in the prices of coconut and coconut oil within a year is the major problem faced by farmers, consumers as well as planners. Farmers depending on the income from coconut and its derivatives like coconut oil and copra should get remunerative price throughout the year for these items. Hence, analysis of time series data of prices of coconut, coconut oil and copra is of prime importance.

A time series is an ordered sequence of values of a variable observed at equally spaced time intervals. Time intervals can be weeks, months, quarters, years, etc. Analysis of a time series is made for two purposes viz., to forecast the future values of the time series by fitting appropriate forecast model for the data and to decompose the time series into the four components namely, trend, seasonal variation, cyclic variation and irregular variation. For any agricultural commodity, information on price variation over different months and forecasts of prices are more important for farmers as well as planners.

Time series forecasting is an important area in which prediction of future values of a variable is made based on past values of the variable. Using the past observations of the same variable, a model describing the pattern of the time series will be developed and the model will be used to obtain future values called forecasts. Time series forecast models are fitted based on the assumption that some aspects of the pattern of past observations will continue to remain in the future. Different forecast models are available for time series data. Broadly, time series forecast models are classified into two categories namely linear and nonlinear.

Autoregressive Integrated Moving Average (ARIMA) models and Exponential smoothing models come under the category of linear models. ARIMA methodology was developed and popularized by Box and Jenkins. Box-Jenkins ARIMA model is widely used in time series forecasting due to its statistical properties and the well-known Box-Jenkins methodology for model building.

Exponential Smoothing is a particular type of moving average technique applied to time series data for producing smoothed data, to make forecast. In the exponential smoothing method, past observations are weighed by exponentially decreasing weights, giving more weights to recent observations, to forecast future values. There are different types of exponential smoothing models viz., Single Exponential Smoothing (SES), Holt's linear /Double Exponential Smoothing (DES) and Holt-Winters'/ Triple exponential smoothing (TES) models. From among these models, suitable model can be selected based on the type of time series data.

Recently, Artificial Neural Networks (ANNs) have been extensively used for time series forecasting. ANN models are unique type of models capable of forecasting non-linear time series data. These models are developed on inspiration by biological system of research on human brain. It has the capacity of capturing the underlying pattern of a time series which are unknown/hard to describe. In ANN modeling for time series, there is no need to specify the model form. Instead ANN models capture the data pattern and give forecasts.

Earlier, price of coconut was determined based on the price of coconut oil in the market. Now, the situation has changed. Coconut is now converted to many value added products like neera, desiccated coconut powder etc. and the demand for tender coconut is also high. Coconut oil and copra on the other hand have its own value for domestic, industrial and export purposes. Variations in prices of these items have adverse effects on Kerala's economy. Hence, price forecasts of coconut, coconut oil and copra are to be made independently.

Hence the present study, 'Price forecast models for coconut and coconut oil' was taken up, with the following objectives:

1. To estimate the seasonal variations in prices of coconut oil , copra and coconut
2. To evaluate different time series forecast models for prices of coconut oil, copra and coconut and to suggest the suitable forecast models for all.

Review of Literature

2. REVIEW OF LITERATURE

In this chapter, a review of previous study of forecasting models has been collected to enable better understanding of the research in forecasting and methods of investigation on the research subject. The chapter is presented under the following titles:

2.1 Seasonality in price

Kahlon and Singh (1967) studied the seasonal movements of price of groundnut in Punjab. The study showed that trend in price of groundnut showed continuous upward movement throughout the years. The extent of seasonal fluctuations was measured through seasonal index of price variation and it was found that variations are uniform throughout the year.

Babu and Sebastian (1996) and Babu (2005) reported that the price of coconut is subjected to pronounced seasonal fluctuations despite the production of nuts round the year. Coconut farmers will be the loser due to the intra - year variation in price. From the middle of 2013, an increasing trend has been observed in the prices of coconut and coconut oil, in Kerala.

Nahatkar *et al.* (1998) studied the nature and magnitude of price fluctuations of cotton in kukshi regulated market, with quarterly price data for 11 years from 1986-87 to 1996-97. The analysis showed that seasonal index of cotton prices was minimum in the second quarter (January-March) and maximum during the third quarter (April-June). The difference between the two was clearly indicating high seasonal fluctuation of cotton prices.

Babu (2005) studied seasonality in prices of coconut, coconut oil and copra prices at three major markets of Kerala, based on the data from 1977-78 to 2004-05. It was inferred that the price movement of coconut, coconut oil and copra prices was almost same throughout the year. Coconut oil price observed that February-July for

Alappuzha and Kozhikode markets and February-August for Kochi market as depressed phase with lowest price in May whereas August-January for Alappuzha and Kozhikode markets and September-January for Kochi market with peak price in May. For copra price, buoyant phase was from September-January with highest price in November for all the three markets and depressed phase from February- August for all the three markets with lowest price from March at Kochi and Kozhikode markets and April for Alappuzha market. And for coconut price November was the peak price period with buoyant phase from September-February and lowest price was in April with March-August as the trough phase for Alappuzha market

Gangadarappa (2005) analysed the price of potato in Bangalore, Belgaum, Kolar, Hassan and Hubli markets of Karnataka using monthly data from April 1996 to March 2004. It was found that prices were high during, April, June and July in all the markets.

Raveendran (2006) analysed 25 years' turmeric price data collected from Erode regulated market and found that fresh turmeric arrivals and prices in Erode regulated market started from mid of January to June and stored products will be available throughout the year with an increase in price after the month of July.

Kumar *et al.* (2009) analysed the seasonality in prices of green chili, onion, potato and tomato in Bangalore market with monthly price data during 1999-2008. The seasonal indices showed that price of green chilly started increasing from March with peak in June and lowest price was observed in November. For onion, the peak price was observed during November and lowest was in May. Seasonal indices for potato showed that price of potato started increasing from May with peak price in July and November.

Anadalkar *et al*. (2011) studied the price pattern of pigeon pea in Amaravathi and Achalpur *Agricultural Produce Market Committees* (*APMC's*) based on the monthly data from 1994-95 to 2008-09. Price index of this data showed that the highest prices for both the *APMC's* was observed from July to September and August to November and concluded that price is having negative impact on arrivals of pigeon pea in Amaravathi and Achalpur *APMC's*.

Adanaliglu and Yercanm (2012) analysed the seasonal price variation of tomato for wholesale price of tomato using data from January 2000 to December 2010 at Antalya, Turkey. It was observed that price was high in September and October while it was lowest in January.

Tiku *et al*. (2013) analysed palm oil prices in Akwa Ibom state, Nigeria. The price instability, seasonality and other components were studied and the results revealed that instability index was 58.49%. Based on the data collected from 2001-2010, it was found that palm oil price was constant over the time of study. Also, demand for palm oil was highest in first quarter from January – March followed by second quarter from April – June, then fourth quarter from October – December and least period of supply by July – September.

Karthikeyan and Nedunchezhian (2014) made an attempt to study seasonal changes in egg prices in Coimbatore poultry associations based on the egg price from January 2009 to December 2012. The results showed that egg prices increased by 28 percent from 2009 to 2012, and was mainly due to increase in consumption and price of feed seasonal indices showed that the prices was high during November and December and lowest price was in April.

Kumaraswamy and Sekar (2014) fitted seasonal indices for potato price in major markets in India and Tamil Nadu. Seasonal indices of potato price revealed that the price was high during May to November. In Mettupalayam, Tamil Nadu, markets the analysis based on 23 years of data on prices of potato revealed that prices was good during September to December.

2.2 ARIMA model for forecasting price

Nabi and Shahabuddin (1998) used Box-Jenkins univariate ARIMA model for forecasting the price of natural rubber (NR) at Malaysia. The analysis was based on the monthly average prices of natural rubber for the period from January 1977 to May 1987. The price of the various grades of rubber was forecasted using a ARIMA (2,0,2) model. The mean absolute percentage error (MAPE) ranged between 2.65 percent and 3.30 percent.

Shamushudin and Arshad (1990) compared the accuracy of econometric model, SARIMA and composite of both models to predict the price of natural rubber in Malaysia based on price from January 1978 to March 1988. Composite model was identified as the best based on RMSE.

In a study conducted by Vroomen and Douvelis (1993) an ARIMA model was used to forecast the seasonal average soybean price in USA for the marketing years from 1979-1990 to 1991-1992. Results indicated that ARIMA models typically outperformed USDA forecasts, especially early in the marketing year, and within-season USDA forecasts may be improved by incorporating information from ARIMA models.

Douvelis (1994) used ARIMA model to forecast the seasonal average sunflower seed price. These forecasts were then weighed by the average estimated volume of the former sales during each month of the marketing year, to calculate the average price received by farmers. The ARIMA forecasts came very close to the actual price.

Silva and Silva (1996) analysed the monthly prices of charcoal during the period 1980-1992 from Minas, Gerias and Brazil. In classical analysis both multiplicative and additive models gave the similar results. ARIMA model was observed as the best model with good estimates than the classical model.

Run-sheng (1999) made short term forecast of timber price in southern states of USA using univariate ARIMA model. Quarterly prices of pine pulpwood and raw timber market prices were used for the study. It was observed that one-lead forecasts are fairly accurate with ARIMA model.

In a study conducted by Krishnakutty (2001) ARIMA model was applied to forecast prices of teak (*Tectonagrandis*) in three girth classes (based on mid-girth, under bark and of lags) in Kerala, based on the average annual current prices of teak from 1999-2000 to 2015-16.

Paul (2005) applied ARIMA model for forecasting rohu (*Labeo rohita*) price in west Bengal. Monthly wholesale price from January 1996 to December 2004 was used for the study. ARIMA (2,1,1) model was identified as the most suitable model based on minimum values of AIC.

Menon *et al.* (2006) used ARIMA model to forecast price of cardamom, based on monthly price for the period from August, 1985 to December, 2005. The price series was checked for stationarity, independent of residuals and significance of autocorrelations. ARIMA (2,1,0) provided satisfactory forecast of the cardamom price with 80 percent accuracy.

Yayar and Bal (2007) conducted a study to forecast corn oil price. ARIMA model was fitted based on price data from January 1994 to December 2005. It was observed that ARIMA approach is suitable for short term price forecasting.

Barathi *et al*. (2011) used ARIMA model for forecasting cocoon price in Shidlaghatta and Ramanagara markets of Karnataka based on the monthly price data for a period of 10 years from 1998-99 to 2007-2008. The adequacy of the model was judged based on Box-Pierce Q-Statistic and AIC, ARIMA(0,1,0)(1,1,1) was identified for both markets.

Khin *et al.* (2011) made an attempt to forecast the price of natural rubber in Malaysia, based on the price data from January 1990 to December 2008. Univariate ARIMA and Multivariate ARMA (MARMA) were used for the study. The accuracy of forecasting was measured based on RMSE, MAE and U-Theil criteria, MARMA was identified as the best model.

Kumar *et al*. (2011) obtained ARIMA (0,1,0) $(0,1,1)_{12}$ as the best model for forecasting price of potato in Bangalore market based on monthly price data from April 1999 to march 2008. MAPE was 18.28 percent for the model.

Adanaliglu and Yercanm (2012) analysed the seasonal price variation of tomato and developed Seasonal ARIMA (SARIMA) model to forecast wholesale price of tomato using data from January 2000 to December 2010 at Antalya, Turkey. SARIMA (1, 0, 0) $(1, 1, 1)_{12}$ model was identified as the best.

Jeethu (2012) studied the price behavior of cashew nut in India and Bangkok markets based on monthly data from 1965-66 to 2010-11. Several models like single and double exponential smoothing models, ANN and Box-Jenkins ARIMA models were tried for forecasting price of cashew nut. ARIMA(3,1,0)$(0,1,1)_{12}$ was identified for Bangkok market as best model with least MAPE of 5.12 whereas ARIMA(0,1,1) was best for domestic market with least MAPE of 2.73 compared to other models.

Sakanin (2012) analysed the price of natural rubber in Malaysia. Univariate ARIMA model and multivariate Vector Auto Regressive (VAR) model were used to forecast the prices based on the data from January 2000 to September 2011. Among the models tried, ARIMA(1,1,2) and VEC(Vector Error Correctional) model provided the least RMSE and MAE values.

Ozer and Ilkdogon (2013) examined Box-Jenkin's method of ARIMA model for forecasting cotton price in Ankara, based on the data from January 2004 to June 2012 ARIMA(1,1,1)$(1,0,1)_{12}$ has been identified as the best model based on the accuracy measure, MAPE and U-Theils statistic.

Based on the monthly average price from January, 2001 to September, 2012 of Ankola market, Maharashtra, Chaudhary and Tingre (2014) identified ARIMA (0,1,0) as the best model for forecasting price of green gram with, MAPE of 6.01 percent.

Khin and Tambiah (2014) tried simultaneous price demand supply system equation model and ARIMA model to forecast the Malaysia natural rubber prices using quarterly data during 1990-2013. ARIMA model was identified as the best based on several accuracy measures (RMSE, MAE, U-Theil's and BIC criteria).

Mohan and Sumathi (2014) identified SARIMA(1,1,1)$(1,1,1)_{12}$ as the suitable model to forecast red chilli prices of Warangal Khamam market of Andhra Pradesh. They used price data of 137 months from May 2002 to September 2013.

Sharma *et al.* (2014) fitted forecast model for soybean price in Kota market of Rajasthan, using the data for a period of 12 years from 2000-01 to 2011-12. Several forms of ARIMA model were tried and ARIMA(1,1,1) model was selected based on the least AIC, SBC and MAPE values.

Vinayak *et al.* (2015) used ARIMA model to forecast the price of onion in Hubli market of northern Karnataka. Based on the monthly data on the prices and arrivals of onion from 1996-97 to 2010-11, ARIMA (1,1,1) $(2,1,1)_{12}$ was found to fit the series.

Guha and Bandyopadyay (2016) made an attempt to forecast future gold prices in India based on monthly data from November 2003 to December 2014. The results revealed that ARIMA (1,1,1) was the best model to forecast gold prices compared to other models.

Michinaka *et al.* (2016) applied exponential smoothing model ARIMA model to forecast monthly prices of three different types of Japanese logs. Monthly price data from January 2002 to September 2015 were used for the study and ARIMA model was the best model.

2.3 Artificial Neural Network models for price forecasting

Ajjan *et al.* (2009 a) compared ANN and ARIMA models for forecasting the price of poovan banana in Trichy, Tamil Nadu. Different ARIMA models were tried and ARIMA (1,0,1) was selected due to lowest standard error and AIC. ANN model was identified as the best model due to the low MAPE value when compared to ARIMA (1,0,1).

Gan-qiong *et al.* (2010) compared ARIMA and ANN models for predicting daily, weekly and monthly wholesale prices of tomato in China using data from 1996 to 2010. The results showed that ANN model was best in forecasting the prices

2.4 Exponential smoothing models for price forecasting

Vasanthakumar *et al.* (2005) forecasted the price of different types of teak using exponential smoothing model based on the price data from May 1987 to May 2001. Single parameter exponential smoothing model was identified for forecasting. The ex-post and ex-ante forecasts were made and compared with actual prices of selected classes of teak. The forecasts were made for four years ahead from May 2001 (ex-ante forecast). They found that the model is good for short term forecast.

Rangoda *et al. (*2006) compared the adequacy of different models like MA method, winters method, single exponential smoothing model, double exponential smoothing model and ARIMA model for forecasting prices of coconut oil and allied products in Sri Lanka, for the study, they used price data on desiccated coconut,

coconut oil and fresh coconut from January 1974 to December 2014. ARIMA and exponential smoothing models were better compared to others based on the accuracy measures MAPE, MAD and MSD.

Jyothi (2011) have studied price behavior of turmeric in India based on the prices of turmeric from 1980-81 to 2008-09 in Nizamabad and Erode markets. Different models like single, double and triple exponential smoothing models, moving average and ARIMA models were compared, out of which double smoothing exponential smoothing model was suitable for Nizamabad and Winters multiplicative model was the best for Erode market.

2.5 Comparison of price forecasting models

Ajjan *et al*. (2009 b) conducted a study for forecasting the price of turmeric in Tamilnadu. Price data on turmeric finger for the period from January, 1986 to September, 2006 collected from erode regulated market. Various ARIMA models and ANN model were tried to forecast the price of turmeric and ARIMA (1,1,1) was preferred due to the low AIC and MAPE values.

Kumar (2010) used trend analysis, ARIMA models, ANN model and exponential smoothing models to forecast the timber prices at two depots of Karnataka (Dandeli and Keruvatti) and for two types of teak (Teak and Indian Kino) for each depot, based on the data of average sold price from 1980 to 2009. It was found that ARIMA model was good for forecasting Indian Kino in Dandeli market, teak in Dandeli and Kiruvatti markets and Single exponential smoothing models was best for Indian kino prices in Kiruvatti market, based on the minimum MAPE and RMSE values.

Kumar *et al.* (2011) made comparative study on ARIMA and Time Delay Neural Network (TDNN) models for forecasting prices of oilseed crops- soybean, groundnut, rapeseed and mustard, traded in Indore, Rajkot and Delhi markets of India. Monthly wholesale prices during 1998 to 2010 were for the study TDNN performed substantially better than other models in prediction.

Kumar *et al.* (2011) compared the suitability of Holt Winter's exponential smoothing model and seasonal ARIMA model for forecasting price of onion in Bangalore market and obtained ARIMA $(1,1,0)(0,1,1)_{12}$ as the best model with MAPE of 16.14 percent . The monthly average price of onion from April, 1999 to March, 2010 was used for the study.

Reeja (2011) compared Moving Average model, Single and double exponential smoothing models, ARIMA and ANN models for forecasting price of natural rubber (RSS-4) in Kottayam and Bangkok markets, and obtained ANN as the best model in Kottayam market and SARIMA$(0,1,0)(1,0,1)_{12}$ in Bangkok market.

Sinha (2011) compared ARIMA and Time Delay ANN (TDANN) and their combination for forecasting the wholesale prices of oilseed crops (Soybean, groundnut, rapeseed and mustard) in different markets (Indore, Rajkot and Delhi) in India. Monthly average price from October, 1991 to September, 2010 was used for the study. It was concluded that results from combined models underperformed the individual models.

Sharma and Burark (2015) compared ARIMA, ANN and exponential smoothing (single, double and triple) models to predict the price of sorghum in Ajmer market of Rajasthan and obtained ARIMA (1,1,2) as the suitable model.

Materials and Methods

3. MATERIALS AND METHODS

The database used for the study "Price forecast models for coconut and coconut oil" and the statistical techniques adopted are discussed in this section under different headings.

3.1. Database for the study

Monthly average price of coconut oil, copra and coconut for the three major markets of Kerala viz., Alappuzha, Kochi and Kozhikode formed the database for the present study entitled "Price forecast models for coconut and coconut oil". For fitting forecast models, only reliable data should be used and hence data maintained at Coconut Development Board (CDB), Kochi were collected. For coconut oil and copra, data were collected from all the three markets, whereas, for coconut, price data was available only for Alappuzha market. Details of data collected for the study from CDB, Kochi are depicted in Table 3.1.

Table 3.1 Details of price data of coconut oil, copra and coconut

Market	Price		
	Coconut oil	Copra	Coconut
Alappuzha	January 1990 to December 2015	January 1990 to December 2015	January 1998 to December 2015
Kochi	January 1990 to December 2015	January 1990 to December 2015	-
Kozhikode	January 1990 to December 2015	January 1990 to December 2015	-

Before detailing the statistical techniques used for the study, some important terms are explained in section 3.2.

3.2. Important terms used in the study

Time series (TS): A time series is an ordered sequence of values of a variable observed at equally spaced time intervals.

In the present study, different time series viz., values of three variables namely prices of coconut oil, copra and coconut recorded at monthly intervals in the different markets were used. These are all univariate time series.

Lag: Lag is the difference in time between an observation and a previous observation, in a TS.

For example, Y_{t-k}, lags Y_t by k periods, where Y_t is the value of TS at time t.

Lead: Lead is the difference in time between an observation and a future observation. Thus Y_{t+k} leads Y_t by k periods.

Moving Average (MA) : For a TS, moving average of order k is defined as the mean of k consecutive observations.

MA of order k = $\frac{\sum_{t=1}^{k} Y_t}{k}$, when k=12, we get MA of order 12.

Autocorrelation: Autocorrelation is the correlation between values of the same time series at different time periods. Let Y_t be the value of the time series at time t. Then, autocorrelation at lag k, r_k is given by

$$r_k = \frac{\sum_{t=k+1}^{n} \left(Y_t - \bar{Y}\right)\left(Y_{t-k} - \bar{Y}\right)}{\sum_{t=1}^{n} \left(Y_t - \bar{Y}\right)^2}$$

Where, Y_{t-k} is the value of the TS at lag k and $\bar{Y}$ is the mean of the TS, $\bar{Y} = \frac{1}{n}\sum_{i=1}^{n} Y_t$.

Autocorrelation Function (ACF): The pattern of autocorrelations for lags 1,2,3, …. is known as Autocorrelation Function (ACF).

ACF plot or Correlogram: ACF plot is the graph obtained by plotting autocorrelations against the corresponding lags and it helps to visualize the ACF quickly and easily. Correlogram is a standard tool in exploring the TS. ACF plot helps to identify the presence of seasonality in a given TS and to determine if the data are stationary so that appropriate TS forecast model can be selected.

Partial Autocorrelation: Partial autocorrelation is a measure of the degree of association between Y_t and Y_{t-k} when the effects at other time lags 1, 2, …, k-1 are removed.

Partial Autocorrelation Function (PACF): The pattern of autocorrelations for lags 1,2,3, …. is known as Partial Autocorrelation Function (PACF).

PACF plot: The graph obtained by plotting partial autocorrelations against the corresponding lags is known as PACF plot.

Stationary TS: If the underlying generating process for a TS is based on a constant mean and a constant variance, then the TS is stationary. More formally, a TS is stationary if its statistical properties are independent of the period during which it is observed.

Time plot: The most important thing to do for exploring a TS is to visualize the data through graph. The graph obtained by plotting time series data against the corresponding time of occurrence is called **time plot**. Time plot helps to understand the pattern of the TS and to identify the presence of any trend over time, any regular seasonal behaviour and other systematic features of the data.

3.3. Price instability

Coefficient of variation (CV) is a measure used to express instability of the TS. It is expressed as the percentage ratio of standard deviation (σ) to mean $\overline{Y}$ of the series. The instability of the price data was checked using CV given by

$$CV = \frac{\sigma}{\overline{Y}} \times 100$$

CV = Coefficient of variation of the TS

σ =Standard deviation of the TS

$\overline{Y}$ = Mean of the TS

The CV of prices of coconut oil, copra and coconut in the different markets were computed to understand the instability in prices.

3.4. Time series model for price data

A multiplicative model was assumed for the TS of prices of coconut oil, copra and coconut. Let Y_t be the price data at time t. Then Y_t is given by

$$Y_t = T_t \times S_t \times C_t \times I_t$$

Where, T_t is the trend value at time t

S_t is the seasonal variation at time t

C_t is the cyclic variation at time t

I_t is the random fluctuations at time t

T_t, S_t, C_t and I_t are called components of the time series. According to this model, S_t, C_t and I_t are indices fluctuating above or below unity and the geometric mean of S_t in a year, C_t in a cycle and I_t in a long term period are unity. The components of the TS are explained briefly.

Trend (T_t): is the general tendency of the TS to increase or decrease during a long period of time. Trend is the result of those forces which are either constant or change very gradually over a long period of time.

Seasonal variation (S_t): Seasonal variations are the periodic and regular movements in a time series with period less than a year. To study seasonal variations in a time series, the data must be recorded monthly, quarterly or weekly. "Season" refers to month, quarter or week accordingly. Seasonal variations cannot be studied if annual figures are used. In the present study, a season is a month.

Cyclic variation (C_t): The oscillatory movements in a TS with period of oscillation more than one year are termed as cyclic variations. A complete period is called a cycle.

Irregular variation (I_t): Irregular variations in a TS are purely random, erratic, unforeseen, non-recurring and irregular circumstances which are beyond the control of human hand. Irregular fluctuations in TS occur due to floods, famines, revolutions, political upheavals etc.

All these components may occur in a TS and is a challenge in forecast modeling. Hence, forecast models that are capable of capturing the different components in the TS and make reliable forecast are to be used.

3.5. Estimation of seasonal variation

In the present study, monthly average price data of coconut, coconut oil and copra were used for fitting forecast models and a month is referred to as a "season". Seasonal variations were estimated as seasonal indices.

Seasonal indices were worked out for the 12 months from January to December for the prices of coconut, coconut oil and copra at Alappuzha, Kochi and Kozhikode markets to understand the seasonal behaviour of the prices in the different markets and to make a comparison among the different markets. 'Ratio to Moving Average' method was used to estimate the seasonal indices. The method involves the following steps:

- Calculate the 12-month Moving Average (MA) of the TS data, Y_t. Work out the Centered Moving Average (CMA) of the 12 month MAs, where CMA is the MA of order 2 of the 12 month MA. CMA values will give estimates of the combined effects of trend and cyclic variations.

$$CMA = T_t \times C_t$$

- Express the original data Y_t as percentages of the CMA values. These percentages would represent Seasonal (S_t) and Irregular(I_t) components i.e.,

$$i.e., \frac{Y_t}{CMA} \times 100 = S \times I$$

- Compute the preliminary seasonal indices, by eliminating the irregular or random component by averaging the above percentages over year.
- The sum of the preliminary seasonal indices (=S) will not be equal to 1200. Finally, an adjustment is done to make the sum of indices S equal to 1200, by multiplying throughout by a constant factor = $\frac{1200}{S}$. The resultant values will be seasonal indices for different months.

3.6. Seasonal Plot

Seasonal plot is the graph obtained by plotting seasonal indices against the individual “season” in which the data were observed. In the present study, a “season” is a month. Thus, seasonal indices of prices of coconut, coconut oil and copra at Alappuzha, Kochi and Kozhikode markets were plotted against the corresponding months to understand the variation in their prices in different months.

3.7. Forecasting in Time series

In TS forecasting, the objective is to estimate how the sequence of observations will continue into the future. For this, past observations of the same variable are analysed to develop a model describing the underlying pattern of the TS. For the known data (Y_t), model fit values ($\hat{Y}_t$) can be obtained and this allows computation of errors,

$e_t = (Y_t - \hat{Y}_t)$. Then forecast values (F_{t+1}, F_{t+2}, …) are obtained and when new observations become available, forecast errors (e_{t+1}, e_{t+2},…) can be computed.

In the present study ARIMA, ANN and exponential smoothing (single, double, Holt-Winters' additive and multiplicative) models were fitted for the price of coconut oil and copra at Alappuzha, Kochi and Kozhikode markets and coconut price at Alappuzha market and the best model was selected in each case. The three models are described from section 3.7.1 to section 3.7.3.

3.7.1 ARIMA modeling

ARIMA stands for 'Autoregressive Integrated Moving Average' and was popularized by George Box and Gwilym Jenkins in early 1970s. It is synonymously called Box- Jenkins ARIMA methodology and has different steps viz., identification, estimation, diagnostics and forecasting.

Identification

The first step in the process of modeling is to check for the stationarity of the TS, as, the estimation procedures are available only for stationary TS. There are two types of stationarity, viz., stationarity in 'mean' and stationarity in 'variance'. Examination of the TS plot and ACF and PACF plots may provide clues for the presence of non-stationarity. Non-stationarity in mean can be removed through the method of differencing. To remove non-stationarity in variance, logarithmic or power transformation can be applied to the data. With seasonal data, which is non-stationary, seasonal difference of the data is to be taken.

Stationarity of a TS can be tested statistically also. Statistical tests to determine whether a TS is stationary are generally known as unit root tests. The most widely used unit root test is Augmented Dickey Fuller (ADF) test. ADF test consists of estimating the following regression equation.

$$Y_t' = \phi Y_{t-1} + b_1 Y_{t-1}' + b_2 Y_{t-2}' + ... + b_p Y_{t-p}'$$

Where Y_t' denotes the differenced series $(Y_t - Y_{t-1})$

The number of lagged terms in the regression, p, is usually set to be about 3. Then, if the original TS, {Y_t} needs differencing, the estimated value of ϕ will be close to zero. The value of ϕ is estimated from the above regression equation using ordinary

least squares. If the parameter ϕ is negative and significant, then the series being tested will be considered stationary.

The next step in the identification process is to find the initial values for the orders of seasonal and non-seasonal parameters, p, q, and P, Q. They could be obtained by looking for significant autocorrelation and partial autocorrelation coefficients. For example, if second order auto correlation coefficient is significant, then an AR (2), or MA (2) or ARMA (2) model could be tried to start with. Final models are obtained after going through the above stages repeatedly.

Estimation

At the identification stage, one or more models were tentatively chosen that seem to provide statistically adequate representations of the TS data. After selecting tentative models, the parameters p and q were estimated. SPSS package was used to obtain precise estimates of the parameters of the model by least squares as advocated by Box and Jenkins.

Diagnostics

From among the different models obtained for various combinations of AR and MA individually and collectively, the best model was selected based on the following diagnostics.

(a) Low Akaike Information Criteria (AIC)/Bayesian Information Criteria (BIC)/ Schwarz-Bayesian Information Criteria (SBC)

AIC is given by

$$AIC = -2\log L + 2m$$

Where m=p+ q+ P+ Q and L is the likelihood function.

Since -2 log L is approximately equal to $\{n(1+\log 2\pi\}+n\log\sigma^2$ where σ^2 is the model Mean Squared Error (MSE), AIC can be written as

$AIC=\{n(1+\log 2\pi\}+n\log\sigma^2+2m$ and since the first term in this equation is a constant, it is usually omitted when the fit of two models are compared.

As an alternative to AIC, sometimes SBC is also used which is given by

$SBC=\log\sigma^2+(m\log n)/n$

(b) Plot of residual ACF

After fitting the appropriate ARIMA model, goodness of fit of the model was examined by plotting the ACF of residuals. If most of the sample autocorrelation coefficients of the residuals are within the limits $\pm\frac{1.96}{\sqrt{n}}$, where n is the number of observations upon which the model is based, then the residuals are white noise indicating that the model is a good fit.

(c) Non-significance of auto correlations of residuals via Portmonteau tests- Ljung-Box test

After tentative model has been fitted to the data, it is important to perform diagnostic checks to test the adequacy of the model and to suggest potential improvements, if needed. One way to accomplish this is through the analysis of residuals using Portmonteau test. Ljung-Box Q* statistic is the commonly used Portmonteau test. The Ljung-Box Q* statistic is given by

$$Q^*=n(n+2)\sum_{k=1}^{h}(n-k)^{-1}r_k^{\ 2}$$

Where, h is the maximum lag for autocorrelations and n is the number of observations in the TS. If the errors are white noise, the Ljung-Box Q* statistic has a chi-square distribution with (h-m) degrees of freedom, where m is the number of parameters in the model. If Q* is greater than the table value of chi-square at (h-m) degrees of freedom, the data are not white noise.

ARIMA representation

After identification of the ARIMA model, the parameters of the model are estimated and the required diagnostic checks will be conducted. There are two types of ARIMA models: Non seasonal ARIMA and Seasonal ARIMA (SARIMA).

Non seasonal ARIMA model

Non seasonal ARIMA model is usually denoted as ARIMA (p,d,q), where, p, d and q denote orders of auto-regression, integration (differencing) and moving average respectively. In ARIMA parlance, TS is a linear function of past actual values and random shocks. For instance, given a TS process {Yt}, a first order auto- regressive process is denoted by ARIMA (1,0,0) or simply AR(1) and is given by

$$Y_t = \mu + \phi_1 Y_{t-1} + \varepsilon_t$$

and a first order moving average process is denoted by ARIMA (0,0,1) or simply MA(1) and is given by

$$Y_t = \mu - \theta_1 \varepsilon_{t-1} + \varepsilon_t$$

Alternatively, the model ultimately derived, may be a mixture of AR and MA processes and of higher orders as well. Thus a stationary ARMA (p, q) process is defined by the equation

$$Y_t = \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + ... + \phi_p Y_{t-p} - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - ... - \theta_q \varepsilon_{t-q} + \varepsilon_t$$

i.e., $$\left(1 - \sum_{i=1}^{p} \phi_i B^i\right) Y_t = \left(1 - \sum_{j=1}^{q} \theta_j B^j\right) \varepsilon_t$$

Y_t, Y_{t-1},…Y_{t-p} are the values of the TS at times t, t-1, t-2,…t-p and B is the backshift operator such that $B^i Y_t = Y_{t-i}$ and $B^j \varepsilon_t = \varepsilon_{t-j}$. Where, $\varepsilon_t, \varepsilon_{t-1}, \varepsilon_{t-2}, ..., \varepsilon_{t-p}$'s are random errors at times t, t-1, t-2,…,t-p independently and normally distributed with zero mean and constant variance σ^2.

