Economic Affairs, Vol. 65, No. 1, pp. 43-50, March 2020
DOI: 10.30954/0424-2513.1.2020.6

Price Behaviour and Forecasting of Onion Prices in Kurnool Market, Andhra Pradesh State

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Received: 14-08-2019 **Revised:** 22-01-2020 **Accepted:** 23-02-2020

ABSTRACT

The objective of present study was to analyse the behaviour of onion prices in Kurnool market and forecasting the prices for the future. Based on secondary data from January 2003 to December 2017, the future prices were predicted for the months of January to June, 2018 by employing the Auto Regressive Integrated Moving Average (ARIMA) technique. The annual increase in prices of onion in Kurnool market was observed to be ₹ 6.22 per quintal per annum. The highest seasonal index was observed in the month of August and lowest seasonal index was recorded in May. Price cycles were not identified in onion prices. Maximum R-Square (62.34), minimum Mean Absolute Percentage Error (MAPE) (34.96), Root Mean Square Error (RMSE) (454.71) and Mean Absolute Error (MAE) (263.19) was used as a criteria to select the best model for price forecasting. Based on the above criteria the model (1,1,1) (1,1,1) was found to fit the time series to predict future prices. The forecasted price of onion would be ranging from ₹ 2956 to ₹ 1651 per quintal for the months from January to June 2018 respectively.

Highlights

- The seasonal price index was high for the month of August and low for the month of May in Kurnool onion market.
- The ARIMA was best technique to forecast prices of onion in the Kurnool market with narrow variations in between the actual and forecasted values.

Keywords: ARIMA technique, Forecasting, MAPE, MAE, RMSE and Seasonality

Onion has become an almost indispensable part of the Indian diet and also its prices are highly volatile. Onion price fluctuations are occurring all over Indian markets and they are causing damage to both onion producers and consumers. The ARIMA model is commonly used in price time series prediction, especially for series that has a cyclic or seasonal pattern. At the same time, Box-Jenkins ARIMA model give the good representation of short time forecasting. The principle of the model contains filtering out the high-frequency noise in the data, detecting local trends based on liner dependence and forecasting the trends. Despite its high predictive performance, the model has some limitations which decrease its scope of application. The model assumes a linear relationship between the dependent and independent variables while the actual data often present non-linear relationships. Besides, the model assumes that the mean and variance of response series are independent of time, which means stationary. Thus, more than one model should be tested to choose a better one. Forecasting of prices of perishable agricultural commodities is very difficult because they are not only governed by demand and supply but also by

How to cite this article: Areef, M., Rajeswari, S., Vani, N. and Naidu, G.M. (2020). Price behaviour and forecasting of onion prices in Kurnool market, Andhra Pradesh state. *Economic Affairs*, **65**(1): 43-50.

so many other factors which are beyond control like weather vagaries, storage capacity, transportation *etc*. Takle (2002) studied the behaviour of market arrivals and prices of *rabi* Jowar for the period from 1981 to 1995 for seven regulated markets of Marathwara region. Chahal *et al.* (2004) examined the price behaviour of green peas in Hoshiarpur and Ludhiana (Punjab) markets from 1994 to 2002. Sangeeta (2004) analyzed the behaviour of arrivals and prices of onion in Lasalgaon and Pune markets (Maharashtra) from 1999-2002. Devi *et al.* (2016) studied the price behaviour of chillies in Guntur market of Andhra Pradesh, India for the years 1997-2014. ARIMA model was employed by Darekar *et al.* (2015) to forecast the prices of onion at Lasalgaon market of Western Maharashtra, Darekar and Reddy (2017) forecasted the prices of cotton in major producing states of India, Chandran and Pandey (2007) forecasted the prices of potato for Delhi market, Devi *et al.* (2011) forecasted sunflower and groundnut prices in Kurnool market.

The main objective of present research was to analyse the price behaviour and forecasting of onion prices in Kurnool market of Andhra Pradesh state.

MATERIALS AND METHODS

The time series data on monthly prices of onion required for the study was collected from the registers maintained by the respective market committees, National horticulture board database (Anonymous 2018) and NHRDF (National Horticulture Research and Development Foundation). The data related to monthly modal prices (₹/qtl) for the period from January 2003 to December 2017 (15 years) was used for time series analysis and for price forecasting from January to June 2018.

