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Price Forecasting of Cotton in Krishna and Kurnool Districts of Andhra Pradesh

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A B S T R A C T

An attempt was made to forecast the prices of cotton in Andhra Pradesh, India. The Box-Jenkins procedure is concerned in fitting a mixed Auto Regressive Integrated Moving Average (ARIMA) model to a given set of data. ARIMA model is a combination of AR and MA models with suitable order of differencing. The first step in developing ARIMA model is to examine data for stationarity. A model was identified for the prices of cotton in Kurnool district. The monthly wholesale prices from April 2007 to March 2019 were used to estimate the ACF and PACF. The price data were tested for stationarity. It can be clearly seen from the table that there is fall in the values of ACF from 0.926 to 0.428.It was observed from the analysis that the model is valid by observing the Mean Absolute Percentage Error (MAPE) and Theil U statistics. Average MAPE was 10.15 per cent for the year 2019 and Theil U was greater than 1 which showed the model (1,1, 3) is best for forecasting. A model was identified for the prices of cotton in Krishna market. The monthly wholesale prices from April 2007 to March 2019 were used to estimate the ACF and PACF. The price data were tested for stationarity. It can be clearly seen from the table that there is fall in the values of ACF from 0.926 to 0.618.It was observed from the analysis as mentioned in the table 4.20 that the model is valid by observing the Mean Absolute Percentage Error (MAPE) and Theil U statistics. Average MAPE was 7.54 percent for the year 2019.

Introduction

Cotton is an important cash crop among the major commercial crops grown in India as well as in Andhra Pradesh. Cotton, popularly known as 'White Gold', dominates India's cash crops, and makes up 65 per cent of the raw material requirements of the Indian textile industry. India is the third largest cotton producer in the world followed by China and the United States, accounting for about 25 per cent of the world acreage but only 14 per cent of world production.

The major cotton growing States are Maharashtra, Gujarat, Andhra Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, Karnataka and Tamil Nadu. Among the cotton growing states, Andhra Pradesh occupies third position in the country in respect of area, production and productivity of cotton. The advent of Bt cotton over the last seven years has coincided with more than doubling of yield(James,2008). It was observed that cotton production in Andhra Pradesh is fluctuating with the vagaries of rainfall. Over the years, it has witnessed several ups and downs in area, production and productivity.

Agricultural marketing plays an important role not only in stimulating production and consumption, but in accelerating the pace of economic development. Insect pests are one of the major limiting factors in cotton production. India is becoming major exporter of cotton given its competitiveness in producing cotton(Reddy et.al,2012: Rani et al.,2014) About 1300 species of Insects have been reported on cotton worldwide(Matthews and Tunstall, 1994). An efficient marketing system ensures higher levels of income for the farmers and widen the market for the products by taking them to remote corners of the country and the worldwide.

Fluctuations in market arrivals largely contribute to the price instability of the produce. In order to device appropriate ways and means for reducing price fluctuations of agricultural commodities, there is a need to have a thorough understanding of price behaviour over time and over space.

This information is further strengthened through forecasts of prices in future markets. Such an analysis is also useful to farmers in order to decide the optimum time for disposing their produce to their best advantage. Proper planning in disposing of the produce by the farmer alone can considerably increase their income without incurring much additional cost.

The present study is aimed to forecast the prices of cotton in the major cotton producing districts of Andhra Pradesh i.e., Kurnool and Krishna districts.

Forecasting of Prices

The Box-Jenkins procedure is concerned in fitting a mixed Auto Regressive Integrated Moving Average (ARIMA) model to a given set of data. The main objective in fitting ARIMA model is to identify the stochastic process of the time series and predict the future values accurately.

Auto Regressive Integrated Moving Average (ARIMA) Model

ARIMA model is a combination of AR and MA models with suitable order of differencing. The first step in developing ARIMA model is to examine data for stationarity.

The ARIMA (p,d,q) model is then formulated as

Zt-b1Zt-1-….. -bpZt-p =Ut-Ø1 Ut-1- …. ØqUt-q

Where, Zt = Yt-$\bar{Y}$ (deviation of Yt from mean Y).