When the TS is non-stationary the ARIMA (p,d,q) model is obtained as

$$\left(1-\sum_{i=1}^{p}\phi_i B^i\right)(1-B)^d Y_t = \left(1-\sum_{j=1}^{q}\theta_j B^j\right)\varepsilon_t$$

ϕ_i, i=1,2,…,p are Auto Regressive (AR) parameters; θ_j, j= 1,2,…,q are Moving Average (MA) parameters

$(1-B)^d Y_t$ is the non-seasonal difference of order d on Y_t.

Seasonal ARIMA (SARIMA) model

When seasonality is present in the TS data Seasonal ARIMA (SARIMA) model is used. Seasonality is defined as the pattern that repeats itself over fixed intervals of time. If the pattern is consistent, for monthly data, autocorrelation coefficient at lag 12 will be highly significant and it indicates the existence of the seasonality. In general, seasonality can be identified by large autocorrelation coefficient or large partial autocorrelations at lags 12, 24 … for monthly data. For seasonal data which is non-stationary seasonal differencing is required. A seasonal difference is the difference between an observation and corresponding observation from the previous year.

Identification of relevant models and inclusion of suitable seasonal variables are necessary for seasonal models. The Seasonal ARIMA i.e. SARIMA (p,d,q) $(P,D,Q)_s$ model is defined by

$$\underbrace{\left(1-\sum_{i=1}^{p}\phi_i B^i\right)}_{\text{(Non seasonal AR(p))}}\underbrace{\left(1-\sum_{i=1}^{P}\Phi_i B^{is}\right)}_{\text{(Seasonal AR(P))}}\underbrace{(1-B)^d}_{\text{(Non-seasonal difference)}}\underbrace{(1-B^s)^D}_{\text{(Seasonal difference)}} Y_t = \underbrace{\left(1-\sum_{j=1}^{q}\theta_j B^{js}\right)}_{\text{(Non-seasonal MA(q))}}\underbrace{\left(1-\sum_{j=1}^{Q}\Theta_j B^s\right)}_{\text{(Seasonal MA(Q))}}\varepsilon_t$$

Where, Φ_i, i=1,2,…,P are the seasonal autoregressive parameters, Θ_j ,j=1,2,…,Q are the seasonal moving average parameters, and all other terms are same as in ARIMA (p,d,q) model. In the present study, since monthly price data were taken, s =12.

Forecasting

Forecasting is predicting the future values of the TS, based on the fitted model. After selecting the suitable ARIMA or SARIMA model for the data, the future price upto three months were predicted based on the model.

3.7.2 Artificial Neural Networks (ANN) model for TS

Any forecasting model assumes that there exists an underlying relationship between the past values of the TS (inputs) and the future values (forecast). Traditional statistical forecasting models are not capable of estimating this underlying relationship due to the complexity of the real system. ANN models have the capability to identify the underlying pattern of the TS and hence it is widely used in TS modeling.

Artificial Neural Networks (ANNs) are capable to capture the non-linearity in the TS data. Compared to other non-linear models the, major advantage of ANN models is that ANNs are universal approximators and can approximate a large class of functions with high degree of accuracy. This is due to the parallel processing of information contained in the data. In the model building process, ANN do not require any prior assumptions of the model form. ANN model is determined by the characteristics of the data.

For TS modeling and forecasting, using ANN, single hidden layer feedforward network model is most widely used (Zhang et al., 1998). This model is characterized by a network of three layers of simple processing units connected by acyclic links. The three layers are input layer, middle layer or the hidden layer and output layer. Input layer accepts external information, hidden layer provide non linearity to the model and the output layer provide the forecast value.

Before an ANN is used to perform any desired task, it must be trained to do so. Training is the process of determining the arc weights which are key elements of an ANN. The knowledge learned by a network is stored in the arc's and nodes biases. Through the linking arcs, ANN carryout nonlinear mapping from its input nodes to its output nodes.

In TS forecasting problem, the inputs are the past observations of the TS and output is the future value. The total available data is divided into a training set (in-sample data) and a test set (out of sample) data. Training set consists of a fixed number of lagged observations of the series, and is used for estimating the arc weights. The test set is used for measuring the generalization ability of the network.

Suppose there are N observations $Y_1, Y_2, \ldots, Y_N$ in the training set and one step ahead forecasting is required, Then, using an ANN with n input nodes, we have N-n training patterns. The first training pattern will contain $Y_1, Y_2, \ldots, Y_n$ as inputs and Y_{n+1} as the target output. The second training pattern will contain $Y_2, Y_3, \ldots, Y_{n+1}$ as inputs and Y_{n+2} as the desired output. Finally, the last training pattern will be $Y_{N-n}, Y_{N-n+1}, \ldots, Y_{N-1}$ for inputs and Y_N for the target. The training algorithm is used to find the weights that minimize an overall error measure as sum of squares (SSE) given by

$$SSE = \frac{1}{2}\sum_{i=n+1}^{N}(Y_i - a_i)^2$$

Where a_i is the actual output of the network and $\frac{1}{2}$ is included to simplify the expression of derivative computed in the training algorithm.

Let Y_t be the value of the TS at time t. Y_t and the lagged observations $Y_{t-1}, Y_{t-2}, \ldots, Y_{t-p}$ which are used as inputs are related by the equation,

$$Y_t = \alpha_0 + \sum_{j=1}^{q}\alpha_j g\left(\beta_{oj} + \sum_{i=1}^{p}\beta_{ij}Y_{t-i}\right) + \varepsilon_t$$

Where α_j (j=0,1,2, …, q) and β_{ij} (i=0,1,2,…,p ; j=0,1,2,…,q) are the model parameters called connection weights; p is the number of input nodes and q is the number of hidden nodes. The logistic function is often used as the hidden layer transfer function, that is

$$g_x = \frac{1}{1+e^{-x}}$$

Hence, the ANN model (A) performs a non-linear functional mapping from the past observations (Y_{t-1}, Y_{t-2}, … , Y_{t-p}) to the future value Y_t.

i.e., $Y_t = f(Y_{t-1}, Y_{t-2}, ..., Y_{t-p}, \omega) + \varepsilon_t$

Where ω a vector of all parameters and f is a function determined by the network structure and connection weights.

3.7.3 Exponential smoothing models

Exponential smoothing is a particular moving average technique applied to TS and to produce smoothed data to make forecast. The exponential smoothing method, weighs past observations by exponentially decreasing weights to forecast future values. In exponential smoothing, one or more smoothing parameters are to be determined explicitly and those choices determine the weights assigned to the observations. Different types exponential smoothing models for forecasting TS are given below:

1. Single Exponential Smoothing model
2. Holt's linear (Double) Exponential Smoothing model
3. Holt-Winters' smoothing/Triple Exponential Smoothing model

Single Exponential Smoothing (SES) model

Single exponential smoothing (SES) is a procedure that repeats enumeration continuously by using the newest data. Let F_t denote the forecast of the TS at time t and Y_t be the actual value. Then, the forecast error is (Y_t -F_t). The method of single exponential forecasting takes the forecast for the previous period and adjusts it using the forecast error. Thus, forecast F_{t+1} for the next period, (t+1) is

$$F_{t+1} = F_t + \alpha(Y_t - F_t)$$

Where F_t is forecast for Y_t and α is the smoothing constant taking values between 0 and 1. A large value of α (say 0.9) gives very little smoothing in the forecast, whereas, a small value of α (say 0.1) gives considerable smoothing. From a grid of values for α (say α=0.1, 0.2,…, 0.9), the values that yields the smallest Mean Absolute Percentage Error (MAPE) is chosen.

Holt's linear (Double) Exponential Smoothing (DES) method

This method allows forecasting TS data with trend. The forecast for Holt's linear/Double Exponential Smoothing (DES) method is found using three equations– one for level, one for trend and one for forecast. The equations are given as

Level: $L_t = \alpha Y_t + (1-\alpha)(L_{t-1} + b_{t-1})$

Trend: $b_t = \beta(L_t - L_{t-1}) + (1-\beta)b_{t-1}$

Forecast: $F_{t+m} = L_t + b_t m$

Where L_t is the level of the TS at time t. b_t is the estimate of trend (slope) of the series at time t. α and β are smoothing constants with values, between 0 to 1 and F_{t+m} is the forecast for m periods ahead of t. The combination of α and β which gives lowest Mean Absolute Percentage Error (MAPE) will be selected.

Holt-Winters' (Triple) exponential smoothing method

When the TS data contain trend and seasonal components, Holt-Winters' (Triple) Exponential Smoothing model is used. There are three smoothing equations- one for the level, one for trend and one for seasonality. Depending on whether seasonality is modeled in an additive or multiplicative way, there are two types of Holt-Winters' exponential smoothing models *viz.,* Holt-Winters' Additive Seasonal

(HWAS) model and Holt-Winters' Multiplicative Seasonal (HWMS) exponential smoothing model. In the present study, Holt-Winters' Multiplicative Seasonal (HWMS) model was used. The basic equations for HWMS model are given below:

Level: $L_t = \alpha \frac{Y_t}{S_{t-12}} + (1-\alpha)(L_{t-1} + b_{t-1})$

Trend: $b_t = \beta(L_t - L_{t-1}) + (1-\beta)b_{t-1}$

Seasonal: $S_t = \gamma \frac{Y_t}{L_t} + (1-\gamma)S_{t-s}$

Forecast: $F_{t+m} = (L_t + b_t m)S_{t-s+m}$

Here s is the length of seasonality. For monthly data, s=12. L_t is the level of the TS at time t, b_t is the estimate of trend (slope) of the series at time t. S_t is the seasonal component at time t. F_{t+m} is the forecast for m periods ahead of t. α, β and γ are smoothing constants, each taking the values between 0 and 1. The combination of α, β and γ which yields minimum value for MAPE is selected. For the price data of coconut, coconut oil and copra all the different types of exponential smoothing models were fitted and selected based on the forecast accuracy measure Mean Absolute Percentage Error (MAPE). Eviews package was used for fitting exponential smoothing models.

3.13 Forecast accuracy measures:

In order to measure the reliability of a forecasting model and to select the forecast method for a given data, accuracy measures are used. Accuracy refers to 'goodness of fit' of the model. If Y_t is the actual observation at time period t and F_t is the forecast for the same period, then forecast error, e_t is defined as

$$e_t = Y_t - F_t$$

F_t is calculated using the data Y_1, Y_2, …,Y_{t-1} ie., Forecast is made using all the observations except Y_t. If there are observations and forecasts for n time periods, then there will be n error terms, and the following are the standard statistical forecast error measures.

$$\text{MAE}=\frac{1}{n}\sum_{i=1}^{n}|\ e_t\ |$$

$$\text{MSE}=\frac{1}{n}\sum_{i=1}^{n}|\ e^2{}_t\ |$$

$$\text{RMSE}=\sqrt{\frac{1}{n}\sum_{i=1}^{n}e_t{}^2}$$

MAE, MSE and RMSE depends on the scale of measurement of the data. Relative percentage error measures are free of scale.

Relative percentage Error (PE_t) $= \frac{Y_t - F_t}{Y_t} \times 100$

Based on the relative percentage error, another forecast accuracy measure *viz.,* Mean Absolute Percentage Error (MAPE) is defined as,

$$\text{MAPE} = \frac{1}{n}\sum_{i=1}^{n}\left|PE_t\right|$$

Where, n is the number of observations in the TS.

For selecting the appropriate model for price of coconut oil, copra and coconut in the different markets, Mean Absolute Percentage Error (MAPE), agreement between actual and fitted price plots, residual ACF and PACF plots for ARIMA models, residual plots for ANN and exponential smoothing models, and forecasts for January, February and March 2016 were used.

Results & Discussion

4. RESULTS AND DISCUSSION

The results of the study "Price forecast models for coconut and coconut oil" are presented along with the interactive discussion as follows:

4.1 Analysis of coconut oil price

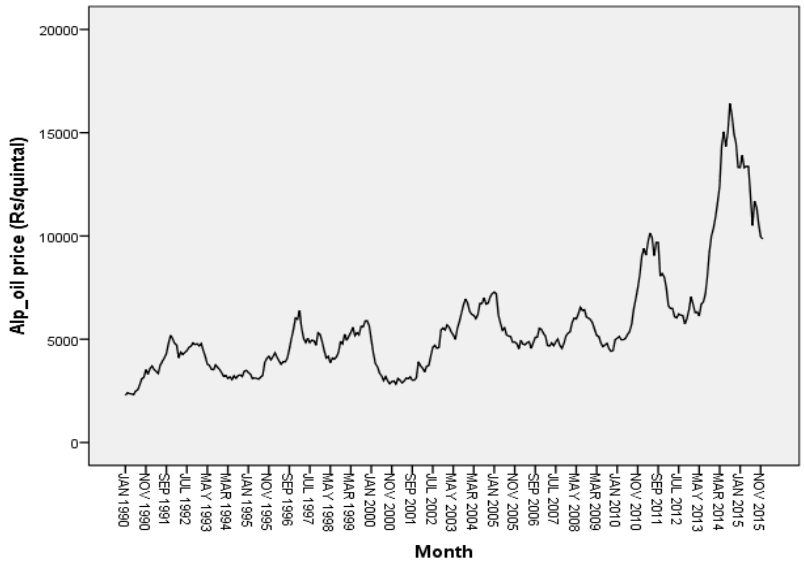
The results obtained from the analysis of coconut oil price data for Alappuzha, Kochi and Kozhikode markets are presented below:

4.1.1 Price pattern of coconut oil

Time plots of price data of coconut oil, from January 1990 to December 2015 were used to study the price pattern of coconut oil in three major markets of Kerala, *viz.*, Alappuzha, Kochi and Kozhikode and details are given below:

4.1.1a. Alappuzha market

Pattern of variation in price of coconut oil at Alappuzha market from January 1990 to December 2015 is exhibited in Fig. 4.1. Wide fluctuations could be observed in the price of coconut oil. During the period from January 1990 to November 2010 (21 years), the price of coconut oil was below Rs.7500/quintal. Although an increase in price was noticed from December 2010 (Rs.8060/quintal) to May 2011 (Rs.10142/quintal), price again started declining after May 2011. In October 2012, the price fell down to Rs.5739/quintal. From November 2012, price again showed an increasing trend and attained the highest price of Rs.16405/quintal in August 2014. From September 2014, the price started declining again and touched Rs.9850/quintal in December, 2015. Declining trend continued after December 2015 also, as per reports from Coconut Development Board, Kochi.



Alp_oil price: coconut oil price at Alappuzha market

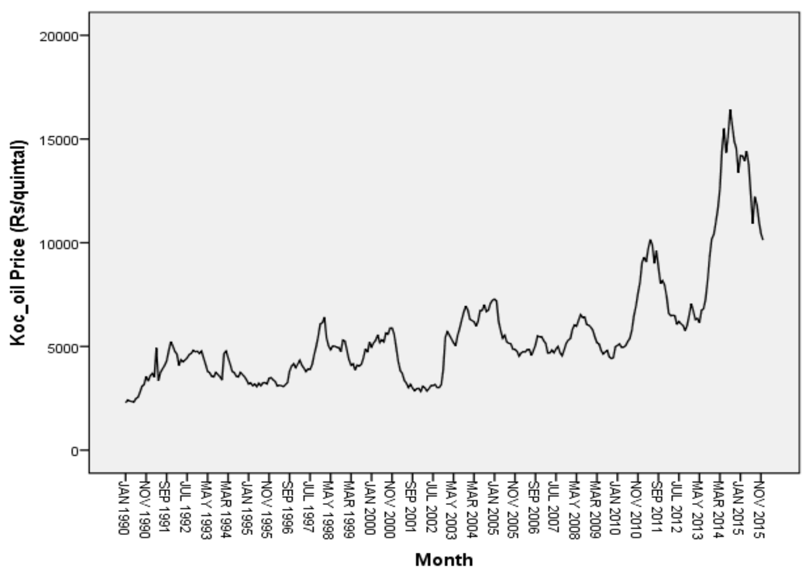
Fig. 4.1.Price pattern of coconut oil at Alappuzha market

4.1.1b. Kochi market

Pattern of variation in price of coconut oil at Kochi market from January 1990 to December 2015 is shown in Fig. 4.2. As in the case of Alappuzha market, wide fluctuation was noticed in the price of coconut oil at Kochi market also. During January 1990 to October 2010, the price of coconut oil was below Rs.7000/quintal. Price was increased to Rs.10148/quintal in May 2011 and after that declining trend was noticed, upto October 2012. The price was Rs.5761/quintal in October 2012. From November 2012, price again showed an increasing trend and attained the highest price of Rs.16421/quintal in August 2014. From September 2014, price started declining again and was Rs.10131/quintal in December 2015. Declining trend continued after December 2015 also, as per reports from Coconut Development Board, Kochi.

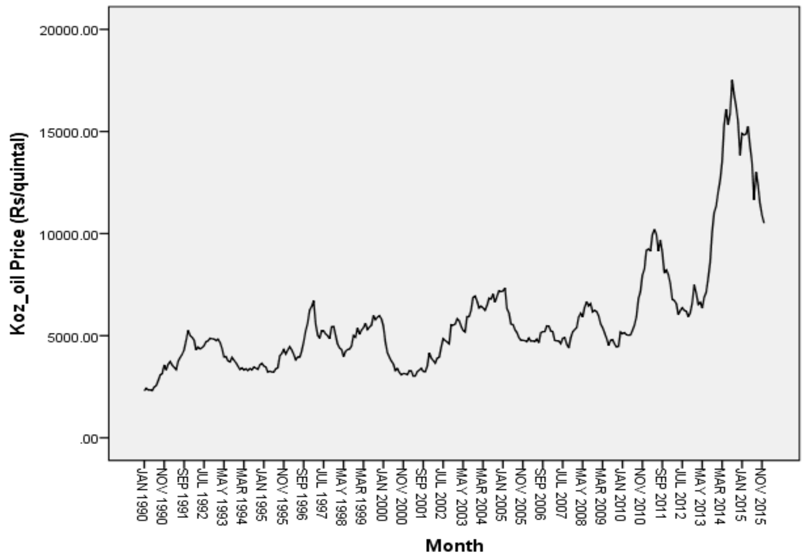
4.1.1c. Kozhikode market

Fig. 4.3 shows the pattern of variation in price of coconut oil at Kozhikode market from January 1990 to December 2015 (312 months). Several ups and downs in price of coconut oil were noted at Kozhikode market also. The price was below Rs.7000/quintal during the period from January 1990 to September 2010. From October 2010 to May 2011, the price varied between Rs.7158/quintal and Rs.10208/quintal. After May 2011, decline in price was noticed upto October 2012 and the price was Rs.5928/quintal in October 2012. From November 2012, price again showed an increasing trend and attained the highest price of Rs.17524/quintal in August 2014. From September 2014, price started declining and was Rs.10512/quintal in December 2015. Declining trend continued after December 2015 also, as per reports from Coconut Development Board, Kochi.



Koc_oil price: Coconut oil price at Kochi market

Fig. 4.2. Price pattern of coconut oil at Kochi market



Koz_oil price: Coconut oil price at Kozhikode market

Fig. 4.3 Price pattern of coconut oil at Kozhikode market

From the analysis of price pattern of coconut oil in the three markets, it could be concluded that, price of coconut oil increased above Rs.10000/quintal once in May 2011 and then during November 2013 to October 2015. At Kochi and Kozhikode markets, the same level was continued upto December 2015. The highest price during the 26 year period was in August 2014 in all the three markets, with Rs.16405/quintal at Alappuzha, Rs.16421/quintal at Kochi, and Rs.17524/quintal at Kozhikode.

4.1.2 Instability in price of coconut oil

To understand the instability in prices of coconut oil in the three markets *viz.*, Alappuzha, Kochi and Kozhikode, coefficient of variation was worked out and is given in Table 4.1.

Table 4.1 Coefficient of variation of price of coconut oil in different markets

Market	Alappuzha	Kochi	Kozhikode
Coefficient of variation (%)	47.52	48.53	49.72

The price of coconut oil showed high variability in all the three markets. It could be noted that variability was higher (49.72 percent) in Kozhikode market followed by Kochi (48.53 percent) and Alappuzha (47.52 percent) markets.

The first step in the TS analysis is isolation of seasonal fluctuations. For this, seasonal indices were calculated as given below:

4.1.3 Seasonal indices of price of coconut oil

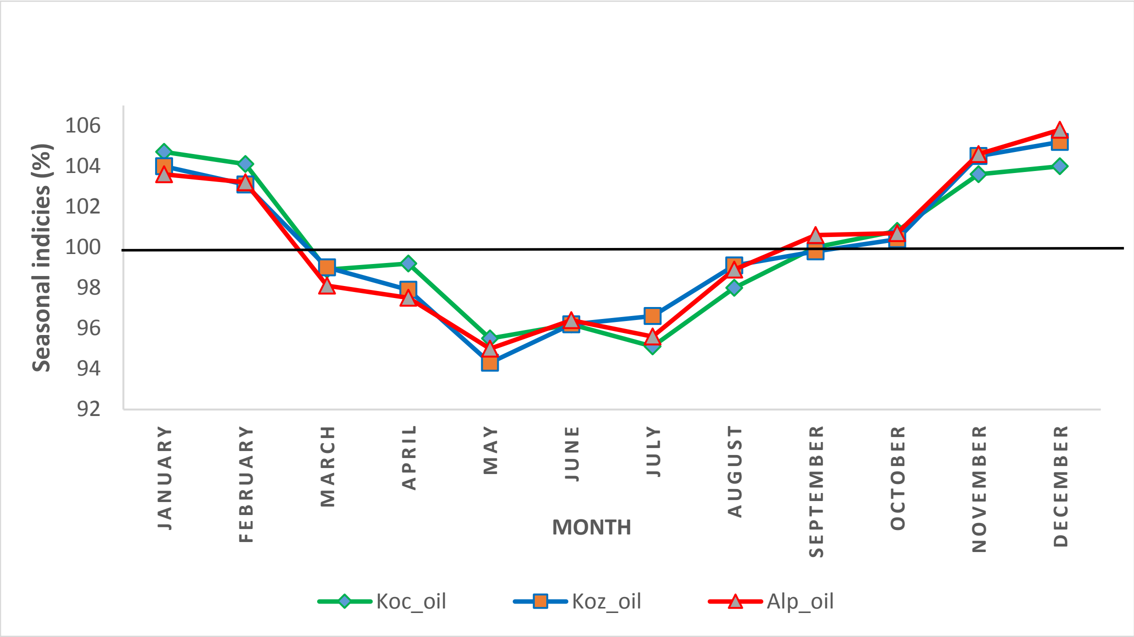
Estimates of seasonal indices of prices of coconut oil at Alappuzha, Kochi and Kozhikode markets are provided in Table 4.2.

Table 4.2 Seasonal indices of price of coconut oil in different markets

Month	Seasonal indices (%) of coconut oil price		
	Alappuzha	Kochi	Kozhikode
January	103.6	104.7	104.0
February	103.2	104.1	103.1
March	98.1	98.9	99.0
April	97.5	99.2	97.9
May	95.0	95.5	94.3
June	96.4	96.2	96.2
July	95.6	95.1	96.6
August	98.9	98.0	99.1
September	100.6	100.0	99.8
October	100.7	100.8	100.4
November	104.6	103.6	104.5
December	105.8	104.0	105.2

It could be observed that seasonal variations in price of coconut oil follow almost the same pattern in all the three markets. Seasonal index was highest in December for Alappuzha (105.8) and Kozhikode (105.2) markets, whereas, in Kochi market, the highest index was in January (104.7). Babu (2005) reported November as the peak price month in all the three markets. Lowest index was obtained in May at

Alappuzha (95.0) and Kozhikode (94.3) markets and in July at Kochi market (95.1). Babu (2005) also reported May as the low price month. The seasonal plots of coconut oil price in the three markets are provided in Fig. 4.4, to have a clear picture of the variation in prices over the different months from January to December.



Alp_oil price: Coconut oil price at Alappuzha market; Koc_oil price: Coconut oil price at Kochi market; Koz_oil price: Coconut oil price at Kozhikode market

Fig. 4.4 Seasonal plot of coconut oil price at Alappuzha, Kochi and Kozhikode markets

From the figure, it could be observed that a buoyant phase in price of coconut oil was observed during September to February at Alappuzha, Kochi and Kozhikode markets. The depressed phase for price of coconut oil was from March to August in the three markets. Babu *et al.* (2009) got August to January as the buoyant phase at Alappuzha and Kozhikode markets and September to January at Kochi market. Babu *et al.* (2009) reported February to July as the depressed phase at Alappuzha and Kozhikode markets and February to August at Kochi. The findings of the present study are more or less in uniformity with the findings of Babu *et al.* (2009) with accommodative minor variations as the TS data considered here is to a more prolonged period.

From the analysis of seasonal variations in price of coconut oil in the three markets, the following conclusions could be made:

Increase in price of coconut oil is observed from August onwards. Peak price is obtained during December and January with buoyant phase from September to February. This period coincides with festival season in Kerala. May is the low price month with depressed phase from March to August. This period coincides with the peak harvesting period of coconut in Kerala.

4.1.4 Forecast modeling for price of coconut oil

ARIMA, ANN and exponential smoothing models, were fitted for price of coconut oil for all the three markets (Alappuzha, Kochi and Kozhikode). The best model in each market was selected based on the forecast accuracy measure, Mean Absolute Percentage Error (MAPE), agreement between actual and fitted price plots, residual ACF and PACF plots for ARIMA models, residual plots for ANN and exponential smoothing models, and forecasts for January, February and March 2016 were used. The results for Alappuzha, Kochi and Kozhikode are provided in sections 4.1.4.1 to 4.1.4.3.

4.1.4.1 Forecast model for coconut oil price at Alappuzha market

The fitting of ARIMA, ANN and exponential smoothing models for coconut oil at Alappuzha market are presented from 4.4.1.1a to 4.4.1.1c.

4.1.4.1a. ARIMA model for coconut oil price at Alappuzha market

The time plot of coconut oil price at Alappuzha market (Fig. 4.1) indicates that it is non-stationary. ACF and PACF for coconut oil price at Alappuzha market are provided in Table 4.3. Significance of autocorrelations upto 16 lags confirms the non stationarity of the data. PACF has very high value for lag1.

Table 4.3. ACF and PACF values for coconut oil price at Alappuzha market

Lag	Auto-correlation	S.E	Ljung- Box Statistic			Partial Auto-correlation	S.E
			Value	Df	Probability (p)		
1	0.982	0.056	303.99	1	<0.001	0.982	0.057
2	0.959	0.056	594.34	2	<0.001	-0.187	0.057
3	0.932	0.056	869.61	3	<0.001	-0.065	0.057
4	0.898	0.056	1126.30	4	<0.001	-0.191	0.057
5	0.859	0.056	1362.04	5	<0.001	-0.119	0.057
6	0.823	0.056	1578.82	6	<0.001	0.104	0.057
7	0.781	0.056	1774.79	7	<0.001	-0.167	0.057
8	0.735	0.056	1949.08	8	<0.001	-0.066	0.057
9	0.691	0.056	2103.42	9	<0.001	0.030	0.057
10	0.647	0.056	2239.04	10	<0.001	-0.013	0.057
11	0.601	0.055	2356.71	11	<0.001	0.007	0.057
12	0.559	0.055	2458.64	12	<0.001	0.033	0.057
13	0.516	0.055	2545.79	13	<0.001	-0.082	0.057
14	0.472	0.055	2619.15	14	<0.001	-0.004	0.057
15	0.432	0.055	2680.66	15	<0.001	0.036	0.057
16	0.392	0.055	2731.59	16	<0.001	-0.043	0.057

p<0.05 indicates significance of autocorrelation

The ACF and PACF plots for coconut oil price at Alappuzha market is depicted in Fig. 4.5. It could be observed that in the ACF plot, spikes upto 16 lags fall above upper confidence limit (UCL) indicating the non-stationarity of the TS. PACF plot also showed spikes for a number of lags (1, 2, 4, 5, 6 and 7) beyond confidence limits.

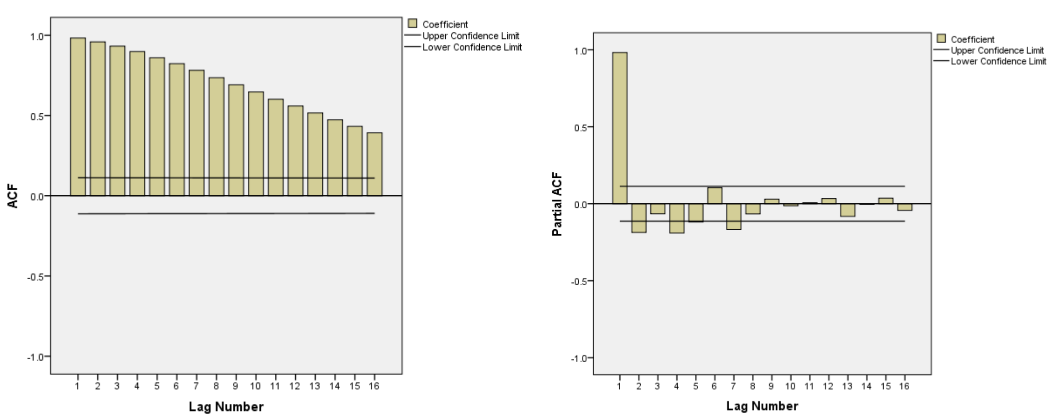


Fig. 4.5 ACF and PACF plots of coconut oil price at Alappuzha market

The stationarity of the data was assessed using ADF test. After first differencing of the data, ADF test was conducted again. Significance of the ADF test statistic as given in Table 4.4 confirmed that first difference is required to make the data stationary. Hence, first difference was taken before fitting ARIMA model for coconut oil price at Alappuzha market.

Table 4.4 ADF test with critical values for coconut oil price at Alappuzha market

	ADF test statistic	Probability (p)	Critical values
Observed price	-2.24[NS]	0.19	-3.45 (1% level)
First difference	-7.02**	0.0001	-2.87 (5% level)

$p < 0.05$ indicate significance, **significant at 1% level

From among the several alternative ARIMA models tried, ARIMA (3,1,0) was identified for coconut oil price at Alappuzha market. Parameters of the model and their tests of significance are provided in Table 4.5.

Table 4.5 ARIMA (3,1,0) model parameters for coconut oil price at Alappuzha market

Model parameter	Estimate	S.E	t	Probability(p)
AR Lag 1 (ϕ_1)	0.263	0.05	4.94**	0.001
AR Lag 3 (ϕ3)	0.218	0.05	4.05**	0.003
Non seasonal difference	1			

$p < 0.05$ indicate significance, ** significant at 1% level

Thus, ARIMA (3,1,0) model for coconut oil price at Alappuzha market is

$$\left(1-\phi_1 B-\phi_2 B^2-\phi_3 B^3\right)(1-B)Y_t=\varepsilon_t$$

Where, $\phi_1 = 0.263$, $\phi_2 = 0$ and $\phi_3 = 0.218$

With these parameters, the ARIMA (3,1,0) model for coconut oil price at Alappuzha market is

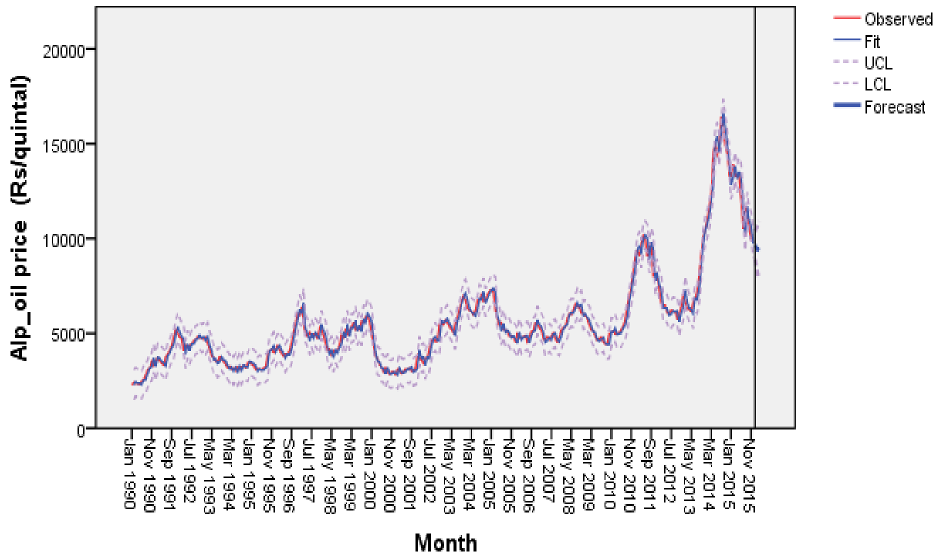
$$\left(1-0.263B-0.218B^3\right)\left(1-B\right)Y_t=\varepsilon_t$$

The model fit statistics obtained for the above model are given in the Table 4.6.