To analyse all the four components of a time series *viz.*, trend, seasonal, cyclical and irregular fluctuations, a multiplicative model of the following type was used as elucidated in Areef *et al.* (2019),

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

where,

Y_t = Time series data on prices at time period '*t*'

T_t = Trend component at time period '*t*'

S_t = Seasonal variations at time period '*t*'

C_t = Cyclical movements at time period '*t*'

I_t = Irregular fluctuations at time period '*t*'

Trend Component

Over a long period, time series is likely to show tendency to either increase or decrease over time. Price trend explains the general direction of the movement of prices over long period of time. Ordinary least square method was employed to ascertain the trend in prices by estimating the intercept (a) and slope coefficient (b) in the following linear functional form:

$$Y_t = a + bX_t + e_t$$

where,

Y_t = Trend value at time *t*

X_t = period (Serial number assigned to the t^{th} month)

e_t = Random disturbance term (assumption of zero mean and constant variance)

a = Intercept parameter

b = Slope parameter

The goodness of fit of trend line to the data was tested by computing the multiple coefficient of determination (R^2).

Seasonal Variations

In order to estimate the seasonal variation, the twelve month centered moving average method was used which gives us the periodic changes without seasonality. To estimate the seasonal index, a 12 month centered moving average was calculated as follows:

$$M_1 = Y_1 + Y_2 + Y_3 + \ldots + Y_{12} / 12$$
$$M_2 = Y_2 + Y_3 + Y_4 + \ldots + Y_{13} / 12$$
$$M_3 = Y_3 + Y_4 + Y_5 + \ldots + Y_{14} / 12 \ldots\ldots \textit{etc.}$$

This is sequential manner for each points of time *t*. In this fashion, a 12 month centered moving average removes a large part of fluctuation due to the seasonal effects so that what remains is mainly attributable to other sources *viz.*, long term effects T_t, cyclical effect C_t and the irregular variation I_t which is due to random causes is also minimized by the process of smoothing out effect. Thus, this affords a means of not only estimating TC effect but also estimating seasonal components. In the next step of computing the seasonal index, the original series is divided by the centered moving average. This gives the first estimate of seasonal component S_t.

$$S_t = Y/(TC)_t = T_t * C_t * S_t * I_t / T_t * C_t$$

It is always expressed in terms of percentages. In this process, we do not have moving average for the first six and last six months. These seasonal components are next arranged month-wise for each year (Table 1). The last row in the Table 1 give estimates of seasonal index for the 12 months adjusted for their total to 1200 or averaged to 100. The last row in the Table. 1 gives the first estimates of seasonal variations. In order to obtain a better estimate *i.e.*, stabilized seasonal indices we need to employ an interactive process as under. The original observation (Y_t) is divided by corresponding (S_t) value and then obtain the residual $(\mathrm{TCI})_t$ corresponding to time point t.

$$(TCI)_t = Y_t / S_t = (TCSI)_t / S_t$$

The residual series $(TCI)_t$ thus obtained is subjected to the same process of determining 12 month centered averages as done earlier to obtain better estimates for trend cycle effect *viz.*, $(TC)_t$. These revised estimates are next employed as above to generate a revised set of seasonal indices by dividing each observation (Y_t) by the corresponding $(TC)_t$ value. This will lead to revise estimates of seasonal indices (S_t) as second interactive ones.

$$(TCI)_t = [S_{(i+j)} - S_i] / S_i \times 100 \leq 5$$

$$i = j = 1, 2, \ldots\ldots\ldots, 12.$$

This interactive process is separately employed until stabilized seasonal indices are obtained i.e., two successive seasonal indices do not differ by more than five per cent.

Where adjusted

Seasonal indices = Seasonal indices × correction factor

and

Correction factor = 1200 / Sum of seasonal indices

Cyclical movements

Cyclical variations are long term oscillatory movements with duration of greater than one year. The most commonly used method for estimating cyclical movement of time series is the residual method by eliminating the seasonal variation and trend. This is accomplished by dividing (Y_t) by corresponding (S) for time 't'

Symbolically,

$$T.C.S.I/S \text{ and } T.C.I/T = C.I$$

Irregular variations: It was estimated as residual component by using the estimates of model prices and cyclical components.

$$I_t = P_t/T_t * C_t \times 100$$
$$= T_t * C_t * I_t / T_t * C_t \times 100$$
$$= I_t * 100$$