The formulation of ARIMA model requires Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF).The ACF can be generated on the basis of auto correlation coefficients (ρ_j) corresponding to different lags (j), defined as;

$$\rho_j = \frac{\Sigma Y_t Y_{t-j} - \frac{1}{n}[(\Sigma Y_t)(\Sigma Y_{t-j})]}{\Sigma Y_t^2 - \frac{1}{n}(\Sigma Y_t)^2} \quad J=1$$

The PACF can be obtained through the Yule-walker's equations on the basis of ρ's. The Yule-walker's equations can be described as

$\rho_j = \phi_{k1}\rho_{j-1} +$…. + Ø k(k-1) $\rho_{j-k+1} +$ Ø kkρ_{j-k}; j = 1,… K

Where,

Ø's = Partial Auto Correlation coefficients

ρ_j=Auto correlations corresponding to the jth lag.

Stationary time series model

An Auto Regressive Process (p, o, o)

If the observation Yt depends on previous observation and error term Ut it is called auto regressive process (AR process).

Yt = a +b1 Yt-1+Ut

Where,

Yt= The value of variable for forecasting at time't' (Price, in the study)
a = Constant
b1= Regression coefficient
Ut = Random error

A Moving Average Process (o,o,q)

If the observation Yt depends on the error term ut and also on one or more previous error terms (ut's) then we have moving average MA(q) process.

Yt = $\mu + \beta_0 u_t + \beta_1 u_{t-1} + \beta_2 u_{t-2} + \ldots + \beta_q u_{t-q}$

Where,

Yt= The value of the variable for forecasting at time't' (i.e., price)
µ= Constant
u = Stochastic error term

An Auto Regressive Moving Average (ARMA) Model

In the model Yt depends on AR as well as MA variables and can be specified

As $Y_t = \theta + \alpha_1 Y_{t-1} + \beta_0 \mu_t + \beta_1 \mu_{t-1}$

An Auto Regressive Integrated Moving Average (ARIMA) model

If the time series data is integrated of order 1 i.e., I (1), its first differences are I (0), that is stationary.

Similarly sometime series data is I (2). Its second difference is I (0). In general, if a time series is I (d), after the differencing it d times we obtain an I (0) series.

The main stages in setting up a Box-Jenkins forecasting model are as follows:

1. Identification
2. Estimating the parameters
3. Diagnostic checking and
4. Forecasting

Identification of models

A good starting point for time series analysis is a graphical plot of the data.

It helps to identify the presence of trends. Before estimating the parameter (p, q) of model, the data are not examined to decide about the model which best explains the data.

Estimation of parameters

After tentatively identifying the suitable model, next step is to obtain least squares estimates of the parameters such that the error sum of squares is minimum.

S(Θ,)= $n \sum_{k=1}^{n} e_t^2$

Where,

t = 1, 2, 3…n

Diagnostic checking

After having estimated the parameters of a tentatively identified ARIMA model, it is necessary to do diagnostic checking to verify that the model is adequate.

Here selection of model was done by criteria like Schwarz Bayesian Information Criterion (SBIC), R2 values.

Shwarz Bayesian Criterion (SBC)

In statistics, the Bayesian information criterion (BIC) or Shwarz criterion (also SBC, SBIC) is a criterion for model selection among a finite set of models.

It is based, in part, on the likelihood function, and it is closely related to Akaike information criterion (AIC).

The formula for the BIC is

$$- 2. \ln p(x/k) \approx BIC = - 2. \ln L + k \ln (n)$$

Under the assumption that the model errors or disturbances are independent and identically distributed according to a normal distribution and that the boundary condition that the derivative of the log likelihood with respect to the true variance is zero.

$$BIC= n. \ In\sigma_e^2 + k.In(n)$$

The error variance in this case is defined as

$$\sigma_\rho^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2$$

R^2-Criteria

R^2 is a statistic that will give information about the goodness of fit of a model.

The most general definition of the coefficient of determination is

$$R^2 = 1 - \frac{ESS}{TSS}$$

ESS-Error Sum of Squares
TSS-Total Sum of Squares

Forecasting

After satisfying about the adequacy of the fitted model, it can be used for forecasting. Forecasts based on the model.

$$(1\text{-}ØB) = (1\text{-}\ \Phi B)e_t$$

were computed for up to 2 years ahead. The above model gives the forecasting equation as

$$Yt = Øyt\text{-}1 + et – \Theta e_t\text{-}1$$

Given the data up to time'ť' the optional forecast of Y model at the t is the conditional expectation of Yt+1.It allows, in particular, that

$$e_t=Yt–Yt\text{-}1$$

"The errors $e_t$in fact the forecast errors for unit lead time.