Table 4.6 Model fit statistics of ARIMA (3,1,0) model for coconut oil price at Alappuzha market

Model Fit statistics				
R^2	RMSE	MAPE (%)	MAE	Normalized BIC
0.981	373.23	**4.73**	268.34	11.88

The model could explain 98% of the variation in the data and the MAPE was only 4.73%. The plot of actual and fit values along with the upper and lower confidence limits and forecasts for coconut oil price at Alappuzha market using ARIMA(3,1,0) model is given in Fig. 4.6. From the figure it could be observed that the actual and predicted (fit) prices are in agreement. Residual ACF and PACF plots for the ARIMA(3,1,0) model fitted for coconut oil price at Alappuzha market is provided in Fig. 4.7. It could be seen that majority of the spikes in the ACF and PACF plots fall within the critical values. This shows the adequacy of ARIMA(3,1,0) model for coconut oil price at Alappuzha market.



Alp_oil price: coconut oil price at Alappuzha market

Fig. 4.6 Observed, fit, LCL, UCL and forecast values with ARIMA(3,1,0) model for coconut oil price at Alappuzha market

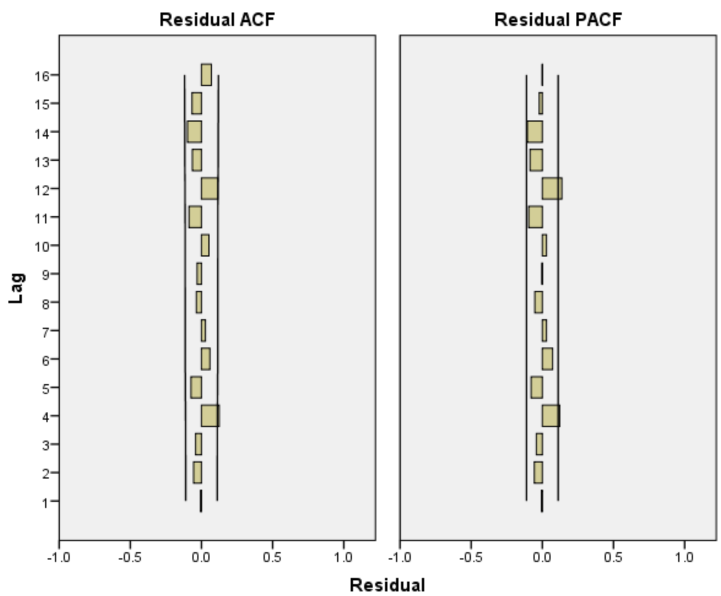


Fig. 4.7 Residual ACF and PACF plots for coconut oil price at Alappuzha market for ARIMA (3,1,0) model

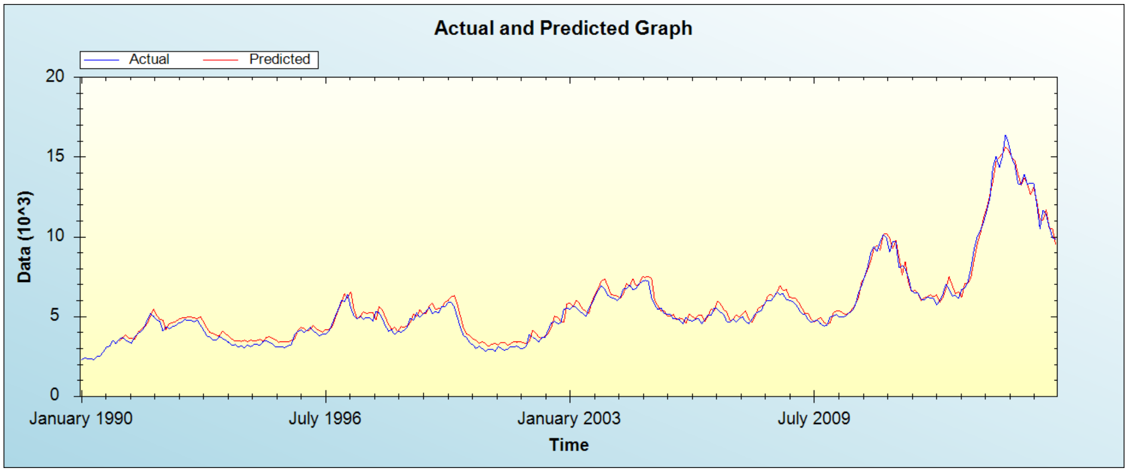
The forecasts of coconut oil price at Alappuzha market based on ARIMA (3,1,0) model fitted from January 2016 to March 2016 are provided in Table 4.7 along with the upper and lower confidence limits and MAPE value.

Table 4.7 Forecasts for ARIMA (3,1,0) model fitted for coconut oil price at Alappuzha market

Month	Forecast price			MAPE (%)
	Forecast price (Rs/quintal)	LCL	UCL	
Jan-16	9648	8913	10382	4.73
Feb-16	9455	8272	10638	
Mar-16	9380	7845	10915	

4.1.4.1b. ANN model

ANN model was fitted for coconut oil price at Alappuzha market. The actual price along with the predicted values of coconut oil price at Alappuzha market using ANN model is plotted in Fig. 4.8.



Data - Coconut oil price at Alappuzha market, Time- Month and 10^3 - 10^3Rs/quintal

Fig. 4.8. Actual and predicted plots from ANN model for coconut oil price at Alappuzha market

It could be observed that the ANN model captures the pattern of the TS data well. The MAPE value was only 5.87%. The actual and predicted values lie on a straight-line as seen from Fig. 4.9, indicating the adequacy of the model for the data. The residual plot from ANN model is provided in Fig. 4.10. The residuals did not exhibit any specific pattern.

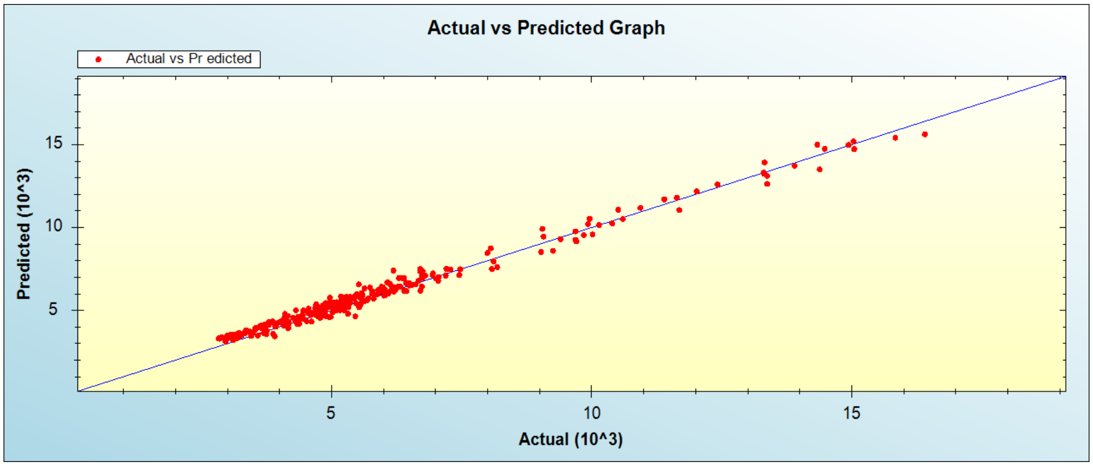


Fig. 4.9 Actual vs. predicted values from ANN model for coconut oil price at Alappuzha market

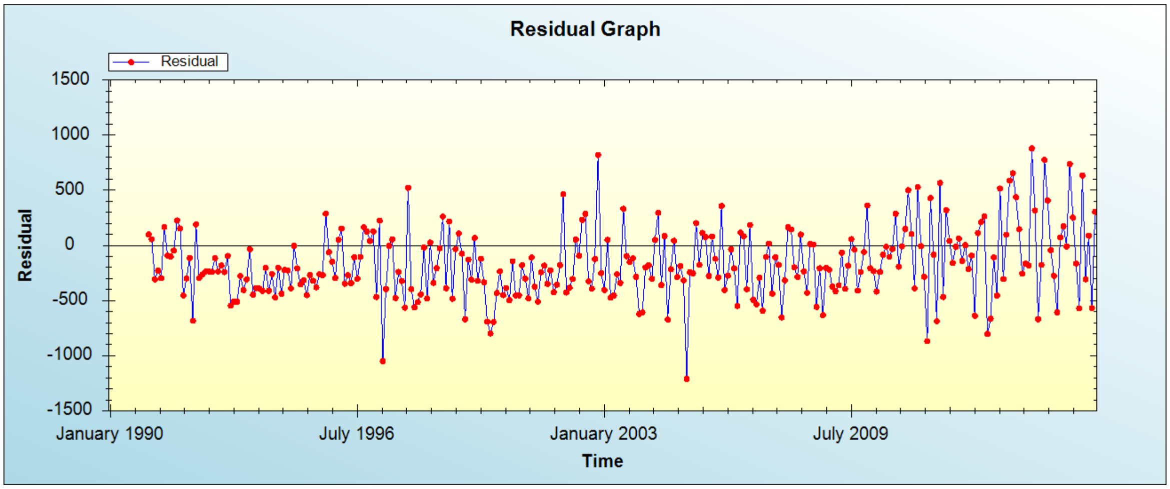


Fig. 4.10. Residual plot for coconut oil price at Alappuzha market from ANN model

The forecasts using ANN model from January 2016 to March 2016 are given in Table 4.8 along with MAPE value. Various accuracy measures for ANN model are provided in Table 4.9.

Table 4.8 Forecasts from ANN model for coconut oil price at Alappuzha market

Month	Forecast price	MAPE (%)
Jan-16	8595	5.87
Feb-16	8272	
Mar-16	8571	

Table 4.9. Model accuracy measures by ANN model for coconut oil price at Alappuzha market

Accuracy measure	Value
RMSE	356.91
MAE	294.36
MAPE (%)	**5.87**

4.1.4.1c. Exponential smoothing model

Holt-Winters' Multiplicative Seasonal (HWMS) model was identified from among the different exponential smoothing models like SES, DES, HWAS and HWMS, for the coconut oil price at Alappuzha market. The estimates of parameters of HWMS model are provided in Table 4.10.

Table 4.10. Estimates of parameters of the HWMS model for coconut oil price at Alappuzha market

Parameter	α	β	γ
Estimate	1.00	0.28	0.00

With these values for the parameters, the equations of the HWMS model for coconut oil price at Alappuzha market are given below:

Level: $L_t = \frac{Y_t}{S_{t-12}}$ Trend: $b_t = 0.28(L_t - L_{t-1}) + 0.72b_{t-1}$

Seasonal: $S_t = S_{t-12}$ Forecast: $F_{t+m} = (L_t + b_t m)S_{t-12+m}$

The values of L_t, b_t, and S_t at time t were estimated first and substituted in the forecast equation F_{t+m}, to obtain the m period ahead forecast. The fit of the HWMS model for coconut oil price at Alappuzha market can be seen from Fig. 4.11. The actual and predicted values are in close agreement.

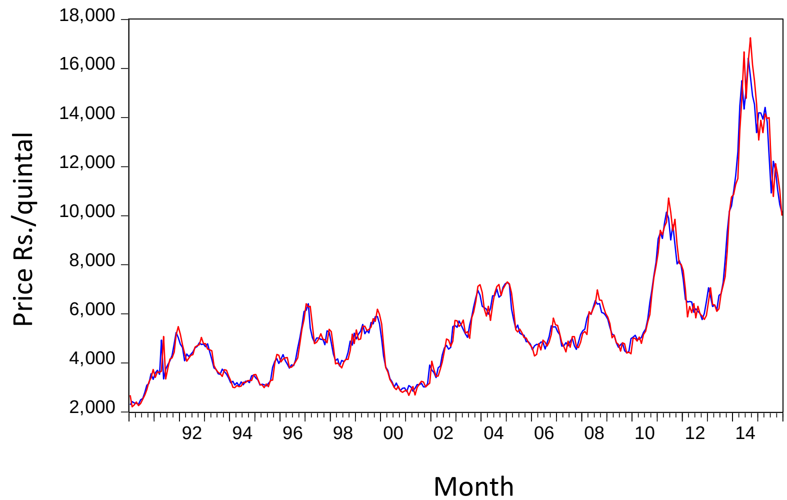


Fig. 4.11. Actual and predicted plots for coconut oil price at Alappuzha market from HWMS model

The residual plot for coconut oil price at Alappuzha market from HWMS model is given in Fig. 4.12.

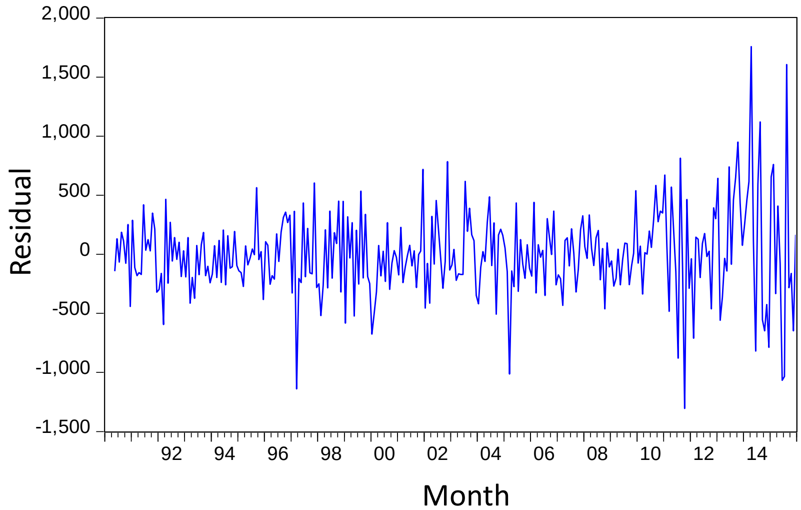


Fig. 4.12 Residual plot for coconut oil price at Alappuzha market for HWMS model

The forecasts obtained for January, February and March, 2016 based on HWMS model are provided in Table 4.11. The MAPE is only 4.21 percent for HWMS model.

Table 4.11 Price forecasts from HWMS model for coconut oil price at Alappuzha market

Month	Forecast price	MAPE (%)
Jan-16	9156	4.21
Feb-16	8691	
Mar-16	7767	

Actual prices for January, February and March, 2016 and forecast prices from ARIMA (3,1,0), ANN and HWMS models for coconut oil price at Alappuzha market are provided in Table 4.12, along with MAPE (%) for validation of the models.

Table 4.12 Validation of forecast price of coconut oil at Alappuzha market

Month	Actual price (Rs./quintal)	Forecast price		
		ARIMA (3,1,0)	ANN	HWMS
Jan-16	8779 (8400-9100)	9648 (8913-10382)	8595	9156
Feb-16	8500 (8400-8700)	9455 (8272-10638)	8272	8691
Mar-16	8025 (7600-8750)	9380 (7845-10915)	8571	7767
MAPE (%)		**4.73**	**5.87**	**4.21**

Values in parenthesis indicate the price range.

Forecast based on HWMS model were in more agreement with the actual price in all the three months compared to ARIMA (3,1,0) and ANN models. For the ARIMA (3,1,0) model fitted all the spikes in the residual PACF plot except few were not within the critical values. But the actual and predicted plots were in more agreement for HWMS model compared to ANN model. Thus, for coconut oil price at Alappuzha market HWMS model was selected as the best forecast model. Daily price data along with the forecast price for coconut oil at Alappuzha market for January, February and March, 2016 are provided in Appendix-I.

4.1.4.2 Forecast models for coconut oil price at Kochi

The fitting of ARIMA, ANN and exponential smoothing models are presented from 4.1.4.2a to 4.1.4.2c.

4.1.4.2a. ARIMA model for coconut oil price at Kochi market

The time plot of coconut oil price at Kochi (Fig. 4.2) indicates the non-stationarity of the data. ACF and PACF for coconut oil price at Kochi are provided in Table 4.13. Significance of autocorrelations upto 16 lags confirms the non- stationarity of the data. PACF had very high value for lag1.

The ACF and PACF plots for coconut oil price at Kochi is depicted in Fig. 4.13. It could be observed that in the ACF plot, spikes upto 16 lags fall above critical values indicating the non-stationarity of the TS. PACF plot also showed spikes for a number of lags (1, 2, 4 and 7) beyond critical values.

Table 4.13. ACF and PACF values for coconut oil price at Kochi market

Lag	Auto-correlation	S.E	Ljung- Box statistic			Partial Auto-correlation	S.E
			Value	Df	Probability (p)		
1	0.982	0.056	303.47	1	<0.0001	0.982	0.057
2	0.958	0.056	593.47	2	<0.0001	-0.148	0.057
3	0.931	0.056	868.18	3	<0.0001	-0.092	0.057
4	0.898	0.056	1124.79	4	<0.0001	-0.147	0.057
5	0.861	0.056	1361.48	5	<0.0001	-0.100	0.057
6	0.825	0.056	1579.55	6	<0.0001	0.053	0.057
7	0.785	0.056	1777.36	7	<0.0001	-0.133	0.057
8	0.740	0.056	1953.84	8	<0.0001	-0.100	0.057
9	0.695	0.056	2109.84	9	<0.0001	-0.016	0.057
10	0.650	0.056	2246.80	10	<0.0001	0.017	0.057
11	0.605	0.055	2365.94	11	<0.0001	0.018	0.057
12	0.562	0.055	2468.93	12	<0.0001	0.003	0.057
13	0.519	0.055	2557.24	13	<0.0001	-0.015	0.057
14	0.476	0.055	2631.73	14	<0.0001	-0.050	0.057
15	0.436	0.055	2694.45	15	<0.0001	0.067	0.057
16	0.399	0.055	2747.09	16	<0.0001	0.026	0.057

$p<0.05$ indicates significance of autocorrelation

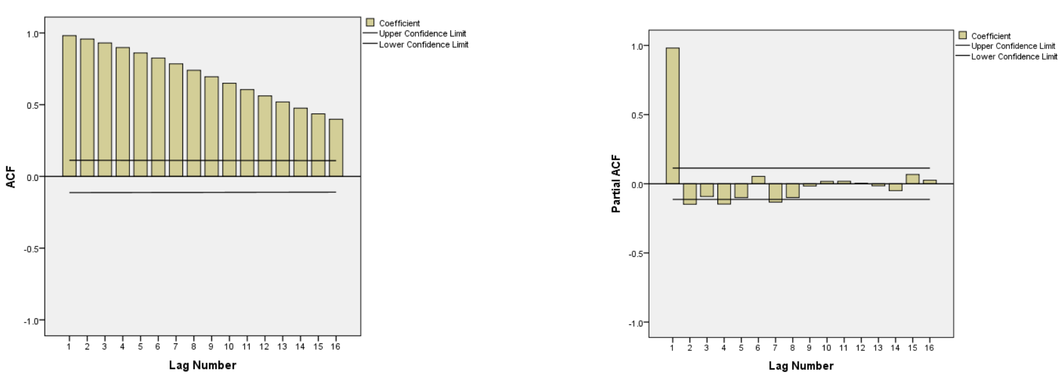


Fig. 4.13. ACF and PACF plots for coconut oil price at Kochi market

ADF test for coconut oil price at Kochi market (Table 4.14) showed that first difference is required to make the TS stationary.

Table 4.14. ADF test with critical values for coconut oil price at Kochi market

	ADF test statistic	Probability (p)	Critical values
Observed price	-1.47^NS	0.55	-3.45 (1% level) -2.87 (5% level)
First difference	-14.38**	0.001	

$p < 0.05$ indicate significance, ** significant at 1% level

For coconut oil price at Kochi market, stationarity in mean was achieved by taking first difference. Natural logarithm of the price data was taken to get stationarity in variance. The model obtained for coconut oil price at Kochi market was SARIMA $(0,1,2)(1,0,1)_{12}$. Parameters of the model and their tests of significance are provided in Table 4.15.

Table 4.15. SARIMA$(0,1,2)(1,0,1)_{12}$ model parameters for coconut oil price at Kochi market

Transformation	Model Parameters	Estimate	SE	t	Probability(p)
$y_t = \log_e Y_t$	Non-seasonal difference	1			
	MA Lag 2 (θ_2)	-0.142	0.06	-2.51**	0.013
	AR, Seasonal Lag 1(Φ_1)	0.950	0.04	24.00**	0.001
	MA, Seasonal Lag 1(Θ_1)	0.861	0.07	11.85**	0.001

$p < 0.05$ indicate significant, ** significant at 1% level

Thus, SARIMA$(0,1,2)(1,0,1)_{12}$ model for coconut oil price at Kochi is

$$(1-\Phi_1 B^{12})(1-B)y_t = (1-\theta_2 B^2)(1-\Theta_1 B^{12})\varepsilon_t \text{ , } y_t = \log_e Y_t$$

Where, $\Phi_1 = 0.950$, $\theta_2 = -0.142$ and $\Theta_1 = 0.861$

With these parameters, the SARIMA(0,1,2)(1,0,1)$_{12}$ model for coconut oil price at Kochi is

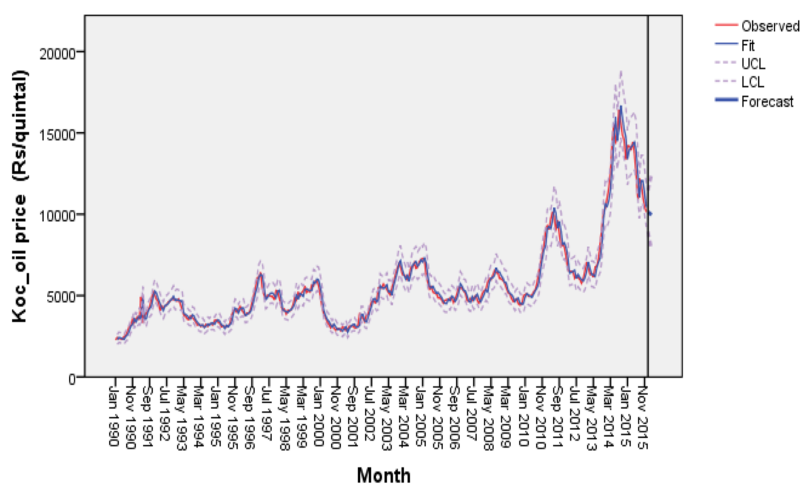
$$(1-0.950B^{12})(1-B)y_t = (1-0.142B^2)(1-0.861B^{12})\varepsilon_t$$

The model fit statistics obtained for the above model are given in the Table 4.16.

Table 4.16. Model fit statistics of SARIMA(0,1,2)(1,0,1)$_{12}$ model for coconut oil price at Kochi market

Model Fit statistics				
R^2	**RMSE**	**MAPE (%)**	**MAE**	**Normalized BIC**
0.98	415.99	**4.79**	283.09	12.12

The model could explain 98% of the variation in the data and the MAPE was only 4.79 percent. The plot of actual and fit values along with the upper and lower confidence limits and forecasts for coconut oil price at Kochi using SARIMA(0,1,2)(1,0,1)$_{12}$ model is given in Fig. 4.14. Fit values are in agreement. It could be been that observed and fit values are in agreement.



Koc_oil price: Coconut oil price at Kochi market

Fig. 4.14 Observed, fit, LCL, UCL and forecast for coconut oil price at Kochi market for SARIMA(0,1,2)(1,0,1)$_{12}$ model

Residual ACF and PACF plots for the SARIMA$(0,1,2)(1,0,1)_{12}$ model fitted for coconut oil price at Kochi is provided in Fig. 4.15. All the spikes in the residual plot fall within the critical values, showing adequacy of the model for coconut oil price at Kozhikode price.

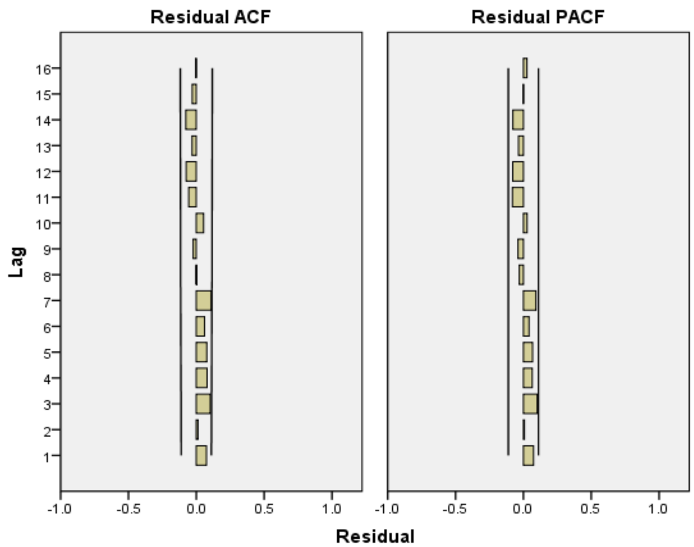


Fig. 4.15. Residual ACF and PACF plots for coconut oil prices at Kochi market for SARIMA$(0,1,2)(1,0,1)_{12}$ model

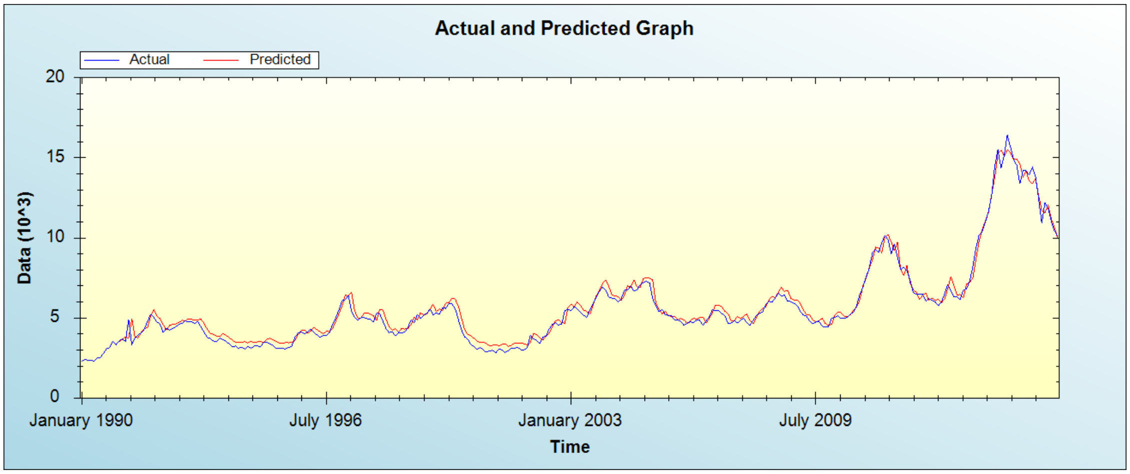
The forecasts of coconut oil price at Kochi market based on SARIMA$(0,1,2)(1,0,1)_{12}$ model fitted from January 2016 to March 2016 are provided in Table 4.17 along with the upper and lower confidence limits and MAPE value.

Table 4.17. Forecasts from SARIMA$(0,1,2)(1,0,1)_{12}$ model fitted for coconut oil price at Kochi market

Month	Forecast price			MAPE (%)
	Forecast price (Rs/quintal)	UCL	LCL	
Jan-16	10141	11464	8936	4.79
Feb-16	10064	11955	8405	
Mar-16	9954	12401	7885	

4.1.4.2b. ANN model

ANN model was fitted for coconut oil price at Kochi. The actual price along with the predicted (fit) values of coconut oil price at Kochi using ANN model is provided in Fig. 4.16.



Data -Coconut oil price at Kochi, Time- Month and 10^3 -10^3 Rs/quintal

Fig. 4.16. Actual and predicted plots from ANN model for coconut oil price at Kochi market

It could be observed that the ANN model captures the pattern of the TS data well. The MAPE value was only 6.01 percent. The actual and predicted values lie very close a straight-line as seen from Fig. 4.17, indicating the adequacy of the model for the data.

The residual plot from ANN for coconut oil price at Kochi is provided in Fig. 4.18. Since the residuals do not show any pattern the ANN model is adequate for the data.

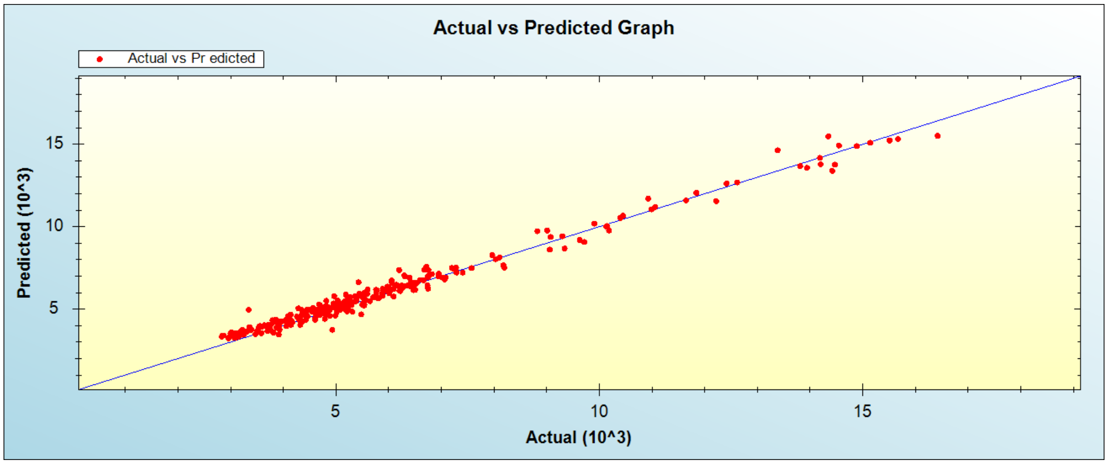
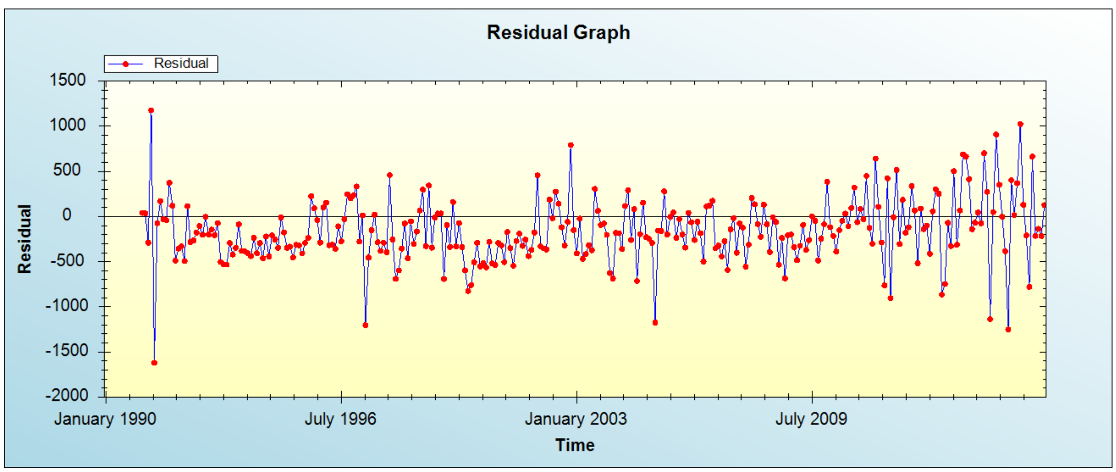


Fig. 4.17 Actual vs. predicted graph from ANN model for coconut oil price at Kochi market



Time-Month

Fig. 4.18. Residual plot for coconut oil price at Kochi market from ANN model

The forecasts using ANN model from January 2016 to March 2016 are given in Table 4.18 along with MAPE value. Various accuracy measures for ANN model are provided in Table 4.19.

Table 4.18. Forecasts from ANN model for coconut oil price at Kochi market

Month	Forecast price	MAPE (%)
Jan-16	8975	6.01
Feb-16	7361	
Mar-16	7010	

Table 4.19. Model accuracy measures for ANN model for coconut oil price at Kochi market

Accuracy measure	Value
RMSE	384.96
MAE	300.14
MAPE (%)	**6.01**

4.1.4.2.3 Exponential smoothing models

Holt-Winters' Multiplicative Seasonal (HWMS) model was identified from among the different exponential smoothing models like SES, DES, HWAS and HWMS models for the coconut oil price at Kochi market. The estimates of parameters of HWMS model are provided in Table 4.20.

Table 4.20. Estimates of parameter of HWMS model for coconut oil price at Kochi market

Parameter	α	β	γ
Estimate	1.00	0.21	0.00

With these values for the parameters, the equations of the HWMS model for coconut oil price at Kochi market is given below;

Level: $L_t = \frac{Y_t}{S_{t-12}}$ Trend: $b_t = 0.21(L_t - L_{t-1}) + 0.79 b_{t-1}$

Seasonal: $S_t = S_{t-12}$ Forecast: $F_{t+m} = (L_t + b_t m) S_{t-12+m}$

The values of L_t, b_t, and S_t at time t were estimated first and substituted in the forecast equation F_{t+m} to obtain the m period ahead forecast. The fit of the HWMS model for coconut oil price at Kochi market can be seen from Fig. 4.19. The actual and predicted values are in close agreement.