The details of ARIMA forecasting model are as follows:

Auto Regressive Integrated Moving Average (ARIMA) Model

Introduced by Box and Jenkins (1976), the ARIMA

Table 1: Average of percentage centered 12 months moving average and computation of seasonal index for observation

Year	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
2003	*	*	*	*	*	*	S	S	S	S	S	S
2004	S	S	S	S	S	S	S	S	S	S	S	S
**	*	*	*	*	*	*	*	*	*	*	*	*
**	*	*	*	*	*	*	*	*	*	*	*	*
2017	S	S	S	S	S	S	S	S	S	S	S	S
Mean	*	*	*	*	*	*	*	*	*	*	*	1200
Adjusted Seasonal Index	*	*	*	*	*	*	*	*	*	*	*	100

model has been one of the most popular approaches for forecasting. The ARIMA model is basically a data oriented approach that is adopted from the structure of the data itself. In an ARIMA model, the estimated value of a variable is supposed to be a linear combination of the past values and the past errors. Generally a time series can be modelled as a combination of past values and errors, which can be denoted as ARIMA (p,d,q) which is expressed in the following form

$$Y_t = \theta_0 + \Phi_1 Y_{t-1} + \Phi_2\ Y_{t-2} + \ldots + \Phi_p\ Y_{t-p} + e_t - \theta_1 e_{t-1} - \theta_2\ e_{t-2} - \ldots - \theta\ e_{t-q}$$

where Y_t and e_t are the actual values and random error at time t, respectively, Φ_i (i = 1,2,……, p) and θ_j (j = 1,2,……, q) are model parameters, p and q are integers and often referred to as orders of autoregressive and moving average polynomials respectively. Random errors are assumed to be independently and identically distributed with mean zero and constant variance. Similarly, a seasonal model is represented by ARIMA (p, d, q) × (P, D, Q), where P is the number of seasonal autoregressive (SAR) terms, D is the number of seasonal differences and Q is the number of seasonal moving average (SMA) terms. Basically this method has four steps identification of the model, estimating the parameters, diagnostic checking and forecasting

RESULTS AND DISCUSSION

The results revealed that there was an increasing trend in onion prices in Kurnool market for the study period. The trend equation estimated for the present study was 264.39 + 6.22*t and graphically shown in Fig. 1. The annual increase in prices of onion in Kurnool market was observed to be ₹ 6.22 per quintal. Areef *et al.* (2019) revealed that the annual increase in prices of onion in Bangalore market was ₹ 6.92 per quintal for the period from Jan-2003 to Dec-2017 and it was found to be statistically significant. In order to analyse the seasonal variation in onion prices in the Kurnool market, seasonal indices were computed by adopting 12 months centered moving average method. The results (Table 2 and Fig. 2) revealed that the highest seasonal index was observed in August, followed by November and July as the indices stood at 140.80, 121.31 and 117.07 respectively. Lowest seasonal index was recorded in May with 62.72. The cyclical and irregular fluctuations in onion prices were graphically shown in Fig. 3 and Fig. 4 respectively. A definite periodic fluctuations were not identified in Kurnool market which was revealed by the absence of price cycles.

Table 2: Seasonal indices (%) in prices of onion in Kurnool market

Months	Seasonal indices
January	108.42
February	99.78
March	72.21
April	70.28
May	**62.72**
June	81.14
July	117.07
August	**140.80**
September	105.55
October	110.74
November	121.31
December	109.98

For forecasting onion prices in Kurnool market, ARIMA model was used after transforming the variable under forecasting into a stationary series. The stationary series is the one whose values vary over time only around a constant mean and constant variance. Identification of the model was concerned with deciding the appropriate values of (p,d,q) (P,D,Q). It was done by observing Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) values (Fig. 5). The Auto Correlation Function helps in choosing the appropriate values for ordering of moving average terms (MA) and Partial Auto-Correlation Function for those autoregressive terms (AR).