Results and Discussion

Forecasting of prices for cotton in Kurnool market

Identification of the model

A model was identified for the prices of cotton in Kurnool district. The monthly wholesale prices from April 2007 to March 2019 were used to estimate the ACF and PACF. The price data were tested for stationarity. It can be clearly seen from the table that there is fall in the values of ACF from 0.926 to 0.428. As observed from the analysis many values are different from zero and fall outside 95 percent confidence interval, indicating the price of cotton to be non-stationary. The analysis of partial autocorrelation coefficients of cotton have been depicted in the table 1. The graphical presentation of ACF and PACF of table are given in Fig. 1. The partial autocorrelation function (PACF) took a fall after the 1st lag period from 0.926 to 0.149, from which the non-stationarity of the series can be inferred.

The table 1 shows that the autocorrelation and partial autocorrelation functions at lag 16 were significantly different from zero and fall outside the 95 per cent confidence interval. 1st difference of price data of cotton was done to make the series stationary.

The Augmented Dickey Fuller based unit root test procedure was carried out to check whether the price series of cotton were stationary or not. From the table 2, it is observed that Augmented Dickey Fuller test values are above the critical value (1%) given by MacKinnon statistical table at levels showing that the series are non-stationary by the presence of unit root. After the 1st difference, the series become stationary which means the calculated values for the market are less than the critical value (1%) and free from the consequence of unit root.

The results of Augmented Dickey Fuller (ADF) unit root test for cotton showed that the level data were not stationary but their 1st differences showed stationarity.

The graphical representation of ACF and PACF is given in the fig. 1 which confirms the results. Therefore, the value of d in the ARIMA model was unity (1) because the 1st difference was carried out only once to attain stationarity.

Model estimation

The best model was chosen from the various ARIMA models viz, ARIMA(1,1,3); ARIMA (3,1,3); ARIMA(4,1,3) ;ARIMA(2,1,1); ARIMA(3,1,4) on the basis of least Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC). The models as identified above were estimated through the Marquardt procedure using SPSS 7.5 and SPSS 20 version of the SPSS package.

On comparing the alternative models on the basis of statistics such as Akaike Information Criterion and Schwarz Bayesian Criterion (SBC), it was inferred that both AIC(-191.40) and SBC (179.67) were the least for ARIMA (1,1,3) model from table 3. Hence ARIMA (1,1,3) was the most representative model for the price of cotton in Kurnool market.

Diagnostic checking

The model verification is concerned with the residuals of the model to see if they still contain any systematic pattern which further could be removed in order to improve the chosen ARIMA, which has been analyzed by examining the autocorrelations and partial autocorrelation functions of various orders of the residuals of ARIMA (1,1,3) up-to 16 lags were analyzed and presented in the table 4. The values of ACF and PACF varies from -0.008 to 0.054 which shows the auto correlation and partial auto correlation functions at lag 16 were significantly different from zero and fall within the 95% confidence interval.

The graphical representation of ACF and PACF is given in the fig. 2 which also confirms the above results that there is no ACF and PACF that lies outside the interval. So we can say that the residual series is stationary. Thus it could be concluded that the selected ARIMA (1,1,3) model was appropriate for forecasting the prices of cotton during the period under study.

It was observed from the analysis as mentioned in the table 5 that the model is valid by observing the Mean Absolute Percentage Error (MAPE) and Theil U statistics. Average MAPE was 10.15 percent for the year 2019 and Theil U was greater than 1 which showed the model (1,1, 3) is best for forecasting.