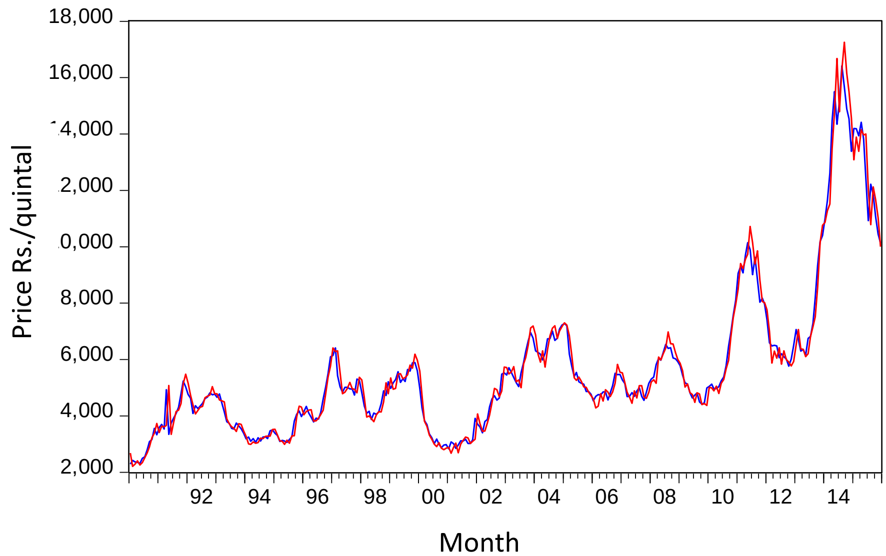


Fig. 4.19. Actual and predicted plots fitted for coconut oil price at Kochi market from HWMS model

The residual plot for coconut oil price at Kochi market from HWMS model is given in Fig. 4.20.

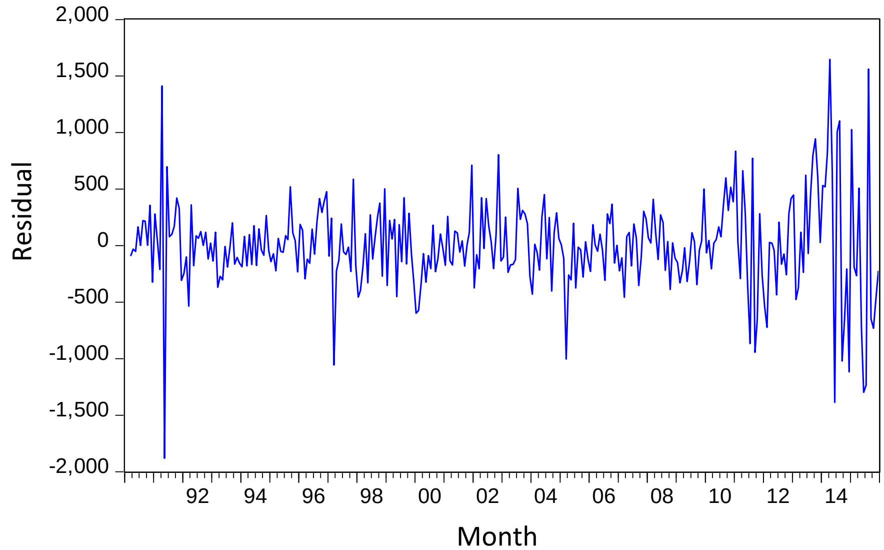


Fig. 4.20. Residual plot for coconut oil price at Kochi market for HWMS model

The forecasts obtained for January, February and March, 2016 based on HWMS model are provided in Table 4.21. The MAPE is only 4.43 percent for HWMS model.

Table 4.21. Price forecasts from HWMS model for coconut oil price at Kochi market

Month	Forecast price	MAPE (%)
Jan-16	9449	4.43
Feb-16	8912	
Mar-16	8004	

Actual prices for January, February and March, 2016 and forecast prices from SARIMA(0,1,2)(1,0,1)$_{12}$, ANN and HWMS models for coconut oil price at Kochi market are provided in Table 4.22, along with MAPE (%) for validation of the models.

Table 4.22 Validation of forecast price of coconut oil at Kochi market

Month	Actual price (Rs./quintal)	Forecast price		
		SARIMA(0,1,2)(1,0,1)$_{12}$	ANN	HWMS
Jan-16	9296 (9000-9600)	10141 (8936-11464)	9276	9736
Feb-16	9093 (8950-9300)	10064 (8405-11955)	8249	9233
Mar-16	8448 (8200-9000)	9954 (7885-12401)	7952	8318
MAPE (%)		**4.79**	**6.01**	**4.43**

Values in parenthesis indicate the price range.

When the forecast prices were compared from the three models HWMS model gave better forecast. MAPE was least for HWMS model. Also, when the actual and predicted plots as well as residual plots in the three models were compared HWMS model was more adequate for forecasting coconut oil price at Kochi. Daily price data along with the forecast price of coconut oil at Kochi market for January, February and March, 2016 are provided in Appendix-II.

4.1.4.3 Forecast model for coconut oil price at Kozhikode market

The fitting of ARIMA, ANN and exponential smoothing models are presented from 4.1.4.3a to 4.1.4.3c.

4.1.4.3a. ARIMA model for coconut oil price at Kozhikode market

The time plot of coconut oil price at Kozhikode market (Fig. 4.3) indicates the non-stationarity of the data. ACF and PACF values for coconut oil price at Kozhikode market are provided in Table 4.23. Significance of autocorrelations upto 16 lags confirms the non-stationarity of the data. PACF had very high value for lag1.

The ACF and PACF plots for coconut oil price at Kozhikode market is depicted in Fig. 4.21. It could be observed that in the ACF plot, spikes upto 16 lags fall above critical values indicating the non-stationarity of the TS. PACF plot also showed spikes for a number of lags (1, 2, 3, 4 and 7) beyond critical values.

Table 4.23 ACF and PACF values for coconut oil price at Kozhikode market

Lag	Auto-correlation	S.E	Ljung- Box Statistic			Partial Auto-correlation	S.E
			Value	df	Probability (p)		
1	0.983	0.057	304.29	1	<0.0001	0.983	0.056
2	0.96	0.057	595.78	2	<0.0001	-0.163	0.056
3	0.934	0.057	872.24	3	<0.0001	-0.114	0.056
4	0.902	0.057	1131.06	4	<0.0001	-0.137	0.056
5	0.866	0.057	1370.5	5	<0.0001	-0.098	0.056
6	0.830	0.057	1591.00	6	<0.0001	0.018	0.056
7	0.789	0.057	1791.00	7	<0.0001	-0.129	0.056
8	0.745	0.057	1969.70	8	<0.0001	-0.085	0.056
9	0.700	0.057	2128.13	9	<0.0001	0.000	0.056
10	0.656	0.057	2267.61	10	<0.0001	0.030	0.056
11	0.612	0.057	2389.32	11	<0.0001	0.001	0.055
12	0.568	0.057	2494.66	12	<0.0001	-0.010	0.055
13	0.526	0.057	2585.17	13	<0.0001	-0.001	0.055
14	0.482	0.057	2661.56	14	<0.0001	-0.066	0.055
15	0.441	0.057	2725.68	15	<0.0001	0.049	0.055
16	0.401	0.057	2778.88	16	<0.0001	-0.023	0.055

$p<0.05$ indicates significance of autocorrelation

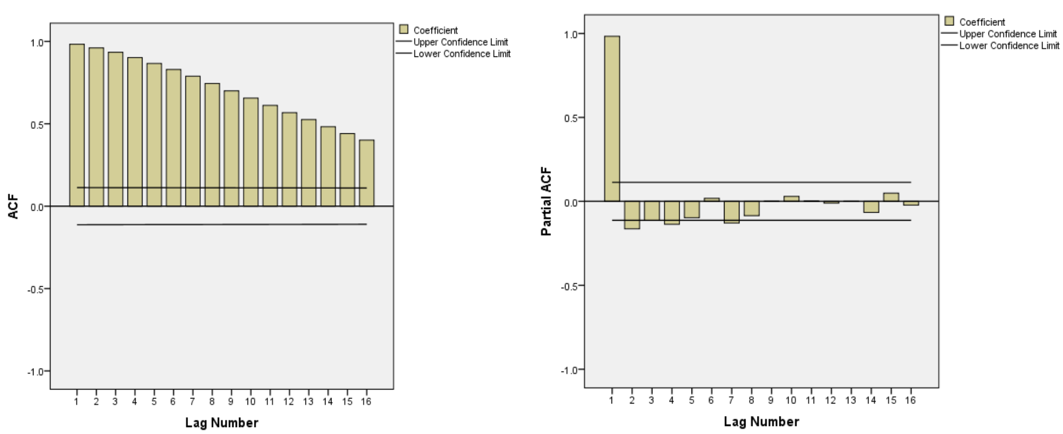


Fig. 4.21. ACF and PACF plots of coconut oil price at Kozhikode market

ADF test was performed on coconut oil price at Kozhikode market to test whether differencing is needed for making the data stationary in mean. ADF test results are provided in Table 4.24. It could be inferred that first differencing is required to achieve stationarity in mean.

Table 4.24 ADF test with critical values for coconut oil price at Kozhikode market

	ADF test statistic	Probability (p)	Critical values
Observed price	-1.44^{NS}	0.56	-3.45 (1% level) -2.87 (5% level)
First difference	-13.97**	0.001	

$p < 0.05$ indicate significance, ** significant at 1% level

Before fitting ARIMA model, natural logarithm was taken to achieve stationarity in variance. The transformed and differenced data were used for fitting ARIMA model. SARIMA$(1,1,1)(1,0,1)_{12}$ was identified from among several alternative models. Parameters of the model and their tests of significance are provided in Table 4.25.

Table 4.25 Parameters of SARIMA $(1,1,1)(1,0,1)_{12}$ model for coconut oil price at Kozhikode market

Transformation	Model Parameters	Estimate	S.E	t	Probability(p)
$y_t = \log_e Y_t$	**AR Lag 1 (ϕ_1)**	0.816	0.091	8.943**	0.001
	Non-seasonal difference	1			
	MA Lag 1 (θ_1)	0.638	0.121	5.286**	0.004
	AR, Seasonal Lag 1(Φ_1)	0.956	0.035	27.306**	0.001
	MA, Seasonal Lag 1 (Θ_1)	0.856	0.071	12.086**	0.002

$p < 0.05$ indicate significance, ** significant at 1% level

Thus, SARIMA$(1,1,1)(1,0,1)_{12}$ model for coconut oil price at Kozhikode market is

$$(1-\phi_1 B)(1-\Phi_1 B^{12})(1-B)y_t = (1-\theta_1 B)(1-\Theta_1 B^{12})\varepsilon_t$$

Where, ϕ_1=0.816 , Φ_1=0.956 and θ_1= 0.638 , Θ_1=0.856 , $y_t=\log_e Y_t$

Thus the model becomes,

$$(1-0.816B)(1-0.956B^{12})(1-B)y_t = (1-0.638B)(1-0.856B^{12})\varepsilon_t$$

$$y_t = 1.816y_{t-1} - 0.816y_{t-2} + 0.956y_{t-12} - 1.73y_{t-13} + 0.78y_{t-14} + \varepsilon_t - 0.638\varepsilon_{t-1} - 0.856\varepsilon_{t-12} + 0.546\varepsilon_{t-13}$$

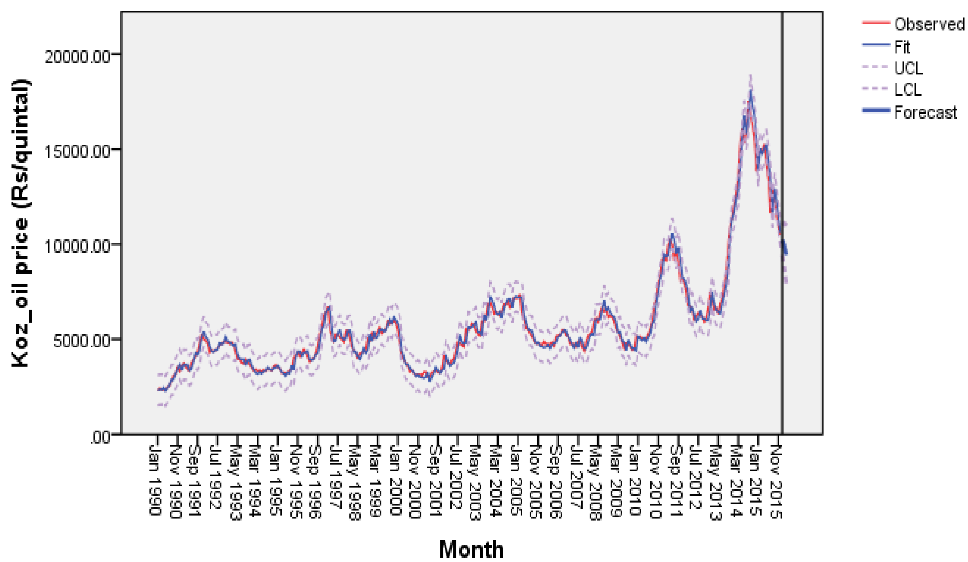
The model fit statistics obtained for the above model are given in the Table 4.26.

Table 4.26 Model fit statistics from SARIMA(1,1,1)(1,0,1)$_{12}$ for coconut oil price at Kozhikode market

Model Fit statistics				
R^2	**RMSE**	**MAPE (%)**	**MAE**	**Normalized BIC**
0.98	407.28	**4.32**	270.63	12.09

The model could explain 98% of the variation in the data and the MAPE was only 4.26 percent. The plot of actual and fit values along with the upper and lower confidence limits and forecasts for coconut oil price at Kozhikode market using SARIMA(1,1,1)(1,0,1)$_{12}$ model is given in Fig. 4.22. From the figure it could observed that actual price and predicted (fit) price based on the model for coconut oil price at Kozhikode market are in agreement.

Residual ACF and PACF plots for the SARIMA (1,1,1)(1,0,1)$_{12}$ model fitted for coconut oil price at Kozhikode market is provided Fig. 4.23. It could be observed that all the autocorrelations upto lags lie within critical values.



Koz_oil price: Coconut oil price at Kozhikode market

Fig. 4.22. Observed, fit, LCL, UCL and forecast for coconut oil price at Kozhikode market for SARIMA (1,1,1)(1,0,1)12 model

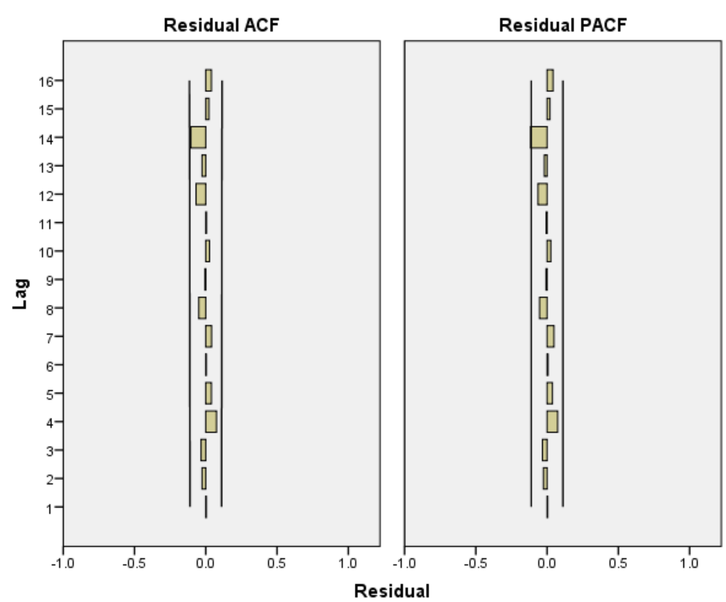


Fig. 4.23. Residual ACF and PACF plots of coconut oil price at Kozhikode market for SARIMA (1,1,1)(1,0,1)12 model

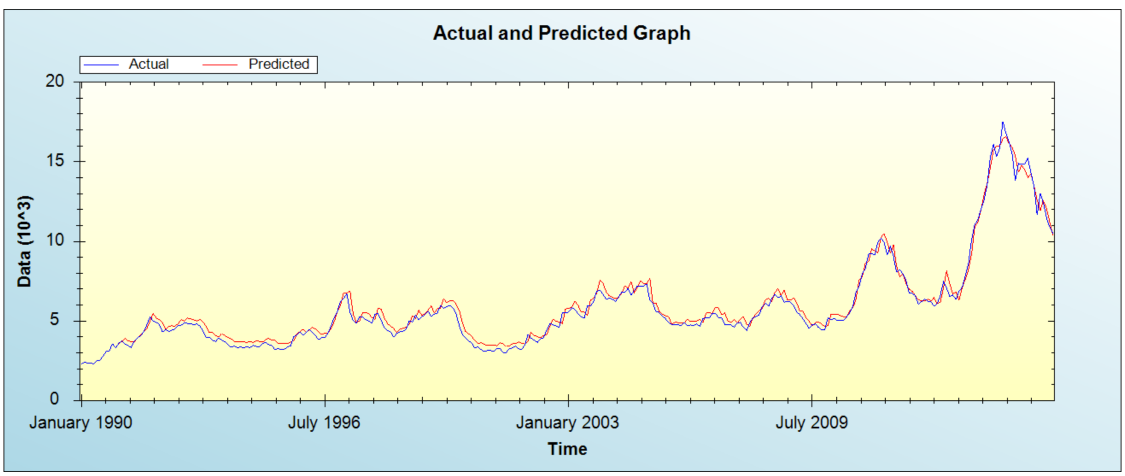
The forecasts of coconut oil price at Kozhikode market based on SARIMA$(1,1,1)(1,0,1)_{12}$ model fitted from January 2016 to March 2016 are provided in Table 4.27, along with the upper and lower confidence limits and MAPE value.

Table 4.27 Forecasts for SARIMA$(1,1,1)(1,0,1)_{12}$ model fitted for coconut oil price at Kozhikode market

Month	Forecast price			MAPE (%)
	Price forecast (Rs/quintal)	LCL	UCL	
Jan-16	10436	9337	11628	4.32
Feb-16	10167	8550	12000	
Mar-16	9904	7872	12301	

4.1.4.3.2 ANN model

ANN model was fitted for coconut oil price at Kozhikode market. The actual price along with the predicted (fit) values of coconut oil price at Kozhikode market based on ANN model is plotted in Fig. 4.24.



Data-Coconut oil price at Kozhikode market, Time- Month and 10^3-0^3 Rs/quintal

Fig. 4.24. Actual and predicted plots from ANN model for coconut oil price at Kozhikode market

Observed that actual price of coconut oil at Kozhikode market and values fitted are in close agreement indicating that the ANN model captures the pattern of the TS data well. Also the actual and predicted values lie very close to a straight-line as seen from Fig. 4.25, indicating the adequacy of the model for the data.

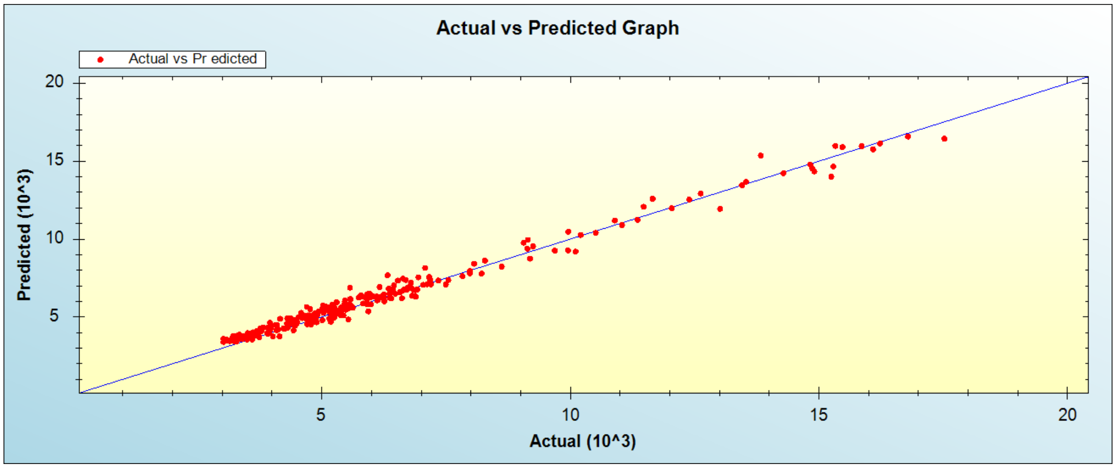


Fig. 4.25. Actual vs. predicted graph from ANN model for coconut oil price at Kozhikode market

The residual plot from ANN model for coconut oil price at Kozhikode market is provided in Fig. 4.26. Since the residuals do not show any pattern the ANN model is adequate for the data.

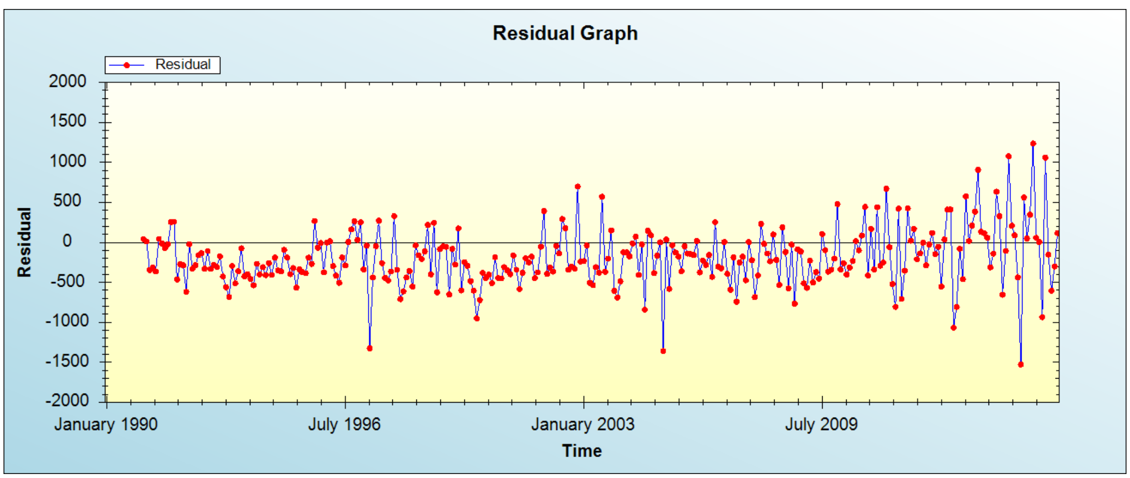


Fig. 4.25 Residual plot for coconut oil price at Kozhikode market from ANN model

The forecasts using ANN model from January 2016 to March 2016 are given in Table 4.28 along with MAPE value. Various accuracy measures for ANN model are provided in Table 4.29.

Table 4.28 Forecasts from ANN model for coconut oil price at Kozhikode market

Month	Forecast price	MAPE (%)
Jan-16	9635	6.14
Feb-16	8204	
Mar-16	7999	

Table 4.29 Model accuracy measures for ANN model for coconut oil price at Kozhikode market

Accuracy measure	Value
RMSE	405.06
MAE	321.94
MAPE (%)	**6.14**

4.1.4.3.3 Exponential smoothing model

Holt-Winters' Multiplicative Seasonal (HWMS) model was identified from among the different exponential smoothing models like SES, DES, HWAS and HWMS models for the coconut oil price at Kozhikode market. The estimates of parameters of HWMS model are provided in Table 4.30.

Table 4.30. Estimates of parameter of the HWMS model for coconut oil price at Kozhikode market

Parameter	α	β	γ
Estimate	1.00	0.22	0.00

With these values for the parameters, the equations of the HWMS model for coconut oil price at Kozhikode market are given below:

Level: $L_t = \frac{Y_t}{S_{t-12}}$ Trend: $b_t = 0.22(L_t - L_{t-1}) + 0.78b_{t-1}$

Seasonal: $S_t = S_{t-12}$ Forecast: $F_{t+m} = (L_t + b_t m)S_{t-12+m}$

The values of L_t, b_t, and S_t at time t were estimated first and substituted in the forecast equation F_{t+m} to obtain the m period ahead forecast. The fit of the HWMS model for coconut oil price at Kozhikode market can be seen from Fig. 4.27. The actual and predicted plots are in close agreement.

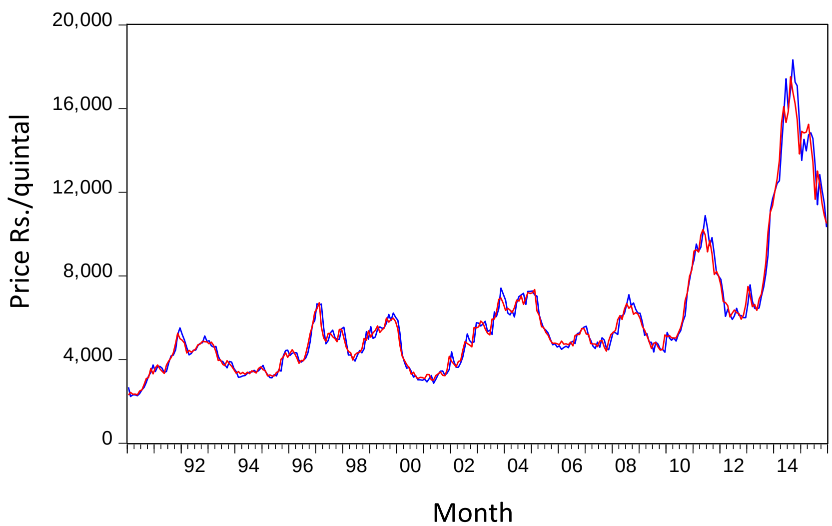


Fig. 4.27. Actual and predicted plots for coconut oil price at Kozhikode market from HWMS model

The residual plot for coconut oil price at Kozhikode market from HWMS model is given in Fig. 4.28. It could be observed that residuals did not exhibit any pattern. This explains the adequacy of the model for the data.

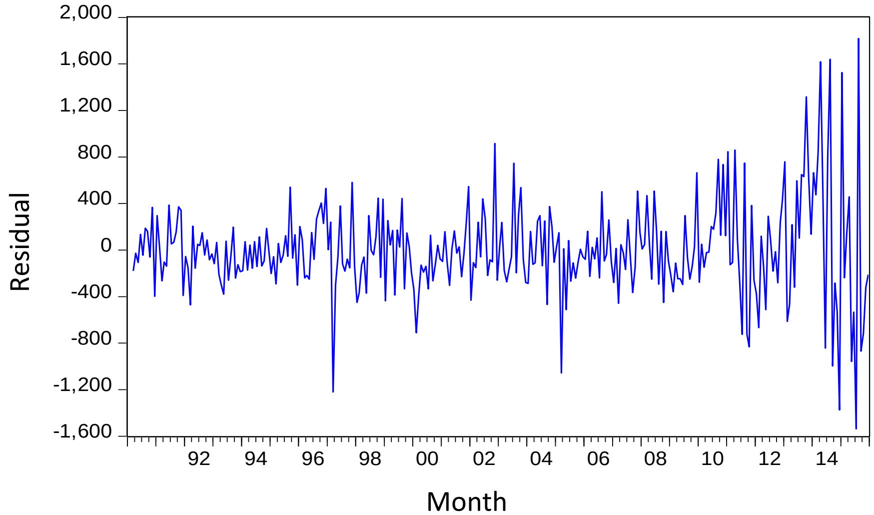


Fig. 4.28. Residual plot for coconut oil price at Kozhikode market from HWMS model

The forecasts obtained for January, February and March, 2016 based on HWMS model are provided in Table 4.31. The MAPE is only 4.37 percent for HWMS model.

Table 4.31 Price forecasts from HWMS model for coconut oil price at Kozhikode market

Month	Forecast price (Rs/quintal)	MAPE (%)
Jan-16	9872	4.37
Feb-16	9280	
Mar-16	8334	

Actual prices for January, February and March, 2016 and forecast prices from ARIMA, ANN and HWMS models for coconut oil price at Kozhikode market are provided in Table 4.32, along with MAPE (%) for validation of the models.

Table 4.32. Validation of forecast price of coconut oil at Kozhikode market

Month	Actual price (Rs/quintal)	Forecast price		
		SARIMA(1,1,1)(1,0,1)$_{12}$	ANN	HWMS
Jan-16	9372 (9000-9500)	10436 (9387-11628)	9635	9872
Feb-16	8896 (8800-9100)	10167 (8550-12001)	8204	9280
Mar-16	8568 (8400-9100)	9904 (7872-12301)	7999	8334
MAPE (%)		**4.32**	**6.14**	**4.37**

Values in parenthesis indicate the price range.

It could be observed from Table 4.32 that none of the models gave good forecasts. But better forecast price range was provided by SARIMA(1,1,1)(1,0,1)$_{12}$ model. MAPE was comparable for both SARIMA(1,1,1)(1,0,1)$_{12}$ and HWMS models. When the actual and predicted plots as well as residual plots were compared, SARIMA(1,1,1)(1,0,1)$_{12}$ and HWMS models could be recommended for coconut oil price at Kozhikode market. Daily price data along with forecast model price of coconut oil at Kozhikode market for January, February and March, 2016 are provided in Appendix-III.

4.2 Analysis of copra price

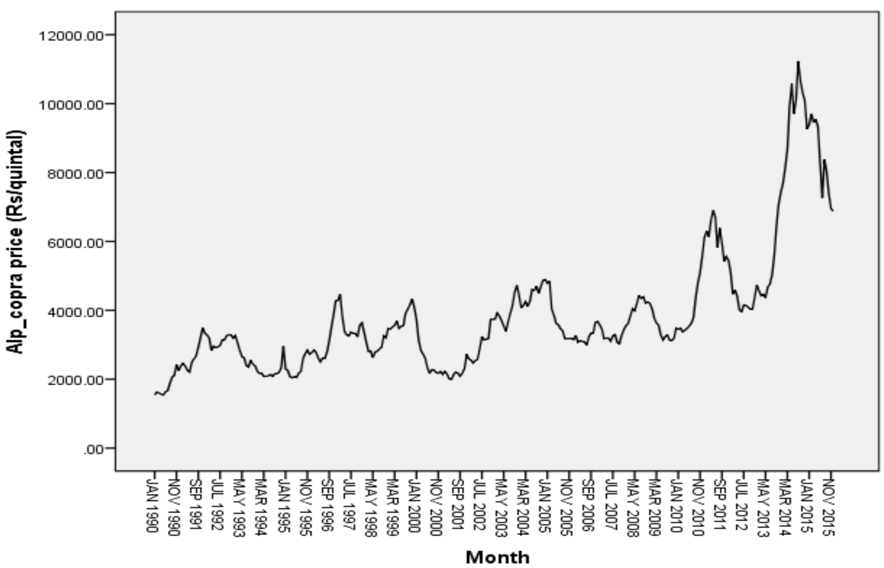
The results obtained from the analysis of copra price for Alappuzha, Kochi and Kozhikode markets are presented below:

4.2.1 Price pattern of copra

The time plot of copra price from January 1990 to December 2015 were used to study price pattern of copra at three markets *viz.*, Alappuzha, Kochi and Kozhikode and the details are given below:

4.2.1a. Alappuzha market

Pattern of variation in Copra price at Alappuzha market from January 1990 to December 2015 is exhibited in Fig. 4.29. Wide fluctuations could be observed in the prices of copra. During the years from January 1990 to October 2010, the price of copra was below Rs.5000/quintal. Although an increase in price was noticed from November 2010 (Rs.5098/quintal) to May 2011 (Rs.6902/quintal), price again stated declining after May 2011. The price was reduced to Rs.3963/quintal in June 2012. From July 2012, the price again showed an increasing trend and attained the highest price of Rs.11233/quintal in August 2014. From September 2014, price started declining and reached Rs.6879/quintal in December 2015. As per the reports of Coconut Development Board, Kochi, the declining continued after December 2015 also.