Table 3: Residual analysis of monthly prices of onion

Sl. No.	Model	R-square	MAPE	RMSE	MAE
1	(1,1,0) (1,111)	58.50	35.98	476.01	274.86
2	**(1,1,1) (1,1,1)**	**62.34**	**34.96**	**454.71**	**263.19**
3	(0,1,1) (1,1,1)	58.54	36.00	475.99	274.93
4	(1,1,1) (0,1,1)	61.37	36.14	459.58	271.25

ARIMA model was estimated after transforming the variables under study into stationary series through computation of either seasonal or non-seasonal or both, order of differencing. Based on the maximum

Fig. 1: Trends in prices of onion in Kurnool market

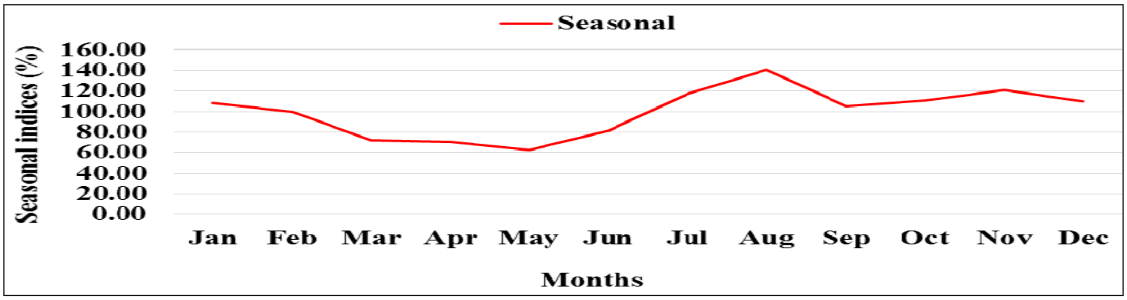

Fig. 2: Seasonal indices of onion prices in Kurnool market

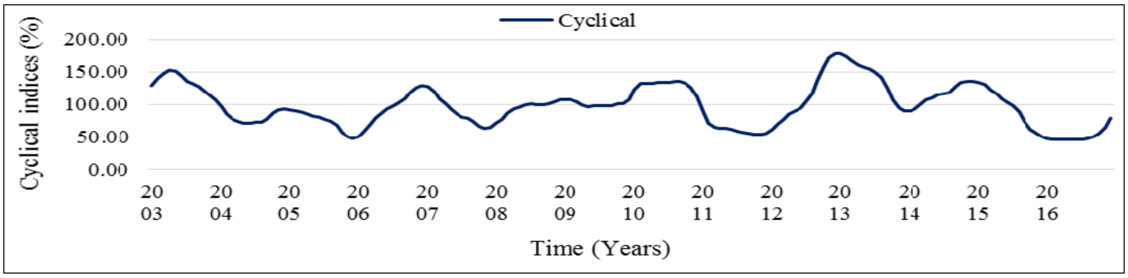

Fig. 3: Cyclical indices of onion prices in Kurnool market

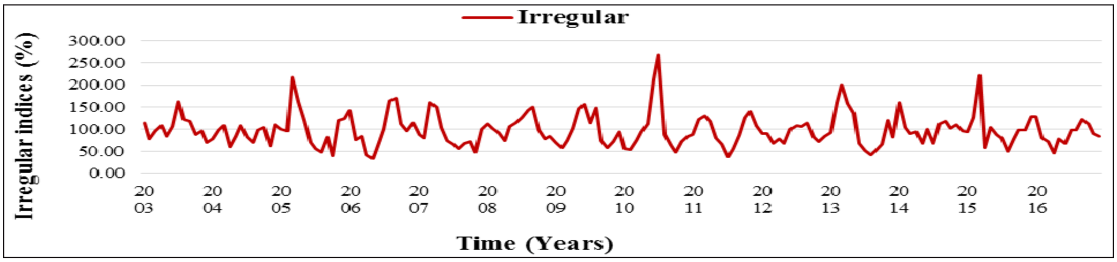

Fig. 4: Irregular indices of onion prices in Kurnool market

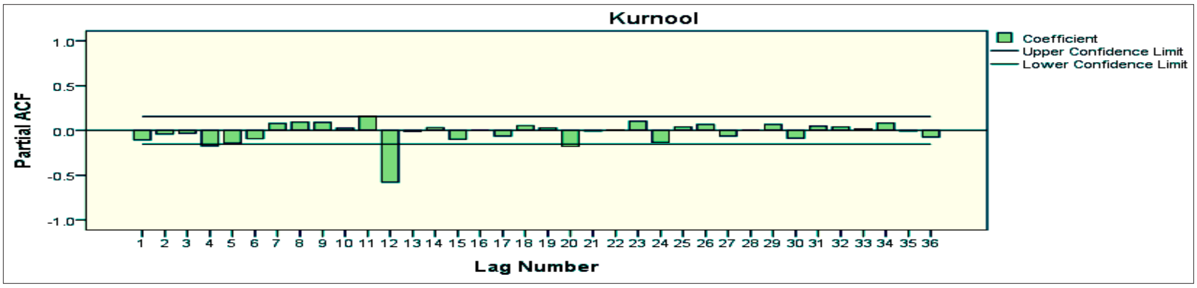

Fig. 5: Autocorrelation and Partial Autocorrelation coefficients of onion prices in Kurnool market