Table.1 Autocorrelation and Partial Correlation Coefficient of cotton in Kurnool market (level)

Lag	Autocorrelation Coefficient		Box-Ljung	Partial Autocorrelation Coefficient	
	Value	S.E		Value	S.E
1	0.926	0.082	126.185	0.926	0.083
2	0.838	0.082	230.232	-0.141	0.083
3	0.764	0.082	317.362	0.064	0.083
4	0.723	0.082	395.827	0.170	0.083
5	0.689	0.081	467.695	-0.002	0.083
6	0.647	0.081	531.553	-0.055	0.083
7	0.607	0.081	588.029	.0042	0.083
8	0.575	0.080	639.114	0.044	0.083
9	0.552	0.080	686.607	0.023	0.083
10	0.532	0.080	730.995	0.012	0.083
11	0.523	0.080	774.157	0.104	0.083
12	0.496	0.079	813.310	-0.131	0.083
13	0.464	0.079	847.830	-0.011	0.083
14	0.439	0.079	878.988	0.068	0.083
15	0.422	0.078	907.987	-0.008	0.083
16	0.428	0.078	938.111	0.149	0.083

The underlying process assumed is independent (white noise)

Table.2 ADF unit root test for prices of cotton in Kurnool market

ADF test value	Augmented Dickey Fuller (ADF)	Critical value (1%)
Level	-2.206 (0.2049)	-3.48
1st difference	s-9.082 (0.000)	

** significant at 1% level

Note: Figures in parenthesis indicate Mackinnon (1996) p- value

Table.3 ARIMA models selected for forecasting the price of cotton based on least AIC &SBC at Kurnool market

Model	Log l	AIC	SBC
ARIMA(1,1,3)	155.29	-191.40	179.67
ARIMA (3,1,3)	156.81	-190.84	-175.20
ARIMA(4,1,3)	157.46	-190.33	-172.73
ARIMA(2,1,1)	153.32	-190.16	-180.38
ARIMA(3,1,4)	156.89	-189.60	-172.01

Table.4 Autocorrelation Coefficient and Partial Correlation coefficient of residual of ARIMA (1,1,3) model for cotton price in Kurnool market

Lag	Autocorrelation Coefficient		Box-Ljung	Partial Autocorrelation Coefficient	
	Value	S.E		Value	S.E
1	-0.008	0.083	0.008	-0.008	0.084
2	-0.015	0.082	0.040	-0.015	0.084
3	0.005	0.082	0.044	0.005	0.084
4	0.040	0.082	0.280	0.040	0.084
5	0.077	0.082	1.179	0.078	0.084
6	0.011	0.081	1.198	0.014	0.084
7	-0.115	0.081	3.229	-0.114	0.084
8	0.000	0.081	3.229	-0.005	0.084
9	0.048	0.080	3.582	0.040	0.084
10	-0.072	0.080	4.386	-0.078	0.084
11	0.144	0.080	7.644	0.155	0.084
12	-0.044	0.079	7.948	-0.028	0.084
13	-0.031	0.079	8.104	-0.031	0.084
14	-0.038	0.079	8.341	-0.056	0.084
15	-0.129	0.079	11.043	-0.140	0.084
16	0.054	0.078	11.527	0.050	0.084

Table.5 One step ahead in Forecasting for prices of cotton in Kurnool market

Months	Actual price	Predicted price
March 18	5169	
April 18	4339	5810.076
May 18	4699	5844.738
June	5669	5879.584
July 18	6099	5914.625
August18	6176	5949.869
September18	6108	5985.321
October 18	5789	6020.982
November 18	5780	6056.854
December 18	5590	6092.94
January 19	5510	6129.241
February 19	5520	6165.757
March19	5620	6202.492
MAPE		10.15
U1		0.05642
U2		1.43

Table.6 Autocorrelation and Partial Correlation Coefficient of cotton in Krishna market (level)

Lag	Autocorrelation Coefficient		Box-Ljung	Partial Autocorrelation Coefficient	
	Value	S.E		Value	S.E
1	0.926	0.082	126.010	0.926	0.083
2	0.851	0.082	233.348	-0.039	0.083
3	0.835	0.082	337.207	0.363	0.083
4	0.825	0.082	439.474	0.042	0.083
5	0.795	0.081	535.019	-0.006	0.083
6	0.764	0.081	624.002	0.030	0.083
7	0.763	0.081	713.373	0.166	0.083
8	0.755	0.080	801.529	-0.048	0.083
9	0.721	0.080	882.576	-0.058	0.083
10	0.702	0.080	959.981	0.090	0.083
11	0.732	0.080	1044.599	0.279	0.083
12	0.754	0.079	1135.160	0.040	0.083
13	0.699	0.079	1213.523	-0.376	0.083
14	0.637	0.079	1279.183	-0.101	0.083
15	0.624	0.078	1342.724	0.044	0.083
16	0.618	0.078	1405.430	0.015	0.083