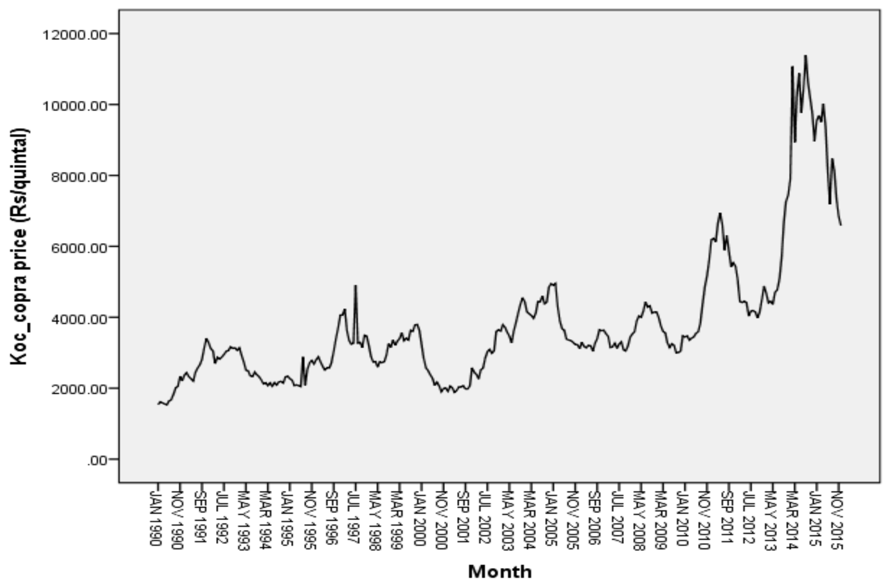


Alp_copra price: Copra price at Alappuzha market

Fig. 4.29. Price pattern of copra at Alappuzha market

4.2.1.2 Kochi market

Pattern of variation in copra price at Kochi market from January 1990 to December 2015 is shown in Fig. 4.30. As in the case of Alappuzha market, wide fluctuation was noticed in the price of copra at Kochi market also. During January 1990 to October 2010 (21 years), the price of copra was below Rs.5000/quintal. However, price was showing increasing trend to Rs.6938/quintal in May 2011 and after that declining trend was noticed upto October 2012. The price was Rs.3987/quintal in October 2012. From November 2012, price again showed an increasing trend and attained the highest price of Rs.11394/quintal in August 2014. From September 2014, price started declining and reached Rs.6585/quintal in December 2015. Also, from the reports of Coconut Development Board, Kochi the declining trend continued after December 2015.



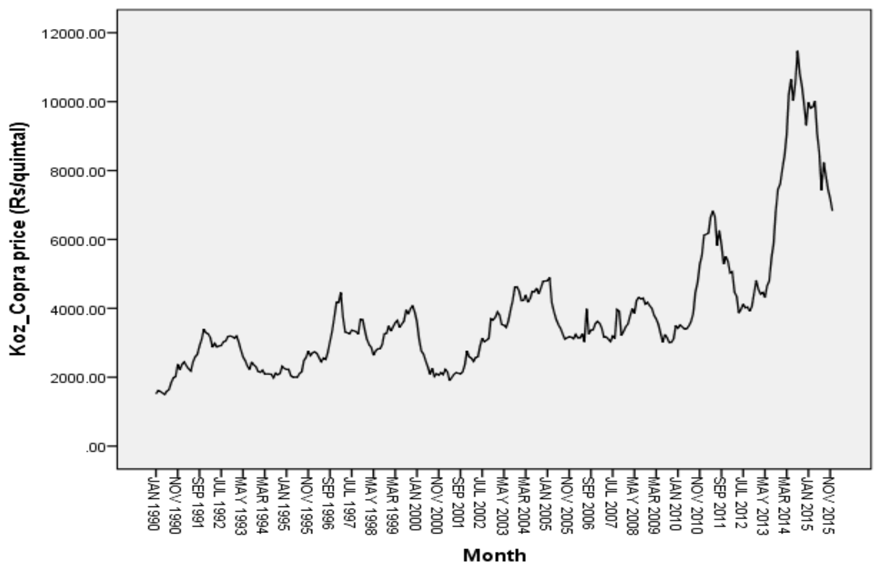
Koc_copra price: Copra price at Kochi market

Fig. 4.30. Price pattern of copra at Kochi market

4.2.1.3 Kozhikode market

Fig. 4.31 shows the pattern of variation in price of copra at Kozhikode market from January 1990 to December 2015 (312 months). Several ups and downs in price of copra were noticed at Kozhikode market also. The price was below Rs.5000/quintal during the 21 year period from January 1990 to October 2010. From November 2010 to May 2011, the price varied between Rs.5267/quintal to Rs.6828/quintal. After May

2011, decline in price was noticed and was reduced to Rs.3686/quintal in October 2012. From November 2012, price again showed an increasing trend and attained the highest price of Rs.11475/quintal in August 2014. From September 2014, price started declining and reached Rs.6829/quintal in December 2015. Declining trend continued after December 2015 also, as per reports from Coconut Development Board, Kochi.



Koz_copra price: Copra price at Kozhikode market

Fig. 4.31. Price pattern of copra at Kozhikode market

The analysis of copra price pattern at Alappuzha, Kochi and Kozhikode markets revealed the fluctuation in price of copra with several ups and downs. In all the three markets, price of copra increased above Rs.6000/quintal once in May 2011 and then during November 2012 - August 2014. The highest price during 26 year period from January 1990 to December 2015 was in August 2014 in all the three markets, with Rs.11233 /quintal at Alappuzha, Rs. 11394/quintal at Kochi, and Rs.11475/quintal at Kozhikode. From September 2014, the price started declining and the trend continues.

4.2.2 Instability in price of copra

The instability in prices of copra at Alappuzha, Kochi and Kozhikode markets is indicated by the co efficient of variation as given in Table 4.33.

Table 4.33. Coefficient of variation of copra price in different markets

Market	Alappuzha	Kochi	Kozhikode
Coefficient of variation (%)	48.20	50.45	49.86

The price of copra showed high variability in all the three markets. It could be noted that Kochi (50.45 percent) market showed maximum variability followed by Kozhikode (49.86 percent) and Alappuzha (48.20 percent) markets.

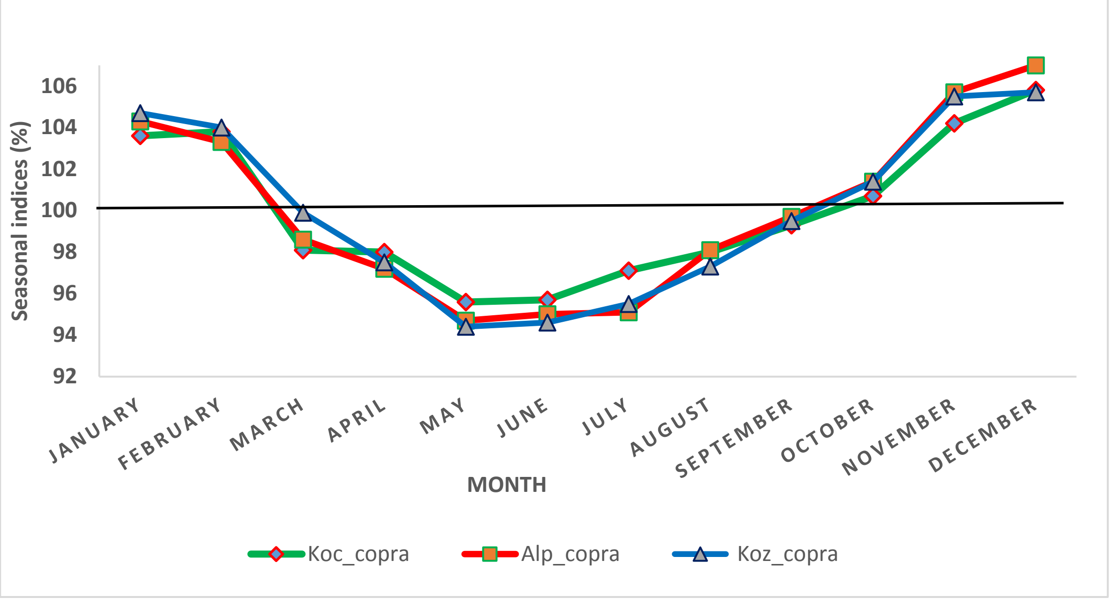
4.2.3 Seasonal variations in price of copra in different markets

Estimates of seasonal indices of copra prices at Alappuzha, Kochi, and Kozhikode markets are provided in Table 4.34.

Table 4.34. Seasonal indices of copra price in different markets

Month	Seasonal indices (%) of copra price		
	Alappuzha	**Kochi**	**Kozhikode**
January	104.3	103.6	104.7
February	103.3	103.8	104
March	98.6	98.1	99.9
April	97.2	98.0	97.5
May	94.7	95.6	94.4
June	95.0	95.7	94.6
July	95.1	97.1	95.5
August	98.1	98.0	97.3
September	99.7	99.3	99.5
October	101.4	100.7	101.4
November	105.7	104.2	105.5
December	107	105.8	104.5

It could be observed that seasonal variations in price of copra follow almost the same pattern in the three markets. Seasonal index was highest in December at Alappuzha (107.0) and Kochi (105.8) markets, whereas, in Kozhikode market the highest index was in November (105.5). Babu (2005) reported November as the peak price month for copra in all the three markets. Lowest index was obtained in May at Alappuzha (94.7), Kochi (95.6) and Kozhikode (94.4) markets. The seasonal plot of copra price in the three markets is provided in Fig. 4.32 to have a clear picture of the variations in prices over the different months from January to December.



Alp_copra price: Copra price at Alappuzha market; Koc_copra price: Copra price at Kochi market; Koz_copra price: Copra price at Kozhikode market

Fig. 4.32. Seasonal plot of copra price at Alappuzha, Kochi and Kozhikode markets

From the figure, it could be observed that buoyant phase in price of copra was observed during October to February and the trough phase was from March to September in all the three markets. Babu et al.(2009) reported September to January as the buoyant phase and February to August as the depressed phase for copra price in all the three markets. The lowest price for copra was reported in March for Kochi and Kozhikode markets and April for Alappuzha market by Babu et al.(2009).

From the analysis of seasonal variations in copra price in the three markets, the following conclusions could be made:

Increase in price of copra is observed from June onwards. Peak price is obtained during December and January with buoyant phase from October to February. Also, the price of copra shows a declining trend from February. May is the low price month with depression from March to September. The trough period for copra price coincides with the harvesting period of coconut in Kerala.

4.2.4 Forecast modeling for price of copra

ARIMA, ANN, and exponential smoothing models, were fitted for price of copra for all the three markets (Alappuzha, Kochi and Kozhikode). The best model in each market was selected based on the forecast accuracy measure, Mean Absolute Percentage Error (MAPE), agreement between actual and fitted price plots, residual ACF and PACF plots for ARIMA models, residual plots for ANN and exponential smoothing models, and forecasts for January, February and March 2016 were used. The results obtained for Alappuzha, Kochi and Kozhikode markets are provided in sections 4.2.4.1 to 4.2.4.3.

4.2.4.1 Forecast model for copra price at Alappuzha market

The fitting of ARIMA, ANN and exponential smoothing models for price of copra at Alappuzha market are presented from 4.2.4.1a to 4.2.4.1c.

4.2.4.1a. ARIMA model for copra price at Alappuzha market

The time plot of copra price at Alappuzha market (Fig. 4.29) indicated that it is non-stationary. ACF and PACF for copra price at Alappuzha market are provided in Table 4.35. Significance of autocorrelations upto 16 lags confirms the non-stationarity of the data. PACF had very high value of 0.981 for lag 1.

The ACF and PACF plots for copra price at Alappuzha market is depicted in Fig. 4.33. It could be observed that in the ACF plot, spikes upto 16 lags fall above critical values indicating the non-stationarity of the TS. PACF plot also showed spikes for a number of lags (1, 2, 4 and 7) beyond critical values.

Table 4.35 ACF and PACF values for copra price at Alappuzha market

Lag	Auto-correlation	S.E	Ljung-Box statistic			Partial Auto-correlation	S.E
			Value	df	Probability (p)		
1	0.981	0.056	303.75	1	<0.001	0.981	0.057
2	0.957	0.056	592.93	2	<0.001	-0.159	0.057
3	0.931	0.056	867.79	3	<0.001	-0.045	0.057
4	0.898	0.056	1124.25	4	<0.001	-0.197	0.057
5	0.859	0.056	1359.94	5	<0.001	-0.119	0.057
6	0.824	0.056	1577.25	6	<0.001	0.108	0.057
7	0.783	0.056	1774.24	7	<0.001	-0.163	0.057
8	0.739	0.056	1950.02	8	<0.001	-0.059	0.057
9	0.695	0.056	2106.33	9	<0.001	0.017	0.057
10	0.652	0.056	2244.20	10	<0.001	-0.025	0.057
11	0.608	0.055	2364.67	11	<0.001	0.041	0.057
12	0.566	0.055	2469.31	12	<0.001	-0.030	0.057
13	0.523	0.055	2558.98	13	<0.001	-0.063	0.057
14	0.479	0.055	2634.36	14	<0.001	-0.042	0.057
15	0.438	0.055	2697.64	15	<0.001	0.062	0.057
16	0.398	0.055	2749.99	16	<0.001	-0.032	0.057

$p<0.05$ indicates significance of autocorrelation

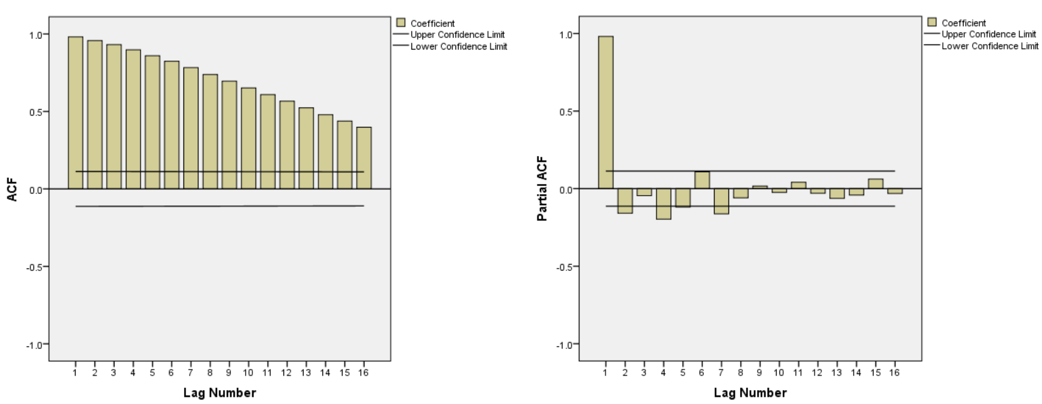


Fig. 4.33. ACF and PACF plots of copra price at Alappuzha market

ADF test was conducted for copra price at Alappuzha, to test whether any differencing is required to make the data stationary. After taking first difference, the ADF test statistic was highly significant (Table 4.36). Thus, first difference is required to make the data stationary. Hence, first difference was taken before fitting ARIMA model for copra price at Alappuzha.

Table 4.36 ADF test with critical values for copra price at Alappuzha market

	ADF test statistic	Probability (p)	Critical values
Observed price	-2.12^{NS}	0.18	-3.45 (1% level) -2.87 (5% level)
First difference	-7.30**	0.001	

$p < 0.05$ indicate significance, ** significant at 1% level

From among several alternative ARIMA models tried, SARIMA$(1,1,4)(1,0,1)_{12}$ was identified for copra price at Alappuzha market. Parameters of the model and their tests of significance are provided in Table 4.37.

Table 4.37. SARIMA$(1,1,4)(1,0,1)_{12}$ model parameters for copra price at Alappuzha market

Transformation	Model Parameters	Estimate	SE	t	Probability (p)
$y_t = \log_e Y_t$	**AR Lag 1(ϕ_1)**	0.18	0.06	3.28**	0.001
	Non-seasonal difference	1			
	MA Lag 4 (θ_4)	-0.17	0.06	3.008**	0.003
	AR, Seasonal Lag 1 (Φ_1)	0.97	0.03	30.75**	0.000
	MA, Seasonal Lag 1 (Θ_1)	0.88	0.07	13.01**	0.000

$p < 0.05$ indicate significance, ** significant at 1% level

Thus, SARIMA (1,1,4)(1,0,1)$_{12}$ model for copra price at Alappuzha market is

$$(1-\phi_1 B)(1-\Phi_1 B^{12})(1-B)y_t = (1-\theta_1 B^1 - \theta_2 B^2 - \theta_3 B^3 - \theta_4 B^4)(1-\Theta_1 B^{12})\varepsilon_t, \quad y_t = \log_e Y_t$$

Where, ϕ_1 =0.184, θ_1=0, θ_2=0, θ_3=0, θ_4=-0. 171, Φ_1=0.966 and Θ_1=0.882,

With these parameters, the model is

$$(1-0.184B)(1-0.966B^{12})(1-B)y_t = (1-0.171B^4)(1-0.882B^{12})\varepsilon_t$$

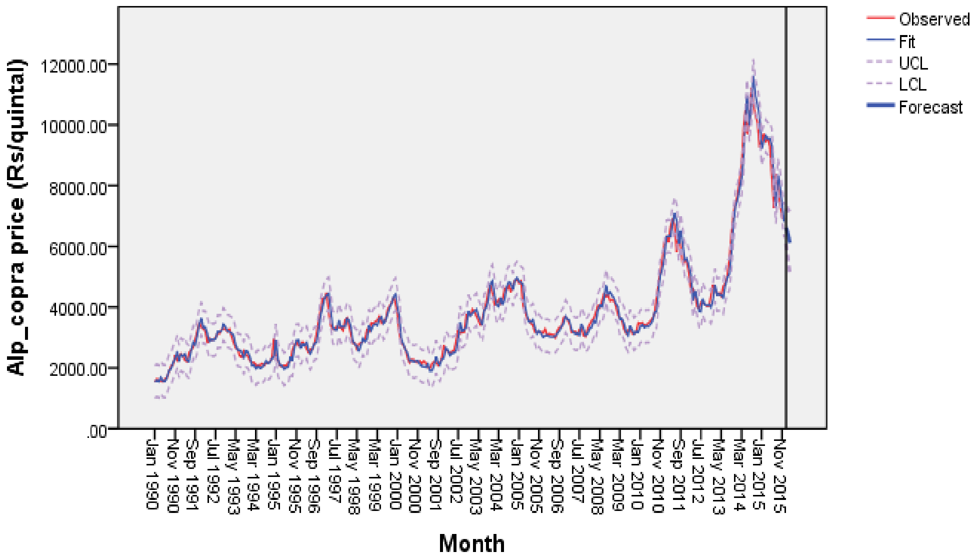
The model fit statistics obtained for the above model are given in Table 4.38.

Table 4.38. Model fit statistics from SARIMA(1,1,4)(1,0,1)$_{12}$ model for copra price at Alappuzha market

Model Fit statistics				
R^2	**RMSE**	**MAPE (%)**	**MAE**	**Normalized BIC**
0.98	274.59	**4.46**	181.10	11.30

The model could explain 98% of the variation in the data and the MAPE was only 4.46%. The plot of actual and fit values along with the upper and lower confidence limits and forecasts for copra price at Alappuzha market using SARIMA(1,1,4)(1,0,1)$_{12}$ model is given in Fig. 4.34. From the figure it could be observed that the actual and predicted (fit) prices of copra are in agreement.

Residuals ACF and PACF plots for the SARIMA(1,1,4)(1,0,1)$_{12}$ model fitted for copra price at Alappuzha market is provided in Fig. 4.35. It could be seen that all the spikes in the ACF and PACF plots fall within the critical values. This shows the adequacy of SARIMA (1,1,4)(1,0,1)$_{12}$ for copra price at Alappuzha market.



Alp_copra price: Copra price at Alappuzha market

Fig. 4.34. Observed, fit, LCL, UCL and forecast for copra price at Alappuzha market for SARIMA(1,1,4)(1,0,1)$_{12}$ model

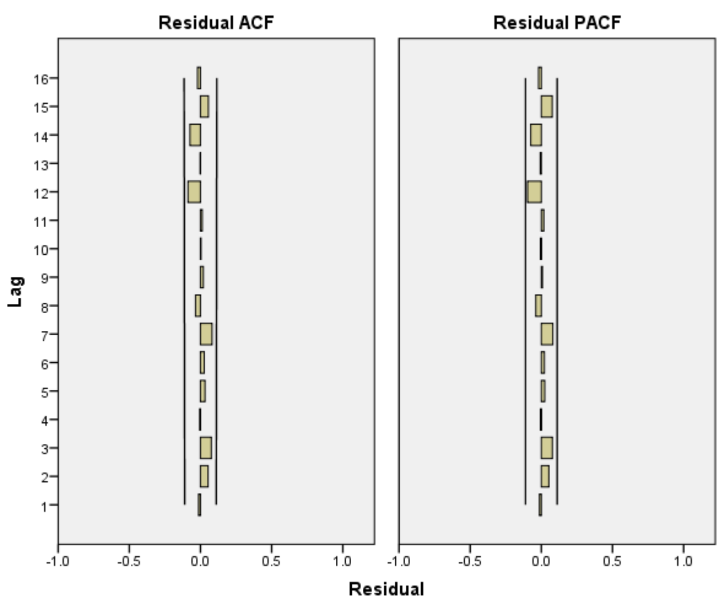


Fig. 4.35. Residual ACF and PACF plots for copra price at Alappuzha market for SARIMA(1,1,4)(1,0,1)$_{12}$ model

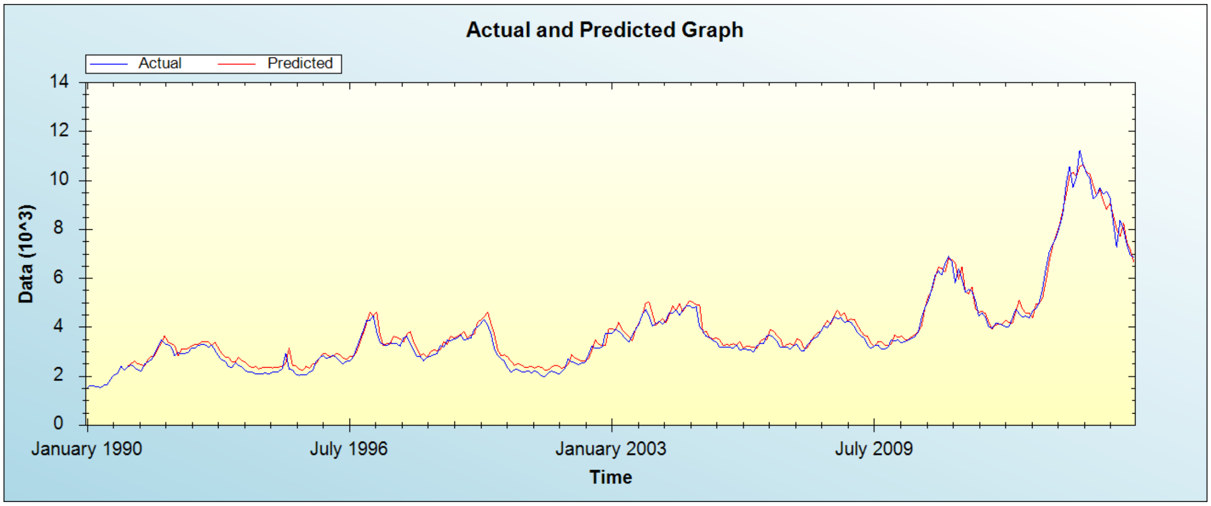
The forecasts of copra price at Alappuzha market based on SARIMA(1,1,4)(1,0,1)$_{12}$ model fitted from January 2016 to March 2016 are provided in Table 4.39 along with the upper and lower confidence limits and MAPE value.

Table 4.39. Forecasts from SARIMA(1,1,4)(1,0,1)$_{12}$ model fitted for copra price at Alappuzha market

Month	Forecast price			MAPE (%)
	Price forecast (Rs/quintal)	LCL	UCL	
Jan-16	6782	6033	7598	4.46
Feb-16	6684	5566	7959	
Mar-16	6518	5157	8128	

4.2.4.1b. ANN model

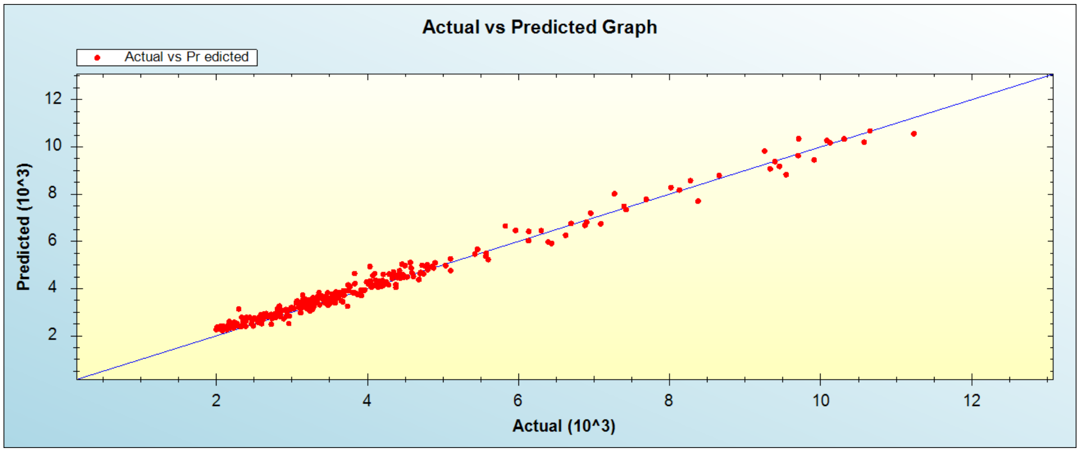
ANN model was fitted for copra price at Alappuzha market. The actual price along with the predicted (fit) values of copra price at Alappuzha market using ANN model is plotted in Fig. 4.36.



Data -Copra price at Alappuzha market, Time- Month and 10^3- 10^3 Rs/quintal

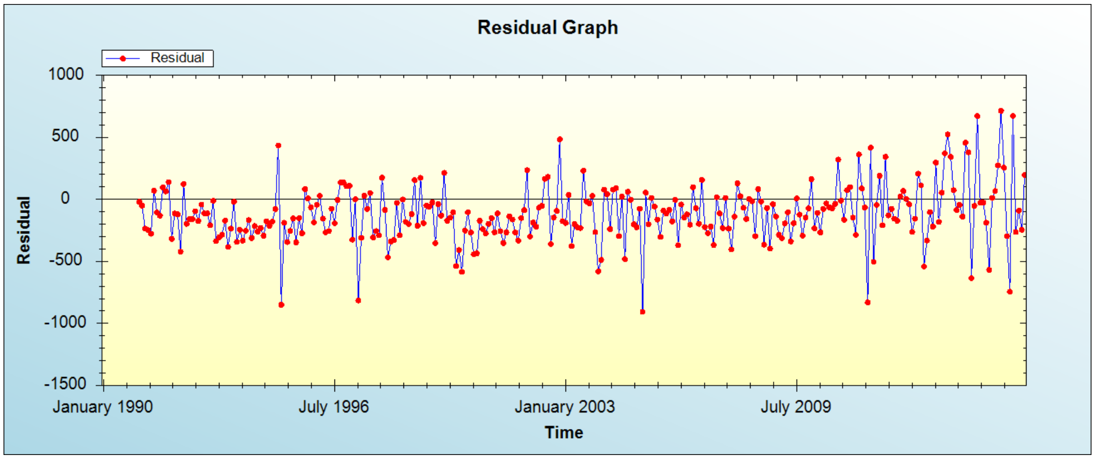
Fig. 4.36. Actual and predicted plots from ANN model for copra price at Alappuzha market

It could be observed that the ANN model captured the pattern of the TS data well. The MAPE value was only 5.89 percent. The actual and predicted values lie close to a straight-line as seen from Fig. 4.37, indicating the adequacy of the model for the data. The residual plot from ANN model is provided in Fig. 4.38. The residuals did not exhibit any specific pattern.



Predicted- Predicted copra price at Alappuzha market, Actual- Actual copra price at Alappuzha market, 10^3- 10^3 Rs/quintal

Fig. 4.37. Actual vs. predicted graph from ANN model for copra price at Alappuzha market



Time-Month

Fig. 4.38. Residual plot for copra price at Alappuzha market from ANN model

The forecasts using ANN model from January 2016 to March 2016 are given in Table 4.40 along with MAPE value. Various accuracy measures for ANN model are provided in Table 4.41.

Table 4.40. Forecasts from ANN model for copra price at Alappuzha market

Month	Forecast price (Rs/quintal)	MAPE (%)
Jan-16	6282	5.89
Feb-16	6104	
Mar-16	6456	

Table 4.41. Model accuracy measures for ANN model for copra price at Alappuzha market

Accuracy measure	Value
RMSE	238.68
MAE	202.46
MAPE (%)	**5.89**

4.2.4.1c. Exponential smoothing model for copra price at Alappuzha market

Holt-Winters' Multiplicative Seasonal (HWMS) model was identified from among the different exponential smoothing models like SES, DES, HWAS and HWMS models for the copra price at Alappuzha market. The estimates of parameters of HWMS model for copra price at Alappuzha market are provided in Table 4.42.

Table 4.42. Estimates of parameters of HWMS model for copra price at Alappuzha market

Parameter	α	β	γ
Estimate	1.00	0.21	0.00

With these values for the parameters, the equations of the HWMS model for copra price at Alappuzha market are given below:

Level: $L_t = \frac{Y_t}{S_{t-12}}$ Trend: $b_t = 0.21(L_t - L_{t-1}) + 0.79b_{t-1}$

Seasonal: $S_t = S_{t-12}$ Forecast: $F_{t+m} = (L_t + b_t m)S_{t-12+m}$

The values of L_t, b_t and S_t at time t were estimated first and substituted in the forecast equation F_{t+m}, to obtain the m period ahead forecast. The fit of the HWMS model for copra price at Alappuzha market can be seen from Fig. 4.39. It could be observed that actual and predicted (fit) values are in close agreement.

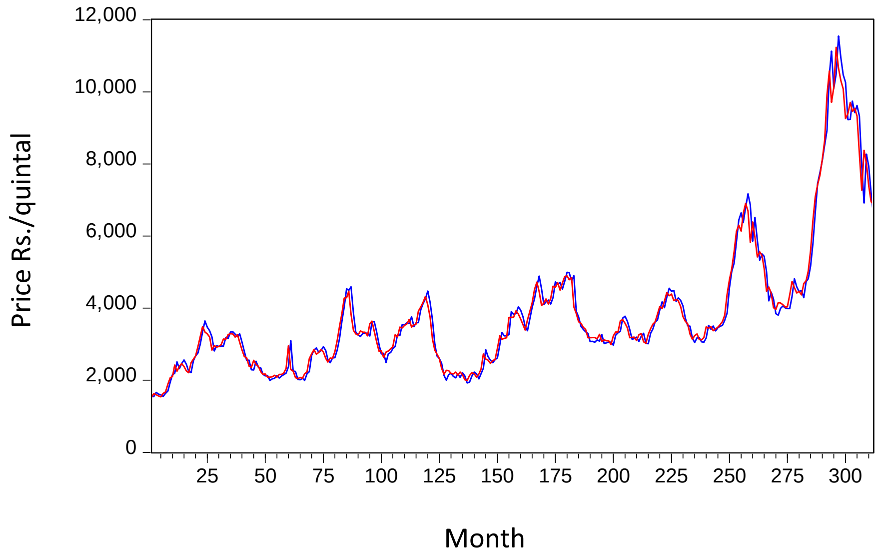


Fig. 4.39. Actual and predicted plots for copra price at Alappuzha market from HWMS model

The residual plot for copra price at Alappuzha market from HWMS model is given in Fig. 4.40. The residual plot did not show any pattern.

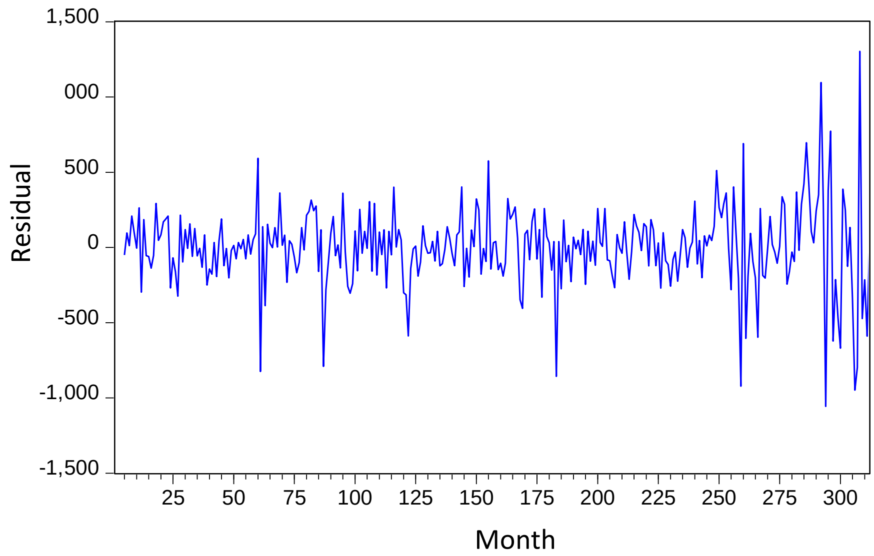


Fig. 4.40. Residual plot for copra price at Alappuzha market for HWMS model

The forecasts for copra price at Alappuzha market for January, February and March, 2016 based on HWMS model are provided in Table 4.43. The MAPE is only 4.42 percent for HWMS model.

Table 4.43. Price forecasts from HWMS model for copra price at Alappuzha market

Month	Forecast price (Rs/quintal)	MAPE (%)
Jan-16	6339	4.42
Feb-16	5961	
Mar-16	5339	

Actual prices for January, February and March, 2016 and forecast prices from SARIMA(1,1,4)(1,0,1)$_{12}$, ANN and HWMS models for copra price at Alappuzha market are provided in Table 4.44, along with MAPE (%) for validation of the models.