R-Square, minimum MAPE (Mean Absolute Percentage Error), RMSE (Root Mean Square Error) and MAE (Mean Absolute Error) the model (1,1,1) (1,1,1) was found to be fit the data and suitable to forecast future prices in Kurnool market (Table 3).

Table 4: Conditional least square estimates of onion prices

	Estimate	SE	t	P value
AR (1)	0.770	0.075	10.331	0.000
MA(1)	0.998	0.502	1.987	0.049
Seasonal AR (1)	-0.197	0.103	-1.923	0.056
Seasonal MA (1)	0.806	0.090	8.967	0.000

The parameters of the tentatively identified model were estimated and are presented in Table 4. The autocorrelation and partial autocorrelations of various orders of the residuals of ARIMA (1,1,1) (1.1,1) up to 36 lags were computed and are shown in Fig. 6. The figures showed that, the autocorrelation at lag 15 and 36 and partial autocorrelation functions at lag 15 and 20 were significantly different from zero and fell slightly outside the 95 per cent confidence interval, which indicated the presence of white noise error in the residuals.

Table 5: Ex-ante and Ex-post forecast of monthly prices of onion

Year	Month	Actual	Predicted	Year	Month	Actual	Predicted
2003	Jan	200	*		Oct	530	488
	Feb	125	*		Nov	880	492
	Mar	125	*		Dec	890	802
	Apr	190	*	2009	Jan	1000	883
	May	270	*		Feb	1030	935
	Jun	505	*		Mar	785	885
	Jul	530	*		Apr	515	661
	Aug	480	*		May	380	494
	Sep	480	*		Jun	550	559
	Oct	600	*		Jul	670	685
	Nov	519	*		Aug	660	703
	Dec	570	*		Sep	630	807
2004	Jan	830	*		Oct	865	575
	Feb	565	755		Nov	1350	762
	Mar	390	585		Dec	1315	1151
	Apr	270	493	2010	Jan	955	1218
	May	250	405		Feb	1145	896
	Jun	225	545		Mar	425	988
	Jul	340	335		Apr	330	394
	Aug	455	348		May	375	341
	Sep	350	477		Jun	675	577
	Oct	195	495		Jul	655	826
	Nov	295	160		Aug	840	733
	Dec	350	343		Sep	875	904
2005	Jan	270	582		Oct	1165	799
	Feb	220	162		Nov	1540	1113
	Mar	240	174		Dec	2700	1350
	Apr	280	238	2011	Jan	3370	2361
	May	160	319		Feb	1025	2874
	Jun	375	311		Mar	545	909
	Jul	495	443		Apr	385	502
	Aug	570	506		May	505	409
	Sep	955	509		Jun	685	720
	Oct	730	875		Jul	825	864
	Nov	580	675		Aug	1105	895
	Dec	305	606		Sep	820	1131
2006	Jan	235	447		Oct	775	854
	Feb	175	136		Nov	565	943
	Mar	200	137		Dec	420	654
	Apr	80	195	2012	Jan	225	532
	May	195	108		Feb	300	420
	Jun	250	320		Mar	325	224
	Jul	445	352		Apr	450	315
	Aug	330	490		May	450	465
	Sep	330	384		Jun	480	690
	Oct	200	286		Jul	640	664
	Nov	200	218		Aug	875	767
	Dec	400	213		Sep	560	938
2007	Jan	600	425		Oct	730	701
	Feb	970	441		Nov	730	961
	Mar	780	804		Dec	1060	1033
	Apr	555	670	2013	Jan	1235	1239
	May	450	493		Feb	1275	848
	Jun	725	549		Mar	1170	947
	Jul	800	773		Apr	945	968
	Aug	830	788		May	795	882
	Sep	1150	881		Jun	1270	962
	Oct	1050	957		Jul	2015	1299
	Nov	745	927		Aug	4145	1904
	Dec	440	674		Sep	3775	3474
2008	Jan	365	498		Oct	3000	3241
	Feb	280	325		Nov	2810	2708
	Mar	235	279		Dec	1260	2630
	Apr	220	220	2014	Jan	900	1357
	May	125	256		Feb	650	693
	Jun	355	296		Mar	510	542
	Jul	630	500		Apr	550	532
	Aug	775	630		May	800	615
	Sep	575	834		Jun	675	975
	Jul	1915	874		Jul	910	1234
	Aug	1570	1884		Aug	670	1422
	Sep	1095	1425		Sep	450	746