The underlying process assumed is independent (white noise)

Table.7 ADF unit root test for prices of cotton in Krishna market

ADF test value	Augmented Dickey Fuller (ADF)	Critical value(1%)
Level	-1.343 (0.6081)	-3.48
1st difference	-5.416 (0.000)	

** significant at 1% level

Note: Figures in parenthesis indicate Mackinnon (1996) p- value

Table.8 ARIMA models selected for forecasting the price of cotton based on least AIC &SBC at Krishna market

Model	Log l	AIC	SBC
ARIMA(4,1,4)	168.66	-203.42	-183.69
ARIMA (2,1,4)	162.62	-198.23	-182.59
ARIMA(3,1,4)	161.76	-195.85	-178.26
ARIMA(1,1,3)	157.74	-194.54	-182.91
ARIMA(4,1,3)	157.05	-189.80	-172.21

Table.9 Auto-Correlation Coefficient and Partial Correlation coefficient of residual of ARIMA (4,1,4) model for cotton price in Krishna market

Lag	Auto-Correlation Coefficient		Box-Ljung	Partial Autocorrelation Coefficient	
	Value	S.E		Value	S.E
1	0.015	0.083	0.032	0.015	0.084
2	0.014	0.082	0.062	0.014	0.084
3	-0.018	0.082	0.110	-0.018	0.084
4	-0.026	0.082	0.212	-0.026	0.084
5	-0.055	0.082	0.662	-0.054	0.084
6	-0.035	0.081	0.843	-0.033	0.084
7	-0.184	0.081	6.007	-0.184	0.084
8	-0.039	0.081	6.236	-0.039	0.084
9	0.026	0.080	6.341	0.026	0.084
10	-0.023	0.080	6.421	-0.036	0.084
11	0.080	0.080	7.432	0.068	0.084
12	0.524	0.079	50.901	0.527	0.084
13	0.014	0.079	50.931	0.018	0.084
14	-0.018	0.079	50.985	-0.091	0.084
15	-0.001	0.079	50.985	0.024	0.084
16	-0.021	0.078	51.057	0.010	0.084

Table.10 One step ahead in Forecasting for prices of cotton in Krishna market

Months	Actual price	Predicted price
March 18	4600	
April 18	4700	4994.766
May 18	4400	4874.78
June	4300	4890.227
July 18	4900	5058.767
August18	5100	5071.276
September18	4700	4920.622
October 18	4800	4926.538
November 18	4600	5106.478
December 18	4600	5146.387
January 19	4550	5023.126
February 19	4575	5048.976
March19	5000	5243.274
MAPE		7.54
U1		0.0401
U2		1.38

Fig.1 Autocorrelation and Partial Autocorrelation coefficient of 1st difference series of cotton prices in Kurnool market

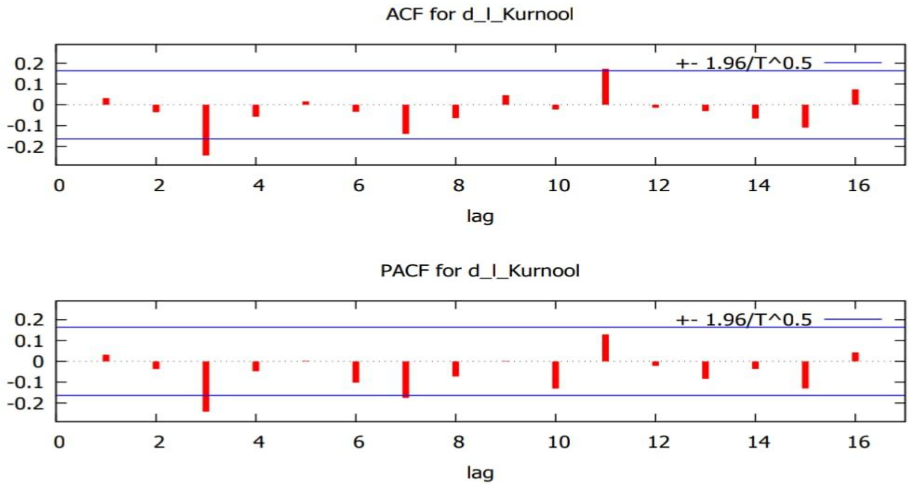


Fig.2 Autocorrelation and Partial Autocorrelation of residual of ARIMA (1,1,3) model for market of cotton in Kurnool market