Table 4.44. Validation of forecast price of copra at Alappuzha market

Month	Actual	Forecast price		
		SARIMA $(1,1,4)(1,0,1)_{12}$	**ANN**	**HWMS**
Jan-16	6244 (6050-6450)	6782 (6033-7598)	6282	6339
Feb-16	6017 (6050-6150)	6684 (5566-7959)	6104	5961
Mar-16	5540 (5520-6000)	6518 (5157-8128)	6456	5339
MAPE (%)		**4.46**	**5.89**	**4.42**

Values in parenthesis indicate the price range.

Forecasts based on HWMS model were in more agreement with the actual price in all the three months compared to SARIMA$(1,1,4)(1,0,1)_{12}$ and ANN models. For the SARIMA$(1,1,4)(1,0,1)_{12}$ model fitted all the spikes in the residual PACF plot were not within the critical values. Also, actual and predicted plots were in more agreement for HWMS model compared to ANN model. Thus, for copra price at Alappuzha market HWMS model was selected as the best forecast model. Daily price data along with the forecast price of copra at Alappuzha market for January, February and March, 2016 are provided in Appendix-IV.

4.2.4.2 Forecast model for copra price at Kochi market

The fitting of ARIMA, ANN and exponential smoothing models are presented from 4.2.4.2a to 4.2.4.2c.

4.2.4.2a. ARIMA model for copra price at Kochi market

The time plot of copra price at Kochi market (Fig. 4.30) indicates that it is non-stationary. ACF and PACF for copra price at Kochi market are provided in Table 4.45. Significance of autocorrelations upto 16 lags confirms the non stationarity of the data. PACF value was very high for lag1 (0.974). The ACF and PACF plots for copra price at Kochi market is depicted in Fig. 4.41. It could be observed that in the ACF plot, spikes upto 16 lags fall above critical values indicating the non-stationarity of the TS. PACF plot also showed spikes for a number of lags (1, 2, 4 and 7) beyond critical values.

Table 4.45. ACF and PACF values for copra price at Kochi market

Lag	Auto-correlation	S.E	Ljung-Box Statistic			Partial Autocorrelation	S.E
			Value	Df	Probability (p)		
1	0.974	0.056	298.60	1	<0.0001	0.974	0.057
2	0.953	0.056	585.35	2	<0.0001	0.089	0.057
3	0.93	0.056	859.32	3	<0.0001	-0.038	0.057
4	0.896	0.056	1114.78	4	<0.0001	-0.220	0.057
5	0.861	0.056	1351.54	5	<0.0001	-0.090	0.057
6	0.829	0.056	1571.49	6	<0.0001	0.033	0.057
7	0.788	0.056	1771.07	7	<0.0001	-0.124	0.057
8	0.745	0.056	1949.86	8	<0.0001	-0.100	0.057
9	0.700	0.056	2108.43	9	<0.0001	-0.072	0.057
10	0.656	0.056	2248.17	10	<0.0001	0.030	0.057
11	0.617	0.055	2372.09	11	<0.0001	0.123	0.057
12	0.579	0.055	2481.38	12	<0.0001	0.024	0.057
13	0.539	0.055	2576.63	13	<0.0001	-0.047	0.057
14	0.499	0.055	2658.5	14	<0.0001	-0.085	0.057
15	0.461	0.055	2728.52	15	<0.0001	0.005	0.057
16	0.421	0.055	2787.12	16	<0.0001	-0.035	0.057

p<0.05 indicates significance of autocorrelation

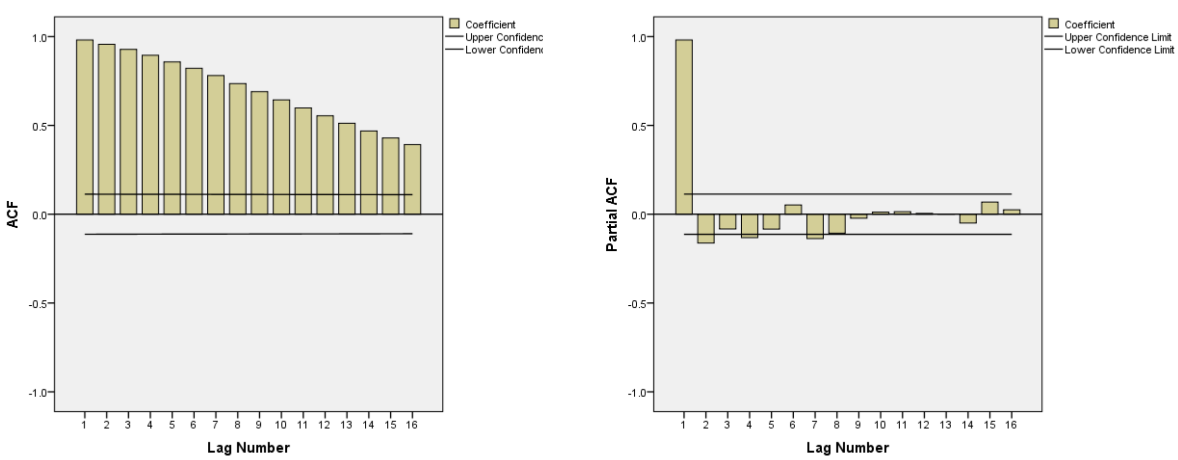


Fig. 4.41 ACF and PACF of copra price at Kochi market

ADF test for copra price at Kochi market (Table 4.46) showed that first difference is required to make the TS stationary.

Table 4.46 ADF test with critical values for copra price at Kochi market

	ADF test statistic	Probability (p)	Critical values
Observed price	-1.94 ^{NS}	0.313	-3.45 (1% level) -2.87 (5% level)
First difference	-8.29**	0.001	

p <0.05 indicate significance, ** significant at 1% level

For copra price at Kochi market, stationarity in mean was achieved by taking first difference. Natural logarithm of the price data was taken to get stationarity in variance. The ARIMA model obtained for coconut oil price at Kochi market was SARIMA(0,1,0)(1,0,1)$_{12}$. Parameters of the model and their tests of significance are provided in Table 4.47.

Table 4.47. SARIMA(0,1,0)(1,0,1)$_{12}$ model parameters for copra price at Kochi market

Transformation	Model Parameters		Estimate	SE	t	Sig.
$y_t = \log_e Y_t$	Non-seasonal difference		1			
	AR, Seasonal	Lag 1(Φ_1)	0.937	0.07	13.82**	0.000
	MA, Seasonal	Lag 1(Θ_1)	0.869	0.10	8.63**	0.000

p <0.05 indicate significance, ** significant at 1% level

Thus, SARIMA(0,1,0)(1,0,1)$_{12}$ model for copra price at Kochi market is given below:

$$(1-\Phi_1 B^{12})(1-B)y_t = (1-\Theta_1 B^{12})\varepsilon_t, \ y_t = \log_e Y_t$$

Where, Φ_1 =0.937 and Θ_1 =0.869

With these parameters model becomes,

$$(1-0.937B^{12})(1-B)y_t = (1-0.869B^{12})\varepsilon_t$$

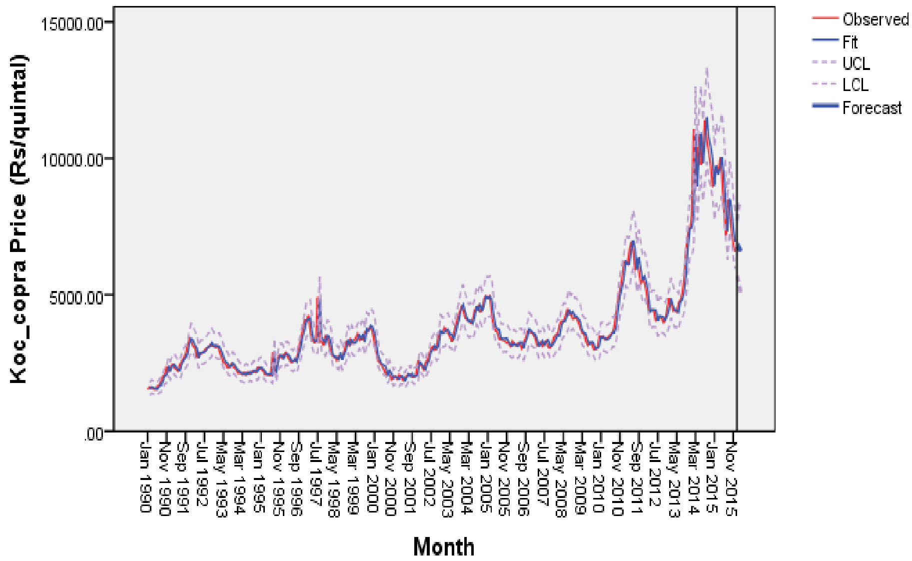
The model fit statistics obtained for the above model are given in the Table 4.48.

Table 4.48. Model fit statistic for SARIMA (0,1,0)(1,0,1)$_{12}$ for copra price at Kochi market

Model Fit statistic				
R^2	**RMSE**	**MAPE (%)**	**MAE**	**Normalized BIC**
0.96	389.66	**5.35**	223.53	11.97

The model could explain 96% of the variation in the data and the MAPE was only 5.35%. The plot of observed and fit values along with the upper and lower confidence limits and forecasts for copra price at Kochi market using SARIMA(0,1,0)(1,0,1)$_{12}$ model is given in Fig. 4.42. It could be seen that observed and fit values are in agreement.

Residual ACF and PACF plots for the SARIMA(0,1,0)(1,0,1)$_{12}$ model fitted for copra price at Kochi market is provided in Fig. 4.43. All the spikes in the residual plot fall within the critical values, showing adequacy of the model for copra price at Kochi market.



Koc_copra price: Copra price at Kochi market

Fig. 4.42. Observed, fit, LCL, UCL and forecast values for copra price at Kochi market with SARIMA(0,1,0)(1,0,1)$_{12}$ model

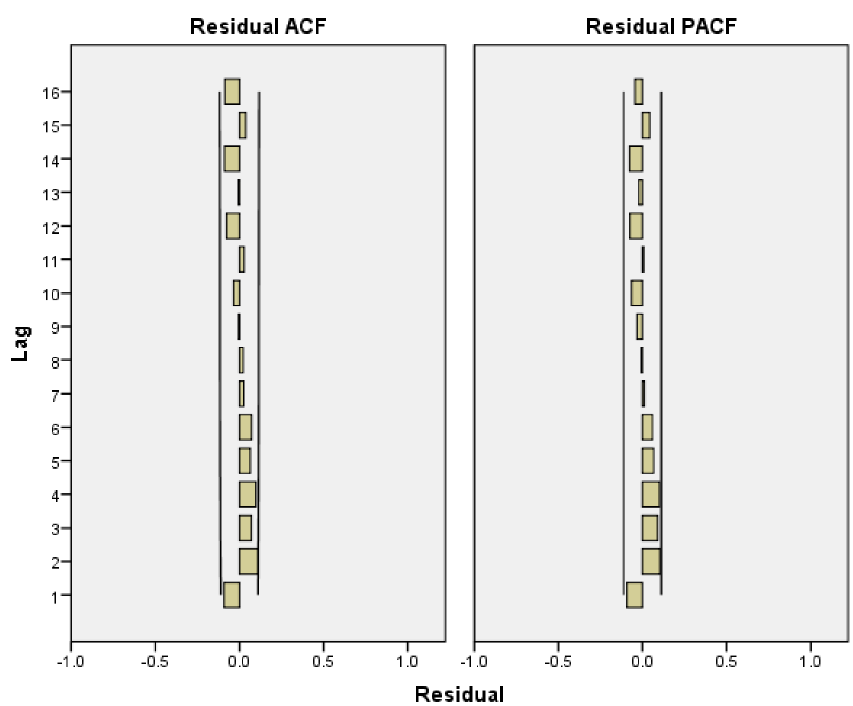


Fig. 4.43. Residual ACF and PACF plots for copra price at Kochi market for SARIMA(0,1,0) (1,0,1)$_{12}$ model

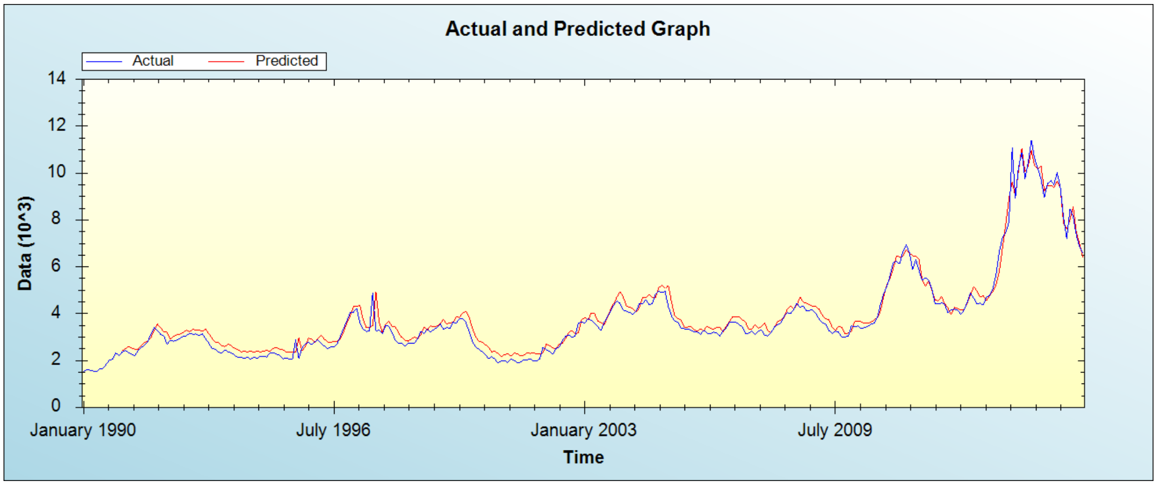
The forecasts of copra price at Kochi market based on SARIMA$(0,1,0)(1,0,1)_{12}$ model fitted from January 2016 to March 2016 are provided in Table 4.49, along with the upper and lower confidence limits and MAPE value.

Table 4.49. Forecasts form SARIMA $(0,1,0)(1,0,1)_{12}$ model fitted for copra price at Kochi market

Month	Forecast price			MAPE (%)
	Price forecast (Rs/quintal)	LCL	UCL	
Jan-16	6653	5708	7709	5.35
Feb-16	6764	5437	8316	
Mar-16	6596	5040	8482	

4.2.4.2b. ANN model

ANN model was fitted for copra price at Kochi market. The actual price along with the predicted (fit) values of copra price at Kochi market using ANN model is plotted in Fig. 4.44.



Data -Copra price at Kochi market, Time- Month and 10^3- 10^3 Rs/quintal

Fig. 4.44. Actual and predicted plots from ANN model for copra price at Kochi market

The MAPE value was 7.46 per cent for ANN model. In Fig. 4.45, the actual price vs predicted (fit) price from ANN model for copra price at Kochi market is plotted. The residual plot from ANN model is provided in Fig. 4.46.

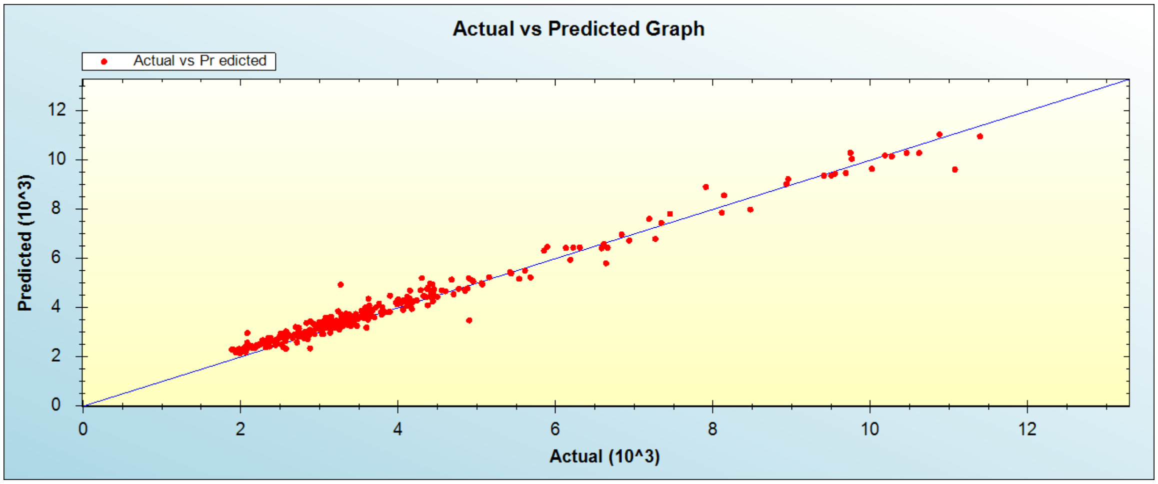
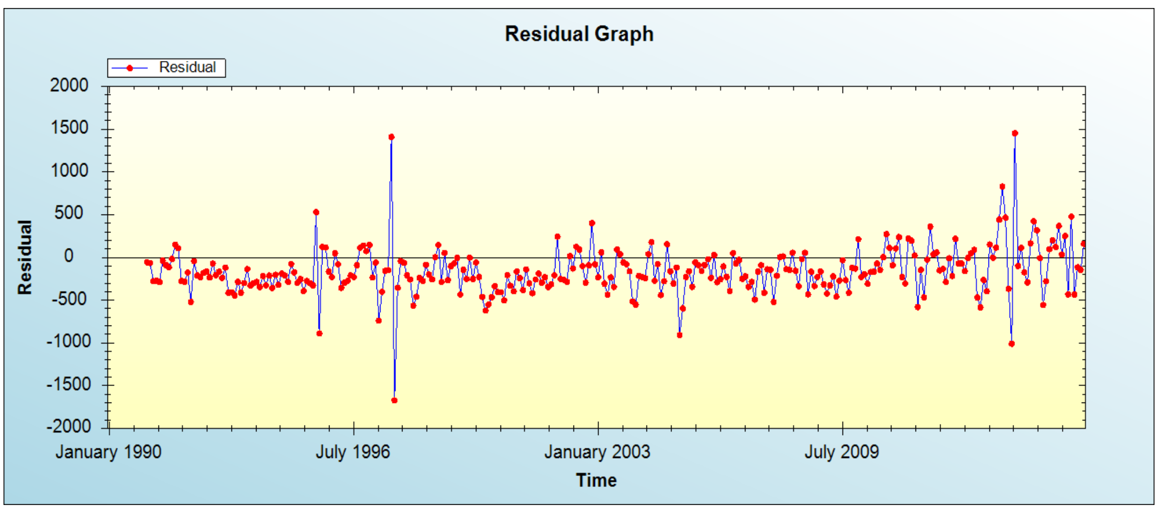


Fig. 4.45. Actual vs. predicted plot from ANN model for copra price at Kochi market



Time-Month

Fig. 4.46. Residual plot for copra price at Kochi market from ANN model

The forecasts using ANN model from January 2016 to March 2016 are given in Table 4.50 along with MAPE value and accuracy measures from ANN model for copra price at Kochi market is predicted in Table 4.51.

Table 4.50. Forecasts from ANN model for copra price at Kochi market

Month	Forecast price (Rs/quintal)	MAPE (%)
Jan-16	5772	6.51
Feb-16	5613	
Mar-16	5219	

Table 4.51. Model accuracy measures for ANN model for copra price at Alappuzha market

Accuracy measure	Value
RMSE	443.6
MAE	231.74
MAPE (%)	**6.51**

4.2.4.2c. Exponential smoothing models

Holt-Winters' Multiplicative Seasonal (HWMS) model was identified from among the different exponential smoothing models like SES, DES, HWAS and HWMS models for the copra price at Kochi market. The estimates of parameters of HWMS model are provided in Table 4.52.

Table 4.52. Estimates of parameters of the HWMS model for copra price at Kochi market

Parameter	α	β	γ
Estimate	0.69	0.28	0.00

Here the following are, the equations of the HWMS model for copra price at Kochi market are

Level: $L_t = 0.69\frac{Y_t}{S_{t-12}} + 0.3(L_t + b_{t-1})$ Trend: $b_t = 0.28(L_t - L_{t-1}) + 0.72b_{t-1}$

Seasonal: $S_t = S_{t-12}$ Forecast: $F_{t+m} = (L_t + b_t m)S_{t-12+m}$

The values of L_t, b_t, and S_t at time t were estimated first and substituted in the forecast equation F_{t+m} to obtain the m period ahead forecast, of t. The fit of the HWMS model for copra price at Kochi market can be seen from Fig. 4.47. The actual and predicted values are in close agreement.

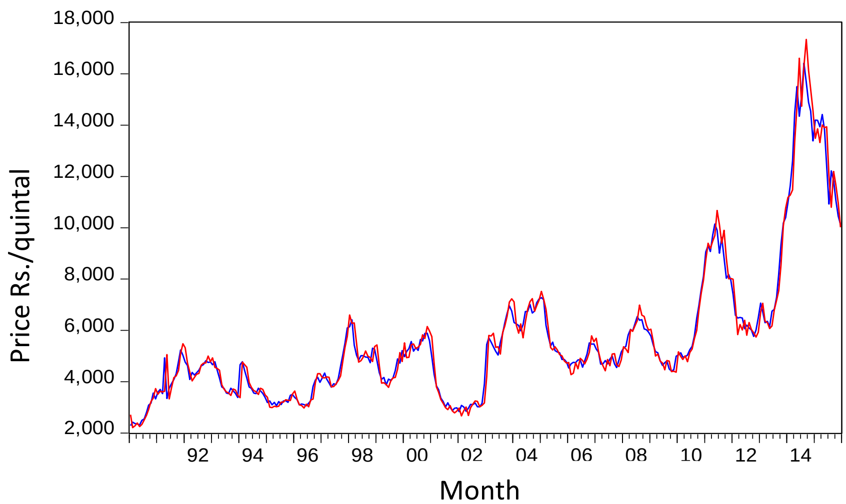


Fig. 4.47. Actual and predicted plots for copra price at Kochi market from HWMS model

The residual plot for copra price at Kochi market from HWMS model is given in Fig. 4.48.

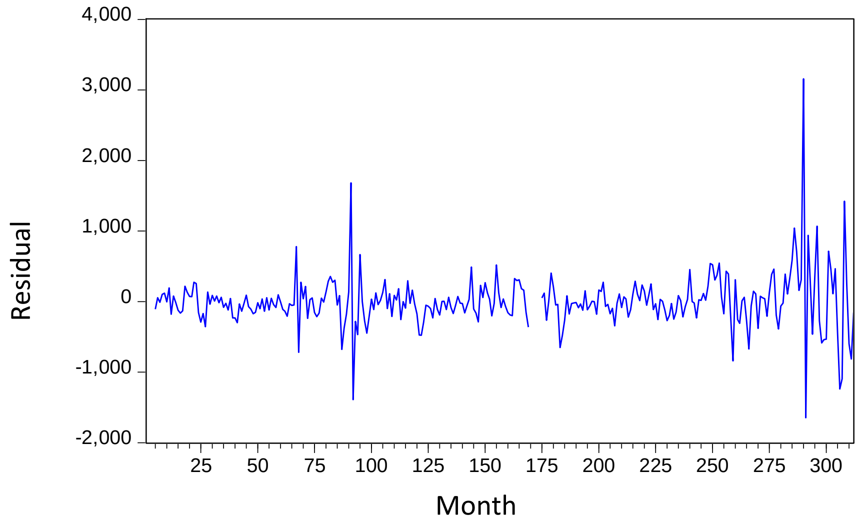


Fig. 4.48. Residual plot for copra price at Kochi market for HWMS model

The forecasts obtained for January, February and March, 2016 based on HWMS model are provided in Table 4.53. The MAPE is only 5.19 percent for HWMS model.

Table 4.53. Forecasts based on HWMS model for copra price at Kochi market

Month	Forecast price (Rs/quintal)	MAPE (%)
Jan-16	6137	5.19
Feb-16	5847	
Mar-16	5123	

Actual prices for January, February and March, 2016 and forecast prices from SARIMA(0,1,0)(1,0,1)$_{12}$, ANN and HWMS models for copra price at Kochi market are provided in Table 4.54, along with MAPE (%) for validation of the models.

Table 4.54. Validation of forecast price of copra at Kochi market

Month	Actual price (Rs/quintal)	Forecast price		
		SARIMA (0,1,0)(1,0,1)$_{12}$	ANN	HWMS
Jan-16	6040 (5800-6150)	6653 (5708-7709)	5772	6137
Feb-16	5926 (5800-6100)	6764 (5437-8316)	5613	5847
Mar-16	5422 (5250-5900)	6596 (5040-8482)	5219	5123
MAPE (%)		5.35	6.51	5.25

Values in parenthesis indicate the price range.

When the forecast prices were compared from the three models, HWMS model gave better forecast. MAPE was least for HWMS model. Also, when the actual and predicted plots as well as residual plots in the three models were compared HWMS model was more adequate for forecasting copra price at Kochi. Daily price data along with the forecast price of copra at Kochi market for January, February and March, 2016 are provided in Appendix-V.

4.2.4.3 Forecast model for copra price at Kozhikode market

The fitting of ARIMA, ANN and exponential smoothing models are presented from 4.2.4.3a. to 4.2.4.3c.

4.2.4.3a. ARIMA model for copra price at Kozhikode market

The time plot of copra price at Kozhikode market (Fig. 4.31) indicates the non-stationarity of the data. ACF and PACF for copra price at Kozhikode market are provided in Table 4.55. Significance of autocorrelations upto 16 lags confirms the non-stationarity of the data. PACF had very high value for lag1 (0.982).

The ACF and PACF plots for copra price at Kozhikode market is depicted in Fig. 4.49. It could be observed that in the ACF plot, spikes upto 16 lags fall above critical value indicating the non-stationarity of the TS. PACF plot also showed spikes for a number of lags (1, 2, 3 4 and 7) beyond critical values.

Table 4.55. ACF and PACF values for copra price at Kozhikode market

Lag	Auto-correlation	S.E	Ljung- Box Statistic			Partial Auto-correlation	S.E
			Value	Df	Probability (p)		
1	0.982	0.056	303.98	1	<0.0001	0.982	0.057
2	0.960	0.056	595.32	2	<0.0001	-0.138	0.057
3	0.933	0.056	871.55	3	<0.0001	-0.127	0.057
4	0.902	0.056	1130.23	4	<0.0001	-0.128	0.057
5	0.867	0.056	1370.37	5	<0.0001	-0.058	0.057
6	0.832	0.056	1592.15	6	<0.0001	-0.004	0.057
7	0.793	0.056	1794.24	7	<0.0001	-0.108	0.057
8	0.752	0.056	1976.34	8	<0.0001	-0.064	0.057
9	0.708	0.056	2138.52	9	<0.0001	-0.052	0.057
10	0.664	0.056	2281.59	10	<0.0001	-0.007	0.057
11	0.620	0.055	2406.85	11	<0.0001	0.014	0.057
12	0.576	0.055	2515.38	12	<0.0001	-0.026	0.057
13	0.534	0.055	2608.78	13	<0.0001	0.018	0.057
14	0.492	0.055	2688.20	14	<0.0001	-0.028	0.057
15	0.450	0.055	2754.96	15	<0.0001	-0.007	0.057
16	0.409	0.055	2810.39	16	<0.0001	-0.007	0.057

p<0.05 indicates significance of autocorrelation

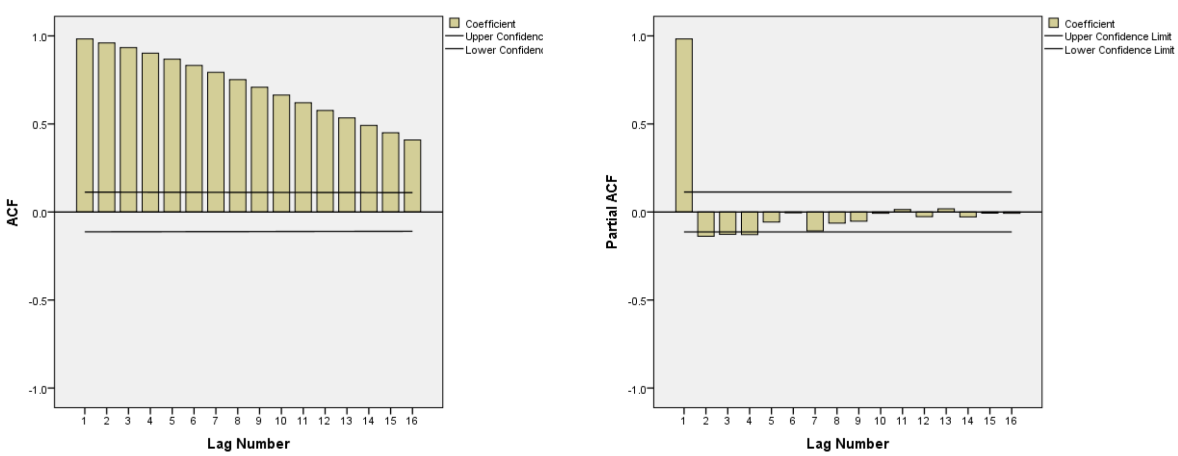


Fig. 4.49. ACF and PACF of copra price at Kozhikode market

ADF test was performed on copra price at Kozhikode market to test whether differencing is needed for making the data stationary in mean. ADF test results are provided in Table 4.56. It could be inferred that first differencing is required to achieve stationarity in mean.

Table 4.56. ADF test with critical values for copra price at Kozhikode market

	ADF test statistic	Probability (p)	Critical values
Observed price	-2.12^{NS}	0.24	-3.45 (1% level) -2.87 (5% level)
First difference	-14.81**	0.001	

p <0.05 indicate significance, ** significant at 1% level

Before fitting ARIMA model, natural logarithm was taken to achieve stationarity in variance. The transformed and differenced data were used for fitting ARIMA model. SARIMA$(1,1,1)(1,0,1)_{12}$ was identified from among different ARIMA models. Parameters of the model and their tests of significance are provided in Table 4.57.

Table 4.57. SARIMA$(1,1,1)(1,0,1)_{12}$ model parameters for copra price at Kozhikode market

Transformation	Model Parameters	Estimate	SE	t	Sig.
$y_t = \log_e Y_t$	**AR Lag 1(ϕ_1)**	0.834	0.112	7.447**	0.000
	Non-seasonal difference	1			
	MA Lag 1 (θ_1)	0.718	0.14	5.111**	0.000
	AR, Seasonal Lag 1 (Φ_1)	0.937	0.053	17.765**	0.000
	MA, Seasonal Lag 1 (Θ_1)	0.853	0.086	9.968**	0.000

p <0.05 indicate significance, ** significant at 1% level

Thus, SARIMA(1,1,1)(1,0,1)$_{12}$ model for copra price at Kozhikode market is

$$(1-\phi_1 B)(1-\Phi_1 B^{12})(1-B)y_t = (1-\theta_1 B)(1-\Theta_1 B^{12})\varepsilon_t \text{ ; } y_t=\log_e Y_t$$

Where, ϕ_1=0.834, Φ_1=0.937and θ_1= 0.718, Θ_1=0.853

Thus the model becomes,

$$(1-0.834B)(1-0.937B^{12})(1-B)y_t = (1-0.718B)(1-0.853B^{12})\varepsilon_t$$

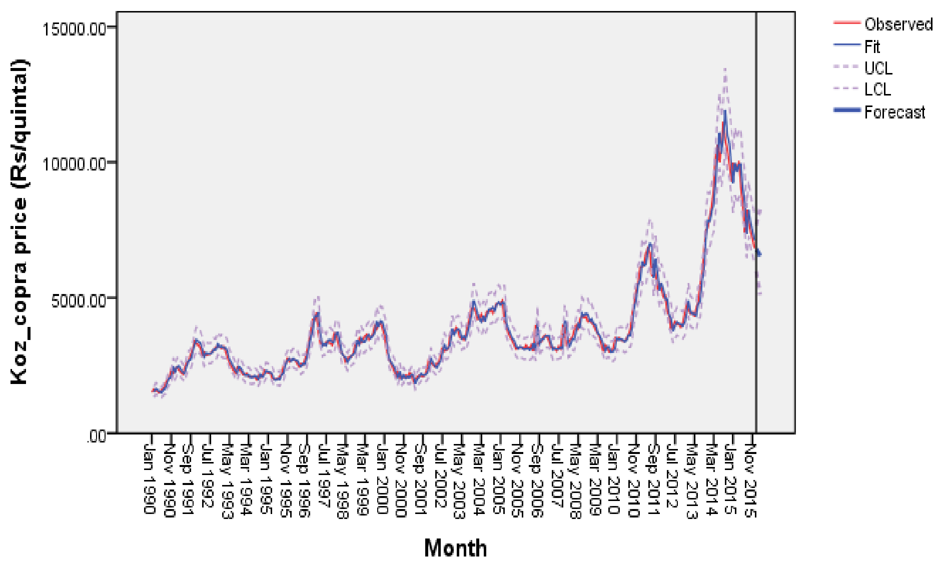
The model fit statistics obtained for the above model are given in the Table 4.58.