	Oct	1280	1173		Oct	300	686
	Nov	1050	1346		Nov	570	571
	Dec	1450	1281		Dec	460	747
2015	Jan	1000	1533	2017	Jan	640	604
	Feb	1560	856		Feb	610	717
	Mar	1295	1305		Mar	600	568
	Apr	1140	1151		Apr	580	627
	May	1105	1078		May	490	693
	Jun	1260	1300		Jun	730	767
	Jul	1775	1493		Jul	610	1288
	Aug	2800	2232		Aug	1730	1325
	Sep	3500	2482		Sep	1060	1787
	Oct	900	3034		Oct	1250	734
	Nov	1700	1106		Nov	3130	1442
	Dec	1230	1547		Dec	3500	2671
2016	Jan	1050	1299	2018	Jan	*	2956
	Feb	560	901		Feb	*	2447
	Mar	520	536		Mar	*	2021
	Apr	540	575		Apr	*	1757
	May	440	671		May	*	1596
	Jun	680	728		Jun	*	1651

Hence, except for lag 15, 20 and 36 autocorrelation was absent in the residuals. This showed that the selected ARIMA model was appropriate for forecasting the price of onion during the period under study. Both ex-ante and ex-post forecasting were done and it was compared with actual observations. The prices were forecasted up to June, 2018. The results of ex-ante and ex-post forecasted prices are presented in Table 5 and illustrated in Fig. 7. The forecast are also depicted that there is narrow variations in between the actual and forecasted values of prices of onion in the Kurnool market. According to the forecasts the price of onion would be ranging from ₹ 2956 to ₹ 1651 per quintal for the months from January to June 2018.

CONCLUSION

Reliable price forecast model enable the government to make appropriate decisions in advance like procurement, regulating export & imports and possibility of check on trader hoardings. The price seasonal indices and forecasted price information was more important for the farmer to selection of crop varieties, allocation of scarce inputs under different crops and adjusting the sowing & harvesting dates to get remunerative prices in a more rational way.

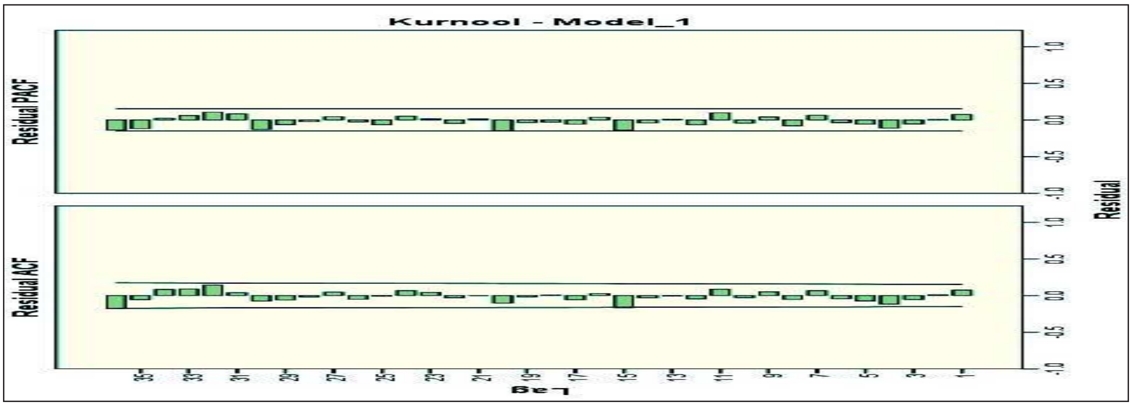

Fig. 6: Autocorrelation and Partial Autocorrelation coefficients of residual of ARIMA (1,1,1) (1,1,1) model for the onion prices