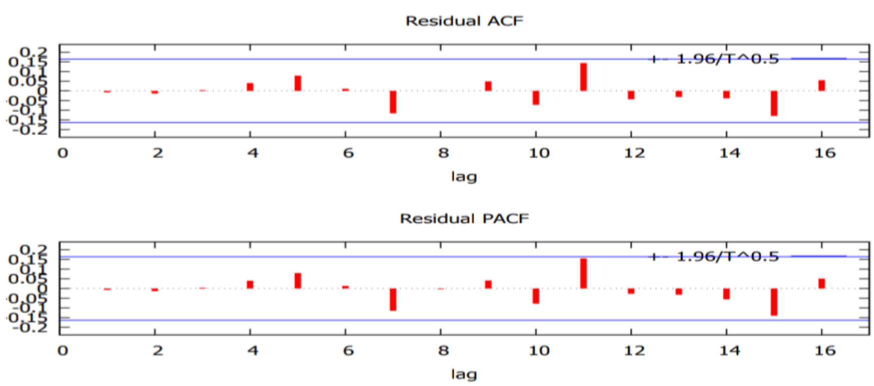


Fig.3 Autocorrelation and partial autocorrelation coefficient of cotton prices in Krishna market (level)

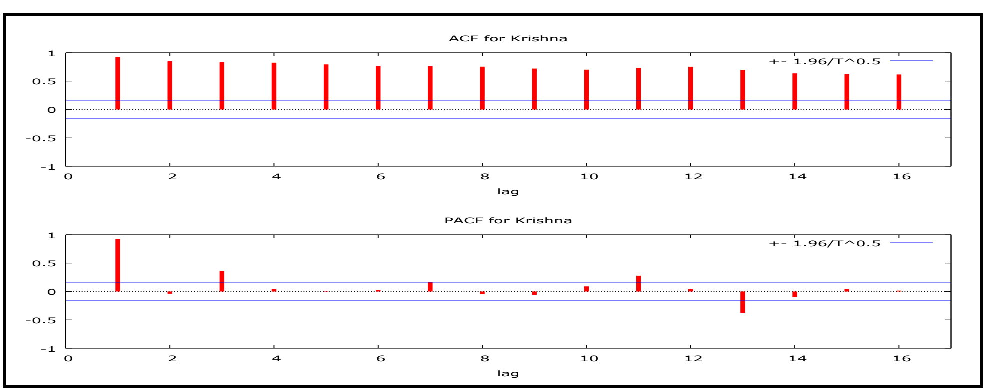


Fig.4 Autocorrelation and partial autocorrelation coefficient of 1st difference series of cotton prices in Krishna market

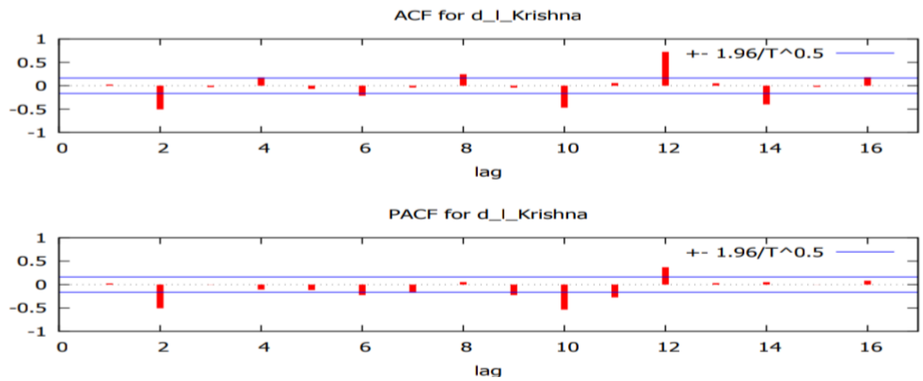
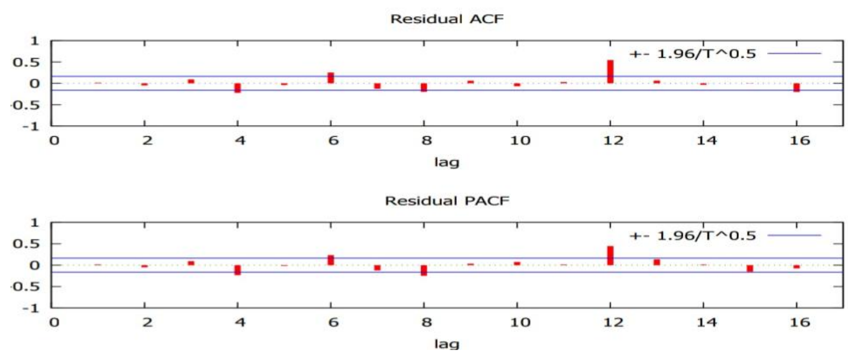