Table 4.58. Model fit statistic of SARIMA(1,1,1)(1,0,1)$_{12}$ for copra price at Kozhikode market

Model Fit statistic				
R^2	**RMSE**	**MAPE (%)**	**MAE**	**Normalized BIC**
0.98	286.50	**4.79**	191.77	11.38

The model could explain 98% of the variation in the data and the MAPE was only 4.79 percent. The plot of actual and fit values along with the upper and lower confidence limits and forecasts for copra price at Kozhikode market using SARIMA(1, 1, 1)(1, 0, 1)$_{12}$ model is given in Fig. 4.50.

From the figure it could observed that actual price and predicted (fit) price based on the model for copra price at Kozhikode market are in agreement. Residual ACF and PACF plots for the SARIMA(1, 1, 1)(1, 0, 1)$_{12}$ model fitted for copra price at Kozhikode market is provided Fig. 4.51. It could be observed that all the ACF and PACF for all lags lie within critical values.



Koz_copra price: Copra price at Kozhikode market

Fig. 4.50. Observed, fit, LCL, UCL and forecast for copra price at Kozhikode market for SARIMA(1, 1, 1)(1, 0, 1)$_{12}$ model

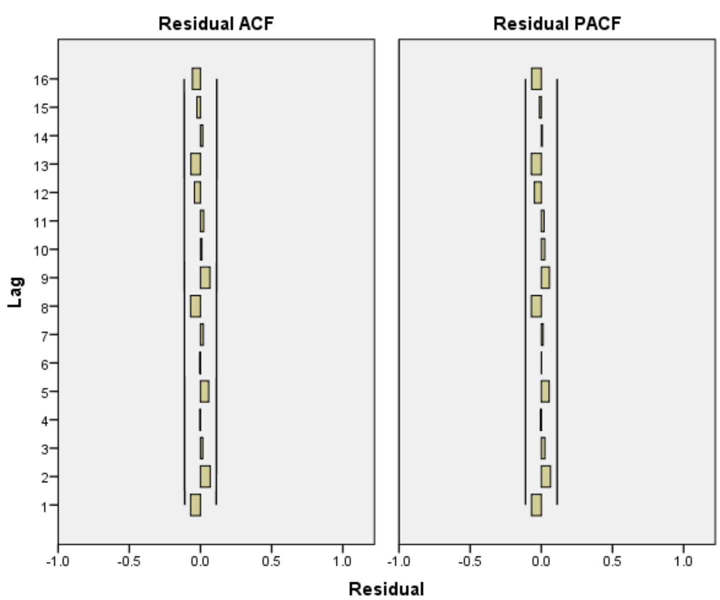


Fig. 4.51. Residual ACF and PACF plots of copra price at Kozhikode market for SARIMA(1, 1, 1)(1, 0, 1)$_{12}$ model

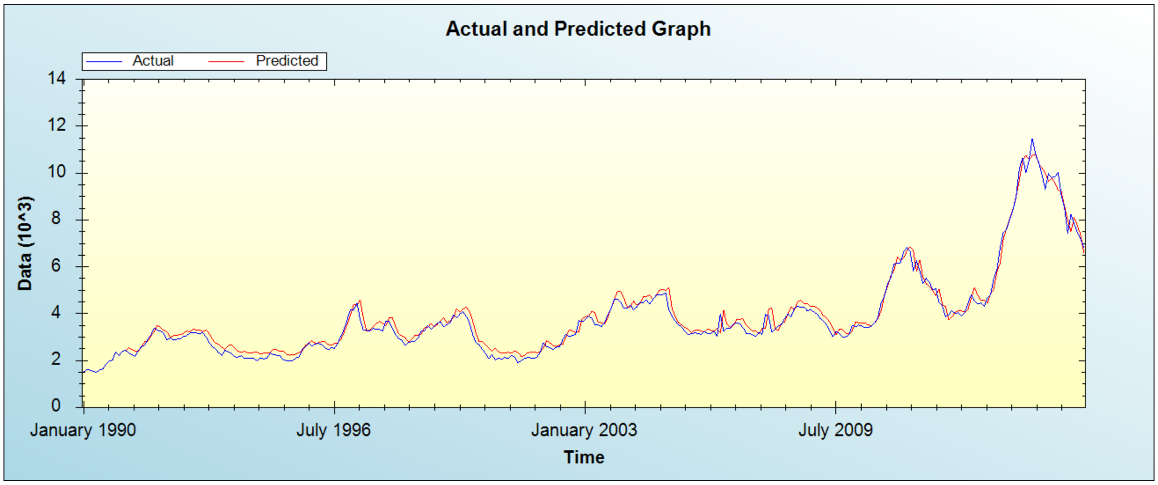
The forecasts of copra price at Kozhikode market based on SARIMA(1, 1, 1)(1, 0, 1)$_{12}$ model fitted from January 2016 to March 2016 are provided in Table 4.59 along with the upper and lower confidence limits and MAPE value.

Table 4.59. Forecasts from SARIMA(1, 1, 1)(1, 0, 1)$_{12}$ model fitted for copra price at Kozhikode market

Month	Forecast			MAPE (%)
	Price forecast (Rs/quintal)	LCL	UCL	
Jan-16	6788	5981	7672	4.79
Feb-16	6689	5526	8025	
Mar-16	6542	5108	8255	

4.2.4.3b. ANN model

ANN model was fitted for copra price at Kozhikode market. The actual price along with the predicted (fit) values of copra price at Kozhikode market using ANN model is plotted in Fig. 4.52.



Data-Copra price at Kozhikode market, Time- Month and 10^3-10^3 Rs/quintal

Fig.4.52. Actual and predicted plots from ANN model for copra price at Kozhikode market

It could observed that actual price of copra at Kozhikode market and values fitted are in close agreement indicating that the ANN model captures the pattern of the TS data well. Also, the actual and predicted values lie very close to a straight-line as seen from Fig. 4.60, indicating the adequacy of the model for the data.

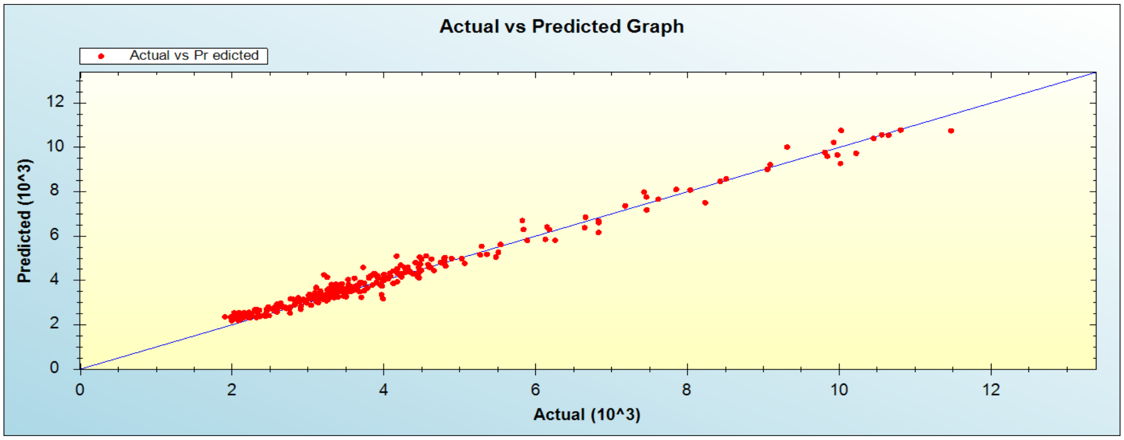


Fig. 4.60. Actual vs. predicted graph from ANN model for copra price at Kozhikode market

The residual plot from ANN model for copra price at Kozhikode market is provided in Fig. 4.54. Since the residuals did not show any pattern, the ANN model is adequate for the data.

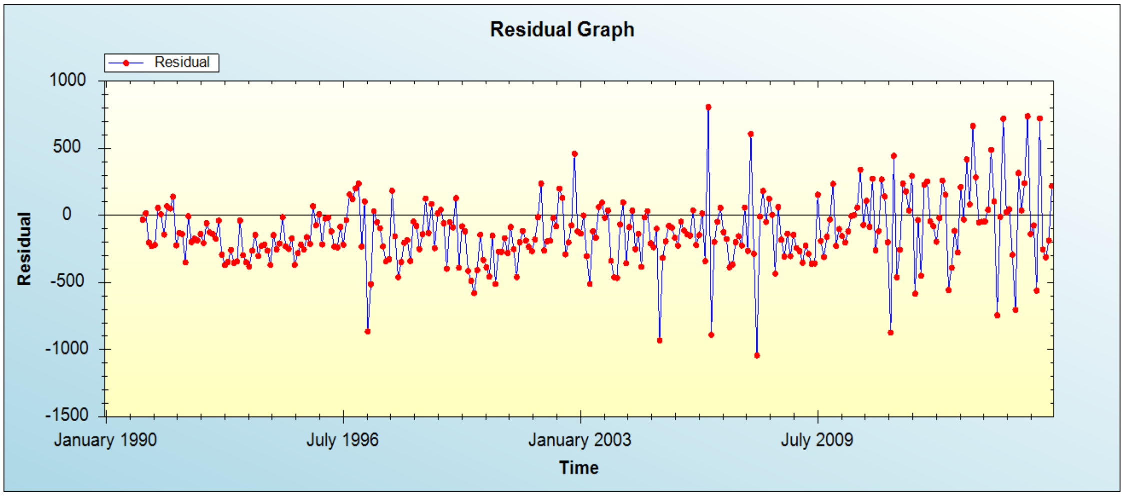


Fig. 4.54 Residual plot for copra price at Kozhikode market from ANN model

The forecasts using ANN model from January 2016 to March 2016 are given in Table 4.60. along with MAPE value. Various accuracy measures for ANN model are provided in Table 4.61.

Table 4.60 Forecasts from ANN model for copra price at Kozhikode market

Month	Forecast price	MAPE (%)
Jan-16	6417	6.46
Feb-16	5695	
Mar-16	5595	

Table 4.61. Model accuracy measures for ANN model for copra price at Kozhikode market

Accuracy measure	Value
RMSE	288.00
MAE	221.29
MAPE (%)	**6.46**

4.2.4.3c. Exponential smoothing models

Holt-Winters' Multiplicative Seasonal (HWMS) model was identified from among the different exponential smoothing models like SES, DES, HWAS and HWMS models for copra price at Kozhikode market. The estimates of parameters of HWMS model are provided in Table 4.62.

Table 4.62. Estimates of parameter of HWMS model for copra price at Kozhikode market

Parameter	α	β	γ
Estimate	1.00	0.18	0.00

With these values for the parameters, the equations of the HWMS model for copra price at Kozhikode market are given below:

Level: $L_t = \frac{Y_t}{S_{t-12}}$ Trend: $b_t = 0.18(L_t - L_{t-1}) + 0.82b_{t-1}$

Seasonal: $S_t = S_{t-12}$ Forecast: $F_{t+m} = (L_t + b_t m)S_{t-12+m}$

The values of L_t, b_t, and S_t at time t were estimated first and substituted in the forecast equation F_{t+m} to obtain the m period ahead forecast. The fit of the HWMS model for copra price at Kozhikode market can be seen from Fig. 4.55. The actual and predicted values are in close agreement.

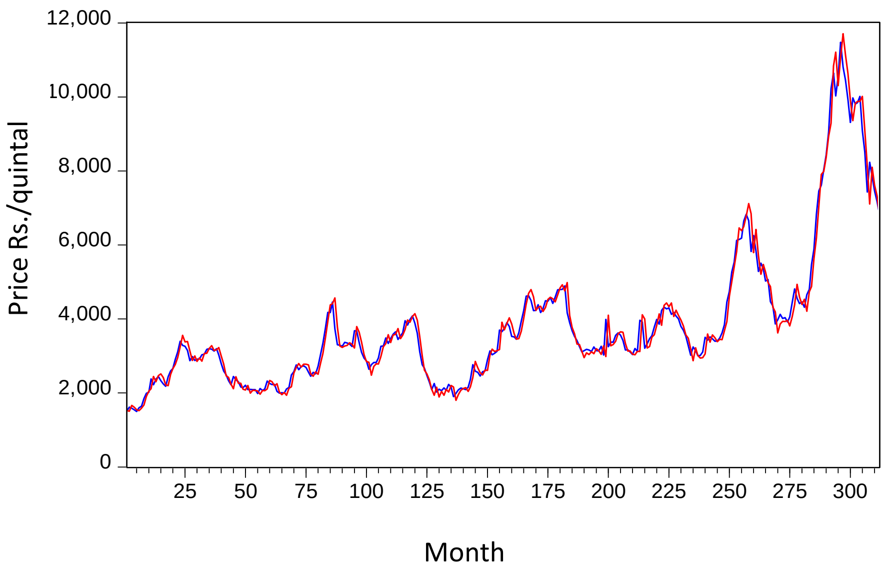


Fig. 4.55. Actual and predicted plots fitted for copra price at Kozhikode market from HWMS model

The residual plot for copra price at Kozhikode market from HWMS model is given in Fig. 4.56. From figure, it could be observed that residuals did not exhibited any pattern. This explains the adequacy of the model for the data.

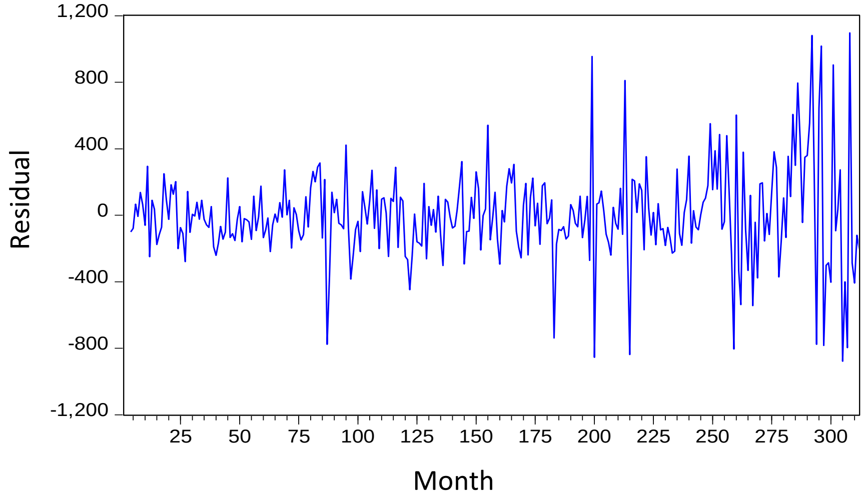


Fig. 4.56. Residual plot for copra price at Kozhikode market for HWMS model

The forecasts obtained for January, February and March, 2016 based on HWMS model are provided in Table 4.63. The MAPE is only 4.76 percent for HWMS model.

Table 4.63 Price forecasts form HWMS model for copra price at Kozhikode market

Month	Forecast price	MAPE (%)
Jan-16	6445	4.76
Feb-16	6106	
Mar-16	5509	

Actual prices for January, February and March, 2016 and forecast prices from SARIMA(1,1,1)(1,0,1)$_{12}$, ANN and HWMS models for copra price at Alappuzha market are provided in Table 4.64, along with MAPE (%) for validation of the models

Table 4.64. Validation of forecast price of copra at Kozhikode market

Month	Actual price (Rs./quintal)	Forecast price		
		SARIMA (1, 1, 1)(1, 0, 1)$_{12}$	ANN	HWMS
16-Jan	6158 (5950-6350)	6788 (5981-7672)	6417	6445
16-Feb	5894 (5800-6050)	6689 (5526-8025)	5695	6106
16-Mar	5524 (5350-5900)	6541.91 (5108-8255)	5595	5509
MAPE (%)		**4.79**	**6.46**	**4.76**

Values in parenthesis indicate the price range.

From Table 4.64, when the forecast prices were compared from the three models HWMS model gave better forecast. MAPE was least for HWMS model. Also, when the actual and predicted plots as well as residual plots in the three models were compared HWMS model was more adequate for forecasting copra price at Kozhikode market. Daily price data along with the forecast price of copra at Kozhikode market for January, February and March, 2016 are provided in Appendix-VI.

In general it could be observed that HWMS is the most suitable model for predicting monthly prices of coconut oil and copra. The exponential smoothing models weigh past observations by exponentially decreasing weights away from the forecast. The prices of coconut oil as also copra experiences frequent fluctuations with very high peaks and troughs intermittently. Only an exponentially decaying phenomenon can capture the exact price fluctuations. HWMS model which accommodates the trend and seasonal components at any pre designated level is the most apt model. Another advantage is that the effect of factors other than the effect of secondary factors influencing the price is automatically accommodated.

4.3. Analysis of coconut price

Price data was available for coconut for Alappuzha market only. The results obtained from the analysis of coconut price are presented below:

4.3.1. Price pattern of coconut at Alappuzha market

Pattern of variation in price of coconut at Alappuzha market from January 1998 to December 2015 (216 months) is shown in Fig 4.57. As in the case of coconut oil and copra prices at Alappuzha, wide fluctuation was noticed in the price of coconut also. The fluctuation in price of coconut severely affects the rural economy. Especially, farmers who depend on the income from coconut are directly affected. Several periods of depression could be noted in the price of coconut (Fig 4.57). From January 1998 to October 2002, the price was less than Rs.6/nut and within the period, the price was less than Rs.4/nut from May 2000 to April 2002. During October 2002 - February 2008, price increased above Rs.6/nut only during August 2003 to March 2005. Again June 2009 - August 2010 was a period of depression for coconut price with less than Rs.6 /nut. September 2010 to June 2011 showed hike in price with Rs.9.9/nut in June 2011. Further, the price declined to Rs.7/nut in November 2012. After November 2012, the price improved again and more than Rs.15 per nut was obtained in October 2014. The price again declined and in December 2015, the price was around Rs.8/nut only. The situation has not improved further, as per reports from Coconut Development Board, Kochi.

Alp_coconut price: coconut price at Alappuzha market

Fig 4.57. Price pattern of coconut at Alappuzha market

4.3.2 Instability in price of coconut

It was observed that coefficient of variation for coconut price at Alappuzha market was 37.41 per cent and was less than that of coconut oil (47.52 percent) price and copra (48.20 percent) price at Alappuzha market.

4.3.3 Seasonal variations in price of coconut

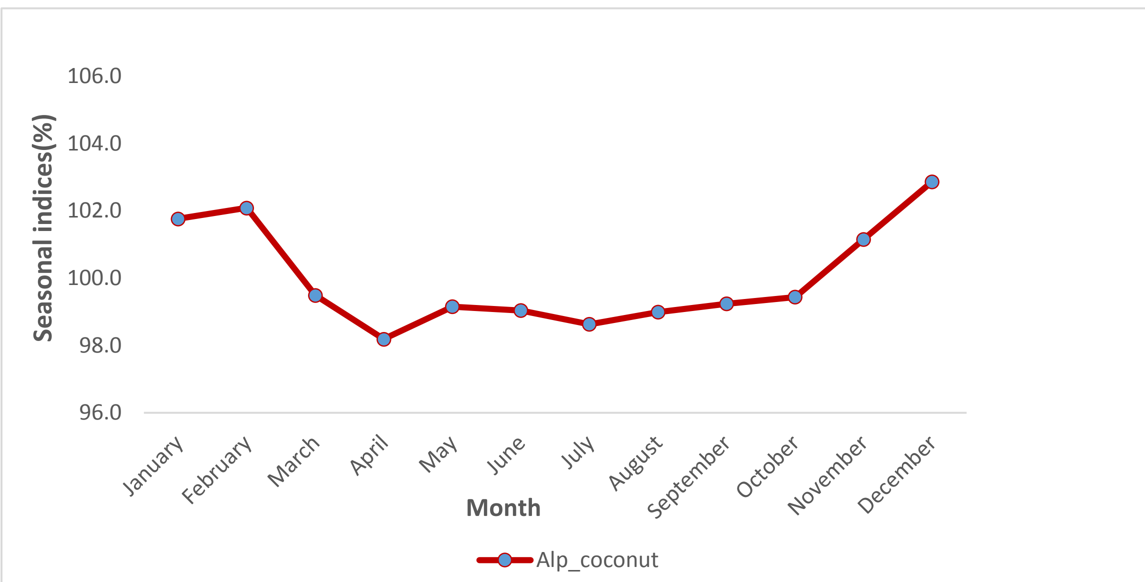
Seasonal indices of coconut price at Alappuzha market for the different months are provided in Table 4.65. It could be observed from the table that seasonal index was above 100 in November, December, January and February. Peak price month is December with seasonal index, 102.9 percent. During March to October, the index ranged between 98.2 and 99.5 percent. Low price month for coconut is April, where, the seasonal index was least (98.2 percent).

The seasonal plot of coconut price is shown in Fig 4.58. From the figure, it could be noted that March to October is the depressed phase for price of coconut. From

August, improvement in price was noted and November-February is the buoyant phase for price of coconut. Babu (2005) also got similar results.

Table 4.65. Seasonal indices of coconut price at Alappuzha market

Month	Seasonal indices of coconut price (%)
January	101.8
February	102.1
March	99.5
April	98.2
May	99.2
June	99.0
July	98.6
August	99.0
September	99.2
October	99.4
November	101.1
December	102.9



Alp_coconut- Coconut price at Alappuzha market

Fig 4.58 Seasonal plot of price of coconut at Alappuzha market

From the analysis of seasonal variations in price of coconut at Alappuzha market, the following conclusions could be made:

Increase in price of coconut is observed from August onwards. Peak price is obtained in December with buoyant phase from November to February. Babu *et al*. (2009) reported November as the peak month for price of coconut with buoyant phase from September to February. April is the low price month with depressed phase from March to October. Babu *et al*. (2009) also reported April as the trough month in price of coconut, but the period of depression in price was from March to August.

The period of depression for coconut price coincides with the peak harvesting period of coconut. Hence, to ensure reasonable income for farmers during this period, efforts should be taken to convert coconut into value added products like activated carbon, desiccated coconut, neera, dry coconut, coconut oil, copra etc, ensuring proper marketing of the products by support from the Government.

4.3.4 Forecast modeling for price of coconut

ARIMA, ANN, and exponential smoothing models, were fitted for price of coconut for Alappuzha market. The best model Alappuzha market was selected based on the forecast accuracy measure Mean Absolute Percentage Error (MAPE), agreement between actual and fitted price plots, residual ACF and PACF plots for ARIMA models, residual plots for ANN and exponential smoothing models, and forecasts for January, February and March 2016 were used. The results are provided in section 4.3.4.1a to 4.3.4.1c.

4.3.4.1a. ARIMA model for coconut price at Alappuzha market

The time plot of coconut price at Alappuzha market (Fig. 4.57) indicates that it is non-stationary. ACF and PACF values for coconut price at Alappuzha market are provided in Table 4.66.

Table 4.66. ACF and PACF values for coconut price at Alappuzha market

Lag	Auto-correlation	S.E	Ljung-Box statistic			Partial Auto-correlation	S.E
			Value	df	Probability (p)		
1	0.980	0.068	210.262	1	<0.0001	0.980	0.068
2	0.951	0.067	409.179	2	<0.0001	-0.231	0.068
3	0.922	0.067	596.984	3	<0.0001	0.033	0.068
4	0.892	0.067	773.728	4	<0.0001	-0.041	0.068
5	0.858	0.067	938.034	5	<0.0001	-0.121	0.068
6	0.821	0.067	1089.091	6	<0.0001	-0.058	0.068
7	0.784	0.067	1227.411	7	<0.0001	0.002	0.068
8	0.744	0.066	1352.768	8	<0.0001	-0.088	0.068
9	0.701	0.066	1464.632	9	<0.0001	-0.079	0.068
10	0.661	0.066	1564.641	10	<0.0001	0.100	0.068
11	0.622	0.066	1653.493	11	<0.0001	-0.067	0.068
12	0.582	0.066	1731.551	12	<0.0001	-0.031	0.068
13	0.545	0.066	1800.383	13	<0.0001	0.108	0.068
14	0.509	0.065	1860.893	14	<0.0001	-0.048	0.068
15	0.474	0.065	1913.543	15	<0.0001	-0.043	0.068
16	0.441	0.065	1959.307	16	<0.0001	0.074	0.068

p<0.05 indicates significance of autocorrelation

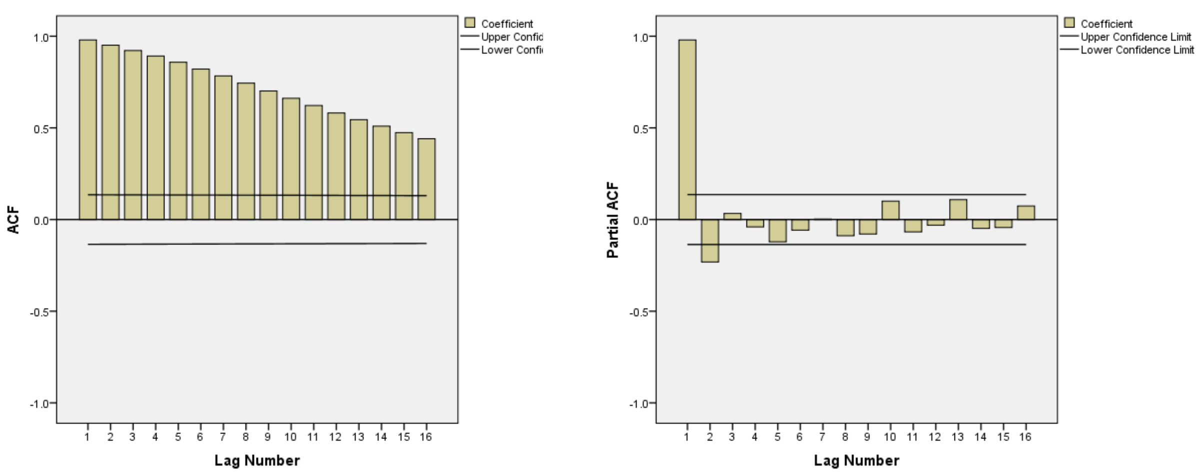


Fig. 4.59. ACF and PACF plots for coconut price at Alappuzha market

Significance of autocorrelations upto 16 lags confirms the non stationarity of the data. PACF has very high value for lag1. The ACF and PACF plots for coconut price at Alappuzha market is depicted in Fig. 4.59. It could be observed that in the ACF plot, spikes upto 16 lags fall above critical values indicating the non-stationarity of the TS. PACF plot also showed spikes for a number of lags (1, 2, and 5) beyond critical values.

ADF test was conducted for coconut price at Alappuzha, to test whether any differencing is required to make the data stationary. After taking first difference, the ADF test statistics was highly significant (Table 4.67) indicating that first difference is required to make the data stationary. Hence, first difference was taken before fitting ARIMA model for coconut price at Alappuzha market.

Table 4.67. ADF test with critical values for coconut price at Alappuzha market

	ADF test statistic	Probability (p)	Critical values
Observed price	-1.79^{NS}	0.38	-3.45 (1% level)
First difference	-11.59**	0.001	-2.87 (5% level)

$p < 0.05$ indicate significance, ** significant at 1% level

From among the different alternative ARIMA models tried, ARIMA (0,1,1) was identified for coconut price at Alappuzha market. Parameters of the model and their tests of significance are provided in Table 4.68.

Table 4.68. ARIMA(0,1,1) model parameters for coconut price at Alappuzha market

Model parameters	Estimate	S.E	t	Probability(p)
Non-seasonal difference	1			
MA Lag 1 (θ_1)	0.25	0.07	-3.72**	0.003

$p < 0.05$ indicate significance, ** significant at 1% level

Thus, ARIMA (0,1,1) model for coconut price at Alappuzha market is

$$(1-B)Y_t = (1-\theta_1 B)\varepsilon_t$$

Where, $\theta 1 = 0.066$

Hence ARIMA (0,1,1) parameter for coconut price at Alappuzha market is

$$(1-B)Y_t = (1-0.066B)\varepsilon_t$$

i.e., $Y_t = Y_{t-1} + \varepsilon_t - 0.066\varepsilon_{t-1}$

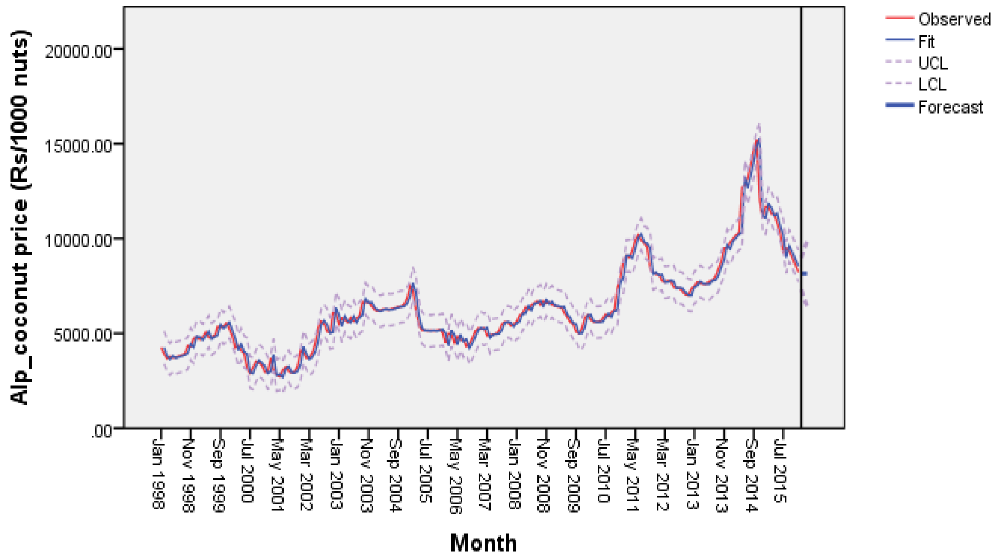
The model fit statistics obtained for the above model are given in the Table 4.69

Table 4.69 Model fit statistics of ARIMA (0,1,1) model for coconut price at Alappuzha market

Model Fit statistics				
R^2	**RMSE**	**MAPE (%)**	**MAE**	**Normalized BIC**
0.97	425.31	**4.25**	257.84	12.13

The model could explain 97% of the variation in the data and the MAPE was only 4.25%. The plot of actual and predicted (fit) values along with the upper and lower confidence limits and forecasts for coconut price at Alappuzha market using ARIMA (0,1,1) model is given in Fig. 4.60. The plot shows the closeness of the actual price and predicted price based on the model.

Residual ACF and PACF plots for the ARIMA (0,1,1) model fitted for coconut price at Alappuzha market is provided in Fig. 4.61. It could be seen that majority of the spikes in the ACF and PACF plots fall within the critical values. This shows the adequacy of ARIMA (0,1,1) model for coconut price at Alappuzha market.



Alp_coconut price: Coconut price at Alappuzha market

Fig. 4.60. Observed, fit, LCL, UCL and forecast for coconut price at Alappuzha market for ARIMA(0,1,1) model

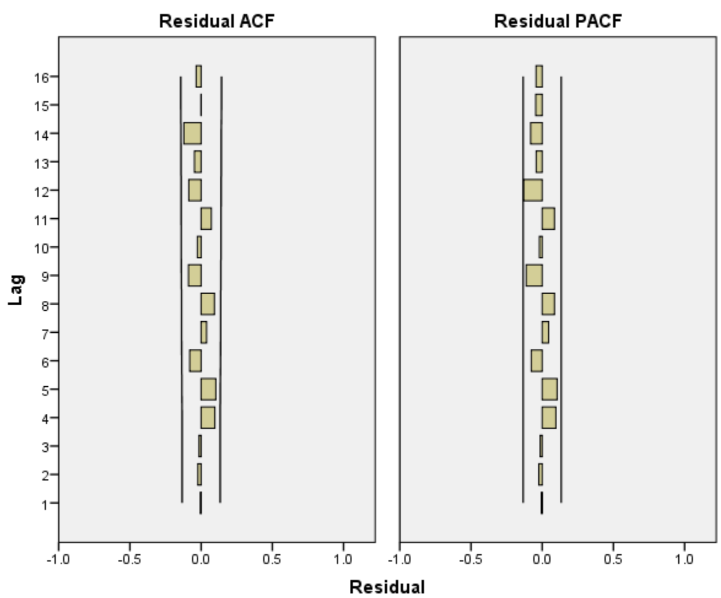


Fig. 4.61. Residual ACF and PACF plots for coconut price at Alappuzha market for ARIMA(0,1,1) model

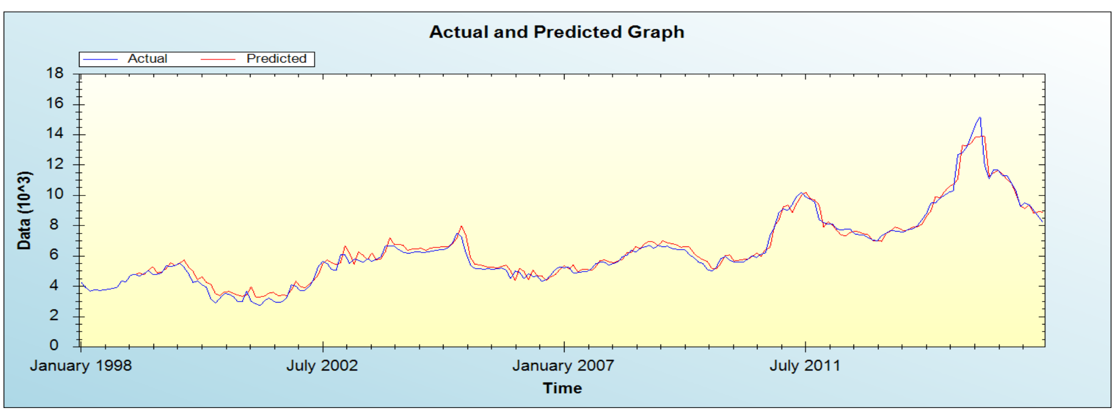
The forecasts of coconut price at Alappuzha market based on ARIMA (0,1,1) model fitted from January 2016 to March 2016 are provided in Table 4.70 along with the upper and lower confidence limits and MAPE values.