Fig.5 Autocorrelation and Partial Autocorrelation Coefficient of residual of ARIMA (4,1,4) model for cotton prices in Krishna market



Forecasting of prices for cotton in Krishna Market:

Identification of the model

A model was identified for the prices of cotton in Krishna market. The monthly wholesale prices from April 2007 to March 2019 were used to estimate the ACF and PACF. The price data were tested for stationarity. It can be clearly seen from the table that there is fall in the values of ACF from 0.926 to 0.618. As observed from the analysis many values are different from zero and fall outside 95 percent confidence interval, indicating the price of cotton to be non-stationary. The analysis of partial autocorrelation coefficients of cotton have been depicted in the table 6. The graphical presentation of ACF and PACF of table are given in Fig. 3. The partial autocorrelation function (PACF) took a fall after the 1st lag period from 0.926 to 0.015, from which the non-stationarity of the series can be inferred.

The table 6 shows that the autocorrelation and partial autocorrelation functions at lag 16 were significantly different from zero and fall outside the 95% confidence interval. 1st difference of price data of cotton was done to make the series stationary.

The Augmented Dickey Fuller based unit root test procedure was carried out to check whether the price series of cotton were stationary or not. From the table 7, it is observed that Augmented Dickey Fuller test values are above the critical value (1%) given by MacKinnon statistical table at levels showing that the series are non-stationary by the presence of unit root. After the 1st difference, the series become stationary which means the calculated values for the market are less than the critical value (1%) and free from the consequence of unit root.

The results of Augmented Dickey Fuller (ADF) unit root test for cotton showed that the level of data was not stationary but their 1st difference was found stationary. The graphical representation of ACF and PACF is given in the fig. 3 which confirms the results. Therefore, the value of d in the ARIMA model was unity (1) because the 1st difference was carried out only once to attain stationarity.

Model estimation

The best model was chosen from the various ARIMA models *viz*, ARIMA(4,1,4); ARIMA (2,1,4); ARIMA(3,1,4) ;ARIMA(1,1,3); ARIMA(4,1,3) based on least Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC). The models as identified above were estimated through the Marquardt procedure using SPSS 7.5 and SPSS 20 version of the SPSS package.

On comparing the alternative models on the basis of statistics such as Akaike Information Criterion and Schwarz Bayesian Criterion (SBC), it was inferred that both AIC(-203.42) and SBC (-183.69) were the least for ARIMA (4,1,4) model from table 8. Hence ARIMA (4,1,4) was the most representative model for the price of cotton in Krishna market (Fig. 4).

Diagnostic checking

The model verification is concerned with the residuals of the model to see if they still contain any systematic pattern which further could be removed in order to improve the chosen ARIMA, which has been analyzed by examining the autocorrelations and partial autocorrelation functions of various orders of the residuals of ARIMA (4,1,4) up-to 16 lags were analyzed and presented in the table 9. The values of ACF and PACF varies from 0.015 to to -0.021 which shows the auto correlation and partial auto correlation functions at lag 16 were significantly different from zero and fall within the 95% confidence interval.

The graphical representation of ACF and PACF is given in the fig. 5 which also confirms the above results that there is no ACF and PACF that lies outside the interval. So we can say that the residual series is stationary. Thus it could be concluded that the selected ARIMA (4,1,4) model was appropriate for forecasting the prices of cotton during the period under study.

It was observed from the analysis as mentioned in the table 10 that the model is valid by observing the Mean Absolute Percentage Error (MAPE) and Theil U statistics. Average MAPE was 7.54 percent for the year 2019 and Theil U was greater than 1 which showed the model (4,1,4) is best for forecasting.

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