Table 4.70 Forecasts from ARIMA(0,1,1) model for coconut price at Alappuzha market

Month	Forecast price			MAPE (%)
	Price forecast (Rs/1000 nuts)	LCL	UCL	
Jan-16	8144	7306	8983	4.25
Feb-16	8144	6805	9484	
Mar-16	8144	6445	9844	

4.3.4.2 ANN model

ANN model was fitted for coconut price at Alappuzha market. The actual price along with the predicted (fit) values of coconut price at Alappuzha market using ANN model is plotted in Fig. 4.62. It could be observed that the ANN model captures the pattern of the TS data well. The actual and predicted values lie very close to a straight-line as seen from Fig. 4.63 indicating the adequacy of the model for the data.



Data - Coconut price at Alappuzha market, Time- Month and 10^3- 10^3 Rs/1000 nuts

Fig. 4.62. Actual and predicted plots from ANN model for coconut price at Alappuzha Market

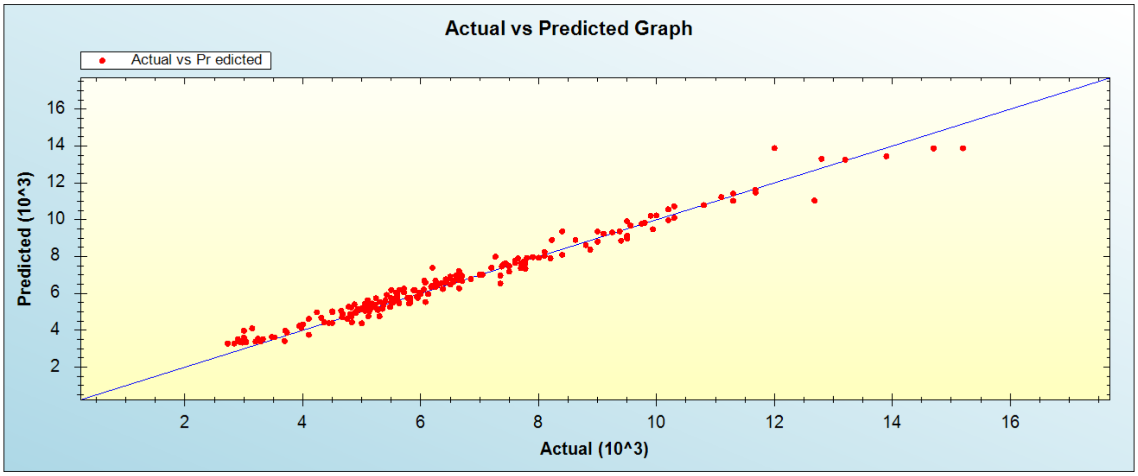
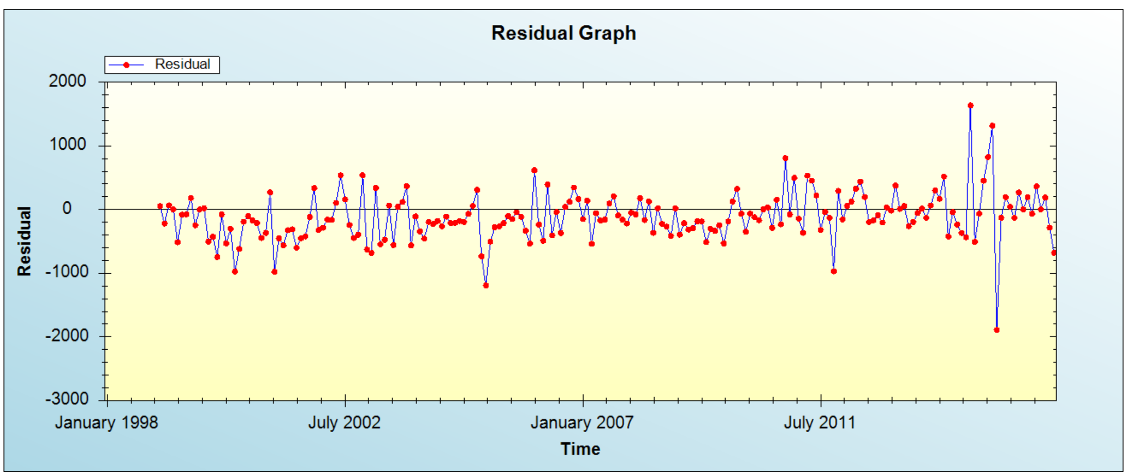


Fig. 4.63. Actual vs. predicted graph from ANN model for coconut price at Alappuzha market

The residual plot from ANN model is provided in Fig. 4.64. The residuals did not exhibit any specific pattern.



Time -Month

Fig. 4.64. Residual plot for coconut price at Alappuzha market from ANN model

The forecasts using ANN model from January 2016 to March 2016 are given in Table 4.71 along with MAPE value. The MAPE value was only 5.15 percent. Various accuracy measures for ANN model are provided in Table 4.72.

Table 4.71. Forecasts from ANN model for coconut price at Alappuzha market

Month	Forecast price (Rs/1000 nuts)	MAPE (%)
Jan-16	8019	5.15
Feb-16	8010	
Mar-16	8252	

Table 4.72. Model accuracy measures for ANN model for coconut price at Alappuzha market

Accuracy measure	Value
RMSE	395.85
MAE	292.79
MAPE (%)	**5.15**

4.3.4.1c. Exponential smoothing models

Holt-Winters' Multiplicative Seasonal (HWMS) model was identified from among the different exponential smoothing models like SES, DES, HWAS and HWMS models for the coconut price at Alappuzha market. The estimates of parameters of HWMS model are provided in Table 4.73.

Table 4.73. Estimates of parameter of HWMS model for coconut price at Alappuzha market

Parameter	α	β	γ
Estimate	1.00	0.00	0.00

With these values for the parameters, the equations of the HWMS model for Coconut price at Alappuzha market are given below:

Level: $L_t = \frac{Y_t}{S_{t-12}}$ Trend: $b_t = b_{t-1}$

Seasonal: $S_t = S_{t-12}$ Forecast: $F_{t+m} = (L_t + b_t m) S_{t-12+m}$

The values of L_t, b_t, and S_t at time t were estimated first and substituted in the forecast equation F_{t+m}, to obtain the m period ahead forecast.

The fit of the HWMS model for coconut price at Alappuzha market can be seen from Fig. 4.65. The actual and predicted values are in close agreement.

The residual plot for coconut price at Alappuzha market from HWMS model is given in Fig. 4.66.

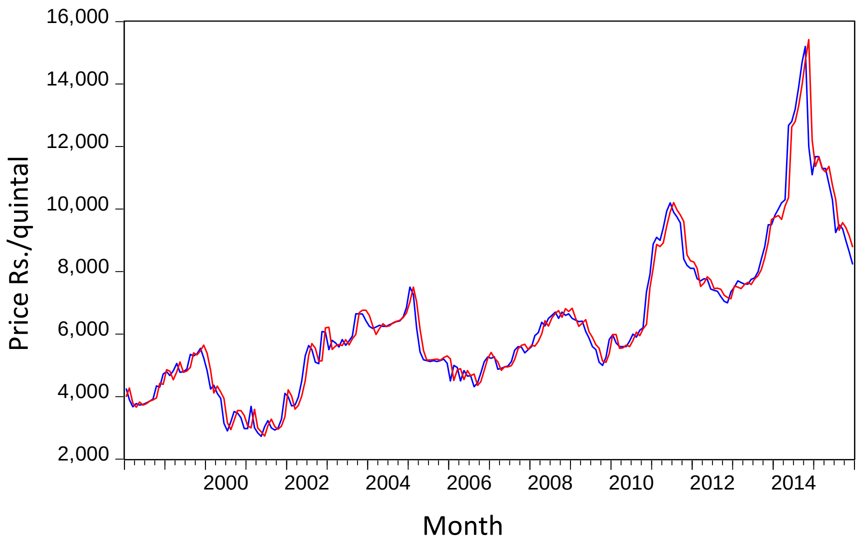


Fig. 4.65. Actual and predicted plots for coconut price at Alappuzha market from HWMS model

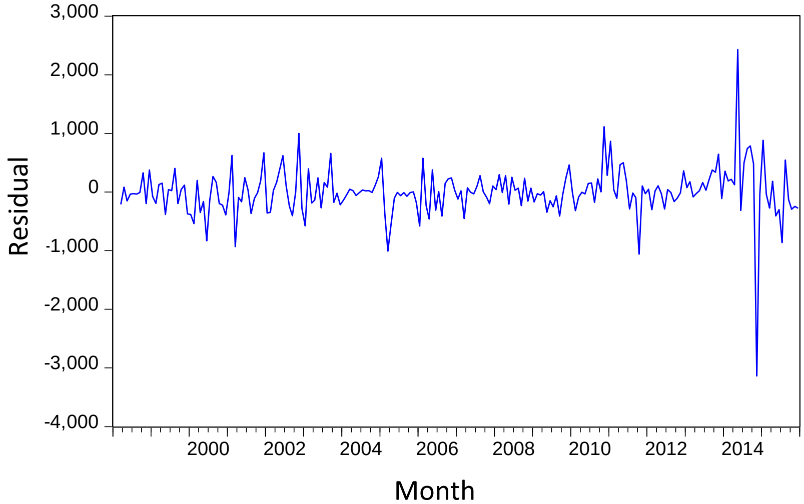


Fig. 4.66. Residual plot for coconut price at Alappuzha market for HWMS model

The forecasts obtained for January, February and March, 2016 based on HWMS model are provided in Table 4.74. The MAPE is only 4.54 percent for HWMS model.

Table 4.74. Forecasts from HWMS model for coconut price at Alappuzha market

Month	Forecast price (Rs/1000 nuts)	MAPE (%)
Jan-16	7871	4.54
Feb-16	7499	
Mar-16	7144	

For coconut price at Alappuzha market, the model was selected as the best forecast model based on MAPE value provided in Table 4.75.

Table 4.75. Validation of forecast price of coconut at Alappuzha market

Month	Actual	Forecast price		
		ARIMA	ANN	HWMS
16-Jan	8000	8144 (7306-8983)	8019	7871
16-Feb	8000	8144 (6805-9484)	8010	7499
16-Mar	7967	8144 (6445-9844)	8252	7144
MAPE (%)		**4.25**	**5.15**	**4.54**

Values in parenthesis indicate the price range.

Forecasts based on ARIMA (0,1,1) model were in more agreement with the actual prices in all the three months compared to ANN and HWMS models. For the ARIMA (0,1,1) model fitted all the spikes in the residual PACF plot were not within the critical values. Also, actual and predicted plots were in more agreement for ARIMA (0,1,1) model compared to ANN model. Thus, for coconut price at Alappuzha market ARIMA (0,1,1) model was selected as the best forecast model.

When the yield of any commodity is sold as raw, it is natural that the immediate past only is the matter of concern because of many factors prevailing in the market, like perishability and freshness of the product, as also the extent of accommodative stock that a wholesaler can recognize. This is a contrasting feature in relation to the value added products *viz.*, coconut and copra. Thus, ARIMA model, the simplest and the most apt, *viz.*, ARIMA(0,1,1), has been identified as the most suitable forecast model for coconut.

Summary

5. SUMMARY

The summary of the study "Price forecast models for coconut and coconut oil" is given in this chapter. The study was undertaken to estimate the seasonal variations in prices of coconut oil, copra and coconut; to evaluate different time series forecast models and suggest suitable forecast models for prices of coconut oil, copra and coconut.

Time series data on monthly average prices of coconut oil, copra and coconut for three markets of Kerala viz., Alappuzha, Kochi and Kozhikode, collected from Coconut Development Board (CDB), Kochi formed the database for the study. For coconut oil and copra, data were collected from January 1990 to December 2015 from all the three markets, whereas, for coconut, price data were available only for Alappuzha market from January 1998 to December 2015.

Time plots of the price data of coconut, coconut oil and copra were used to understand the pattern of price variation in the different markets. Coefficient of variation was worked out for price of each commodity in all the three markets, to understand the instability in their prices. Seasonal indices were worked out to have an idea about the variation over different months from January to December, in each market for the prices of coconut, coconut oil and copra.

Different time series forecast models viz., Auto regressive Integrated Moving Average (ARIMA), Artificial Neural Network (ANN) and exponential smoothing models (single, double, Holt-Winters' additive and multiplicative) were fitted for prices of coconut oil and copra in all the three markets; and for coconut at Alappuzha market. The different criteria used for selecting the appropriate model for price of each commodity in each market were: Mean Absolute Percentage Error (MAPE); agreement between actual and fitted price plots; residual ACF and PACF plots (ARIMA models); residual plots (ANN and exponential smoothing models); and forecasts for January, February and March 2016.

Analysis of price pattern of coconut oil revealed that wide fluctuation exists in the price of coconut oil in all the three markets. During the period from January 1990 to December 2015, the price of coconut oil increased above Rs.10000/quintal; once in May 2011 and next during November 2013 to October 2015. At Kochi and Kozhikode markets, the same price level was maintained upto December 2015. The highest price during the 26 year period from January 1990 to December 2015 was in August 2014 in all the three markets, with Rs.16405/quintal at Alappuzha, Rs.16421/quintal at Kochi, and Rs.17524/quintal at Kozhikode. After August 2014, the price of coconut oil started declining in all the three markets and the trend continued.

Wide fluctuations with several ups and downs was noticed in the price of copra at Alappuzha, Kochi and Kozhikode markets. In all the three markets, price of copra increased above Rs.6000/quintal once in May 2011 and then during November 2012 to August 2014. The highest price during the 312 months from January 1990 to December 2015 was in August 2014, with Rs.11233/quintal at Alappuzha, Rs.11394/quintal at Kochi, and Rs.11475/quintal at Kozhikode. After August 2014, copra price also started declining and the trend continued.

As in the case of coconut oil and copra, price of coconut was also subjected to wide fluctuation. During 216 months from January 1998 to December 2015, better price was obtained for coconut only during September 2010 - June 2011 and then during November 2012- October 2014 and the highest of Rs.15200/1000 nuts was obtained in October 2014. After October 2014, the price started declining and the trend continued. The low price for coconut is the major problem faced by coconut farmers. Earlier, price of coconut was fixed based on the market price of coconut oil. Now, the situation has changed. Apart from coconut oil and copra, demand for many value added products like activated carbon, desiccated coconut, virgin coconut oil etc. has increased. Hence, to overcome the low price for coconut, efforts are to be taken to convert coconut into value added products, according to the market demand.

High instability in price of coconut oil was noticed with coefficient of variation of 47.52, 48.53 and 49.72 per cent respectively at Alappuzha, Kochi and Kozhikode markets. Similarly, copra price also showed high variation during the period from January 1990 to December 2015. The coefficient of variation was highest in Kochi (50.45 per cent) followed by Kozhikode (49.86 per cent) and Alappuzha (48.2 per cent) markets. Compared to coconut oil and copra, price variability was low for coconut with coefficient of variation of 37.41 per cent.

It could be observed that seasonal variations in price of coconut oil follow almost the same pattern in all the three markets. Increase in price of coconut oil is observed from August onwards. December is the peak price month for coconut oil at Alappuzha and Kozhikode markets, whereas it is in January at Kochi. Lowest price is observed in May at Alappuzha and Kozhikode market, whereas, at Kochi it is in July. In all the three markets, September – February is the buoyant phase and price depression is during March - August. Price of copra showed increasing trend from June. Peak price is in December at Alappuzha and Kochi markets, whereas, it is in November at Kozhikode. The price starts declining from February and the lowest price of copra is in May in all the three markets. October to February is favourable for copra price in all the three markets, whereas, depressed phase is from March to September. From the estimates of seasonal indices, it could be observed that increase in price of coconut starts from August. Peak price of coconut at Alappuzha markets is in December and the buoyant phase is from November to February. April is the low price month with depressed phase from March to October.

During the summer season, there is high demand for tender coconut and products like neera. Thus, during March to May, harvest the coconuts as tender and increase the production of neera. Also, since price of coconut oil and copra is comparatively low during March- September, the only way to overcome the crisis is to take all steps to convert coconut into value added products other than coconut oil and copra during the above period.

When different forecast models were fitted for coconut oil price at Alappuzha market, MAPE values were low for ARIMA (3,1,0), ANN and Holt-Winters' Multiplicative Seasonal (HWMS) models. But, on comparing forecasts for January, February and March 2016, agreement between actual and fitted plots as well as residual plots, HWMS model was selected as the best forecast model for coconut oil price at Alappuzha. Although for coconut oil price at Kochi, SARIMA$(0,1,2)(1,0,1)_{12}$, ANN and HWMS models gave low MAPE values, HWMS model was selected as the best, on comparing the forecast prices for January, February and March 2016, the agreement between actual and predicted plots as well as residual plots. For coconut oil price at Kozhikode market, MAPE was low for SARIMA$(1,1,1)(1,0,1)_{12}$, ANN and HWMS models. None of the models gave good forecasts. But, on comparing the actual and predicted plots as well as residual plots, SARIMA$(1,1,1)(1,0,1)_{12}$ and HWMS models were suitable.

For the copra price at Alappuzha market, low values for MAPE were obtained for SARIMA$(1,1,4)(1,0,1)_{12}$, ANN and HWMS models. But HWMS was selected as the best model for forecasting copra price at Alappuzha market, since, actual and predicted plots were in more agreement and good forecasts for January, February and March 2016 were provided by the HWMS model. At Kochi market also, HWMS model was found to be more adequate for copra price; since, it gave better forecasts, least MAPE value, and more agreement between actual and predicted plots compared to SARIMA$(0,1,0)(1,0,1)_{12}$ and ANN models. For copra price at Kozhikode market also, HWMS model was selected as the best forecast model, on comparing with SARIMA $(1, 1, 1)(1, 0, 1)_{12}$ and ANN models, based on MAPE value; forecasts for January, February and March 2016; and agreement between actual and predicted plots.

For coconut price at Alappuzha market, MAPE values were low and comparable for ARIMA (0,1,1), ANN and HWMS models. But forecasts for January, February and March 2016 based on ARIMA (0,1,1) model were in more agreement with the actual prices. Also, actual and predicted plots were in more agreement, and all spikes were within the critical values in the residual ACF and PACF plots for ARIMA (0,1,1) model. Thus, ARIMA (0,1,1) model was selected as the best forecast model for coconut price at Alappuzha market.

Thus, Holt-Winters' Multiplicative Seasonal (HWMS) model is recommended as the appropriate forecast model for price of coconut oil at Alappuzha and Kochi markets. At Kozhikode market, SARIMA(1,1,1)(1,0,1)12 and HWMS models are suitable. For copra price, HWMS model is the best forecast model at all markets. ARIMA (0,1,1) model is suitable for forecasting price of coconut at Alappuzha market.

Following conclusions were made from the study:

1. Wide fluctuation exists in the price of coconut, coconut oil and copra. Price instability was high for coconut oil and copra compared to coconut.
2. December is the peak price month for coconut oil at Alappuzha and Kozhikode markets, whereas it is in January at Kochi. Lowest price is observed in May at Alappuzha and Kozhikode markets, whereas, at Kochi it is in July.
3. For copra, peak price is in December at Alappuzha and Kochi markets, whereas, it is in November at Kozhikode. The lowest price of copra is in May in all the three markets.
4. September- February is the buoyant phase and March – August is the trough phase for coconut oil price.
5. For copra price, October- February is the buoyant phase and March – September is the trough phase.
6. Better price is obtained for coconut during November- February with peak in December at Alappuzha market. April is the low price month with trough phase from March to October.
7. During the summer months from March to May, harvest the coconuts as tender and increase the production of neera.

8. Convert coconut into value added products other than coconut oil and copra during March- September.
9. Holt-Winters' Multiplicative Seasonal (HWMS) model is the appropriate forecast model for price of coconut oil at Alappuzha and Kochi markets. At Kozhikode market, SARIMA$(1,1,1)(1,0,1)_{12}$ and HWMS can be used.
10. HWMS model is selected as the suitable forecast model for copra at all markets.
11. ARIMA (0,1,1) model is suitable for forecasting price of coconut at Alappuzha market.

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Appendices

Appendix-I

Price validation of coconut oil at Alappuzha market

Date	Jan-16	Feb-16	Mar-16
01.01.16	9100	8400	8700
02.01.16	9100	8400	8700
03.01.16	SUNDAY	8400	8700
04.01.16	9000	8400	8700
05.01.16	8900	8400	8400
06.01.16	8900	8400	SUNDAY
07.01.16	8900	SUNDAY	8700
08.01.16	8900	8400	8700
09.01.16	8900	8400	8750
10.01.16	SUNDAY	8400	8700
11.01.16	8800	8400	7900
12.01.16	8800	8500	7900
13.01.16	8800	8500	SUNDAY
14.01.16	8800	SUNDAY	7900
15.01.16	8800	8600	7900
16.01.16	8800	8600	7600
17.01.16	SUNDAY	8600	7600
18.01.16	8800	8600	7600
19.01.16	8800	8500	7600
20.01.16	8800	8500	SUNDAY
21.01.16	8800	SUNDAY	7600
22.01.16	8700	8500	7600
23.01.16	8700	8500	7600
24.01.16	SUNDAY	8500	7600
25.01.16	NA	8700	NA
26.01.16	NA	8700	7600
27.01.16	8400	8700	SUNDAY
28.01.16	8400	SUNDAY	7600
29.01.16	8400	NA	7600
30.01.16	8400	NA	7600
31.01.16	SUNDAY	-	7800
Average	**8779**	**8500**	**8025**
HWMS	**9156**	**8691**	**7767**

NA- Not Available

Appendix-II

Price validation of coconut oil at Kochi market

Date	16-Jan	16-Feb	16-Mar
01.01.16	NA	9000	9100
02.01.16	9600	9000	9100
03.01.16	SUNDAY	9000	9100
04.01.16	9500	8950	9000
05.01.16	9400	8950	8900
06.01.16	8800	8950	SUNDAY
07.01.16	9400	SUNDAY	NA
08.01.16	9400	8950	8700
09.01.16	9400	8950	8800
10.01.16	SUNDAY	9000	8500
11.01.16	9400	9100	8400
12.01.16	9400	9100	8300
13.01.16	9400	9100	SUNDAY
14.01.16	9400	SUNDAY	8200
15.01.16	9400	9100	8200
16.01.16	9400	9100	8200
17.01.16	SUNDAY	NA	8200
18.01.16	9400	9100	8200
19.01.16	9400	9100	8200
20.01.16	9400	NA	SUNDAY
21.01.16	9400	SUNDAY	8200
22.01.16	9300	9100	8200
23.01.16	9200	9200	8200
24.01.16	SUNDAY	9300	8200
25.01.16	9100	9300	NA
26.01.16	NA	9300	8200
27.01.16	9000	9300	SUNDAY
28.01.16	9000	SUNDAY	8200
29.01.16	9000	9200	8300
30.01.16	9000	9093	8300
31.01.16	SUNDAY	-	8300
Average	**9296**	**9093**	**8448**
HWMS	**9736**	**9233**	**8318**

NA- Not Available

Appendix-III

Price validation of coconut oil at Kozhikode market

Date	Jan-16	Feb-16	Mar-16
01.01.16	9800	9000	NA
02.01.16	9700	9000	9000
03.01.16	SUNDAY	8900	9000
04.01.16	9500	8900	9000
05.01.16	9500	8900	8800
06.01.16	9500	8900	SUNDAY
07.01.16	9400	SUNDAY	9000
08.01.16	9400	8800	8800
09.01.16	9400	8800	8800
10.01.16	SUNDAY	8800	8700
11.01.16	9400	8800	8500
12.01.16	9400	8800	8500
13.01.16	9400	8800	SUNDAY
14.01.16	9400	SUNDAY	8500
15.01.16	9400	8800	8400
16.01.16	9400	NA	8400
17.01.16	SUNDAY	8800	8400
18.01.16	9400	8800	8400
19.01.16	9400	8800	8400
20.01.16	9400	8800	SUNDAY
21.01.16	9400	SUNDAY	8400
22.01.16	9400	8800	8400
23.01.16	9300	8900	8400
24.01.16	NA	9000	8400
25.01.16	NA	9100	NA
26.01.16	9200	9100	8400
27.01.16	9100	9100	SUNDAY
28.01.16	9100	SUNDAY	8400
29.01.16	9000	9100	8400
30.01.16	9000	NA	8400
31.01.16	SUNDAY	-	8400
Average	**9372**	**8896**	**8568**
SARIMA(1,1,1)(1,0,1)$_{12}$	**10436**	**10167**	**9904**

NA- Not Available

Appendix-IV

Price validation of copra at Alappuzha market

Date	Jan-16	Feb-16	Mar-16
01.01.16	6450	6050	6000
02.01.16	6450	6050	6000
03.01.16	SUNDAY	6050	6000
04.01.16	6350	6050	6000
05.01.16	6300	6050	5800
06.01.16	6300	6050	SUNDAY
07.01.16	6300	SUNDAY	6000
08.01.16	6300	6050	6000
09.01.16	6300	6050	5700
10.01.16	SUNDAY	6050	5500
11.01.16	6250	6050	5400
12.01.16	6250	6100	5400
13.01.16	6250	6100	SUNDAY
14.01.16	6250	SUNDAY	5400
15.01.16	6250	6100	5400
16.01.16	6250	6100	5250
17.01.16	SUNDAY	6100	5250
18.01.16	6250	6100	5250
19.01.16	6250	6050	5250
20.01.16	6250	6050	SUNDAY
21.01.16	6250	SUNDAY	5350
22.01.16	6150	6050	5350
23.01.16	6150	6000	5350
24.01.16	SUNDAY	6050	5300
25.01.16	NA	6100	NA
26.01.16	NA	6100	5350
27.01.16	6150	6150	SUNDAY
28.01.16	6050	SUNDAY	5350
29.01.16	6050	NA	5300
30.01.16	6050	NA	5350
31.01.16	SUNDAY	-	5350
Average	**6244**	**6017**	**5525**
HWMS	**6339**	**5961**	**5339**

NA- Not Available

Appendix-V

Price validation of price of copra at Kochi market

Date	16-Jan	16-Feb	16-Mar
01.01.16	NA	5800	5900
02.01.16	6200	5800	5900
03.01.16	SUNDAY	5800	5900
04.01.16	6150	5800	5800
05.01.16	6100	5800	5725
06.01.16	6100	5800	SUNDAY
07.01.16	6100	SUNDAY	NA
08.01.16	6100	5800	5600
09.01.16	6100	5800	5525
10.01.16	SUNDAY	5850	5450
11.01.16	6100	5950	5400
12.01.16	6100	5950	5300
13.01.16	6100	5950	SUNDAY
14.01.16	6100	SUNDAY	5250
15.01.16	6100	5950	5250
16.01.16	6100	5950	5250
17.01.16	SUNDAY	NA	5250
18.01.16	6100	5950	5250
19.01.16	6100	5950	5250
20.01.16	6100	NA	SUNDAY
21.01.16	6100	SUNDAY	5250
22.01.16	6000	5950	5250
23.01.16	6000	6050	5250
24.01.16	SUNDAY	6100	5250
25.01.16	5900	6100	NA
26.01.16	NA	6100	5250
27.01.16	5800	6100	SUNDAY
28.01.16	5800	SUNDAY	5250
29.01.16	5800	6000	5350
30.01.16	5800	NA	5350
31.01.16	SUNDAY	-	5350
Average	**6040**	**5926**	**5422**
HWMS	**6137**	**5847**	**5123**

NA- Not Available

Appendix-VI

Price validation of price of copra at Kozhikode market

Date	Jan-16	Feb-16	Mar-16
01.01.16	6350	5950	NA
02.01.16	6300	5950	5900
03.01.16	SUNDAY	5900	5850
04.01.16	6200	5900	5850
05.01.16	6150	5900	5750
06.01.16	6150	5900	SUNDAY
07.01.16	6200	SUNDAY	5850
08.01.16	6200	5850	5650
09.01.16	6250	5850	5650
10.01.16	SUNDAY	5850	5500
11.01.16	6250	5850	5450
12.01.16	6200	5850	5800
13.01.16	6200	5850	SUNDAY
14.01.16	6200	SUNDAY	5400
15.01.16	6200	5800	5400
16.01.16	6200	NA	5400
17.01.16	SUNDAY	5800	5400
18.01.16	6200	5800	5400
19.01.16	6200	5800	5400
20.01.16	6150	5800	SUNDAY
21.01.16	6150	SUNDAY	5400
22.01.16	6150	5900	5400
23.01.16	6100	5900	5400
24.01.16	SUNDAY	6000	5350
25.01.16	NA	6050	NA
26.01.16	6050	6050	5350
27.01.16	6000	6000	SUNDAY
28.01.16	6000	SUNDAY	5350
29.01.16	5950	5950	5400
30.01.16	5950	NA	5400
31.01.16	SUNDAY		5400
Average	**6158**	**5894**	**5524**
HWMS	**6445**	**6106**	**5509**

NA- Not Available

PRICE FORECAST MODELS FOR COCONUT AND COCONUT OIL

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ABSTRACT OF THE THESIS

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Abstract

The study on “Price forecast models for coconut and coconut oil” was conducted to estimate seasonal variations in prices of coconut oil, copra and coconut, to evaluate different time series forecast models for prices of coconut oil, copra and coconut and to suggest suitable forecast models for Alappuzha, Kochi and Kozhikode markets.

Time series data on monthly average prices of coconut oil and copra for Alappuzha, Kochi and Kozhikode markets from January 1990 to December 2015 and for coconut price at Alappuzha market from January 1998 to December 2015 were collected from Coconut Development Board (CDB), Kochi formed the database.

Analysis of price pattern revealed that wide fluctuation exists in the prices of coconut oil and copra at Alappuzha, Kochi and Kozhikode markets and price of coconut at Alappuzha market. For coconut oil and copra price, the coefficient of variation was around 50 per cent indicating the instability in prices and a coefficient of variation of 37 per cent for coconut price showed that variability in price is lower than that of coconut oil and copra.

Seasonal indices for the 12 months from January to December showed that December is the peak price month for coconut oil at Alappuzha and Kozhikode markets, whereas it is in January at Kochi. Lowest price is observed in May at Alappuzha and Kozhikode market, whereas, at Kochi it is in July. In all the three markets, September – February is the buoyant phase and price depression is during March - August. For copra, peak price is in December at Alappuzha and Kochi markets, whereas, it is in November at Kozhikode. Trough price for copra is in May in all the three markets. October to February is favourable for copra price in all the three markets, whereas, depressed phase is from March to September.

For coconut, peak price at Alappuzha market is in December and the buoyant phase is from November to February. April is the low price month with

depressed phase from March to October. During the summer months from March to May, harvest the coconuts as tender and increase the production of neera. Also, during March- September, where the price of coconut oil and copra is low, steps are to be taken to convert coconut into other value added products like desiccated coconut powder, virgin coconut oil, activated carbon etc. and to identify regular markets in major cities of India as also outside India.

Different forecast models were fitted viz., Auto regressive Integrated Moving Average (ARIMA), Artificial Neural Network (ANN) and exponential smoothing models (single, double, Holt-Winters' additive and multiplicative) were fitted and compared for prices of coconut, coconut oil and copra in different market.

Holt-Winters' Multiplicative Seasonal (HWMS) model is the appropriate forecast model for price of coconut oil at Alappuzha and Kochi markets. At Kozhikode market, $SARIMA(1,1,1)(1,0,1)_{12}$ and HWMS can be used. HWMS model is selected as the suitable forecast model for copra at all markets. ARIMA (0,1,1) model is suitable for forecasting price of coconut at Alappuzha market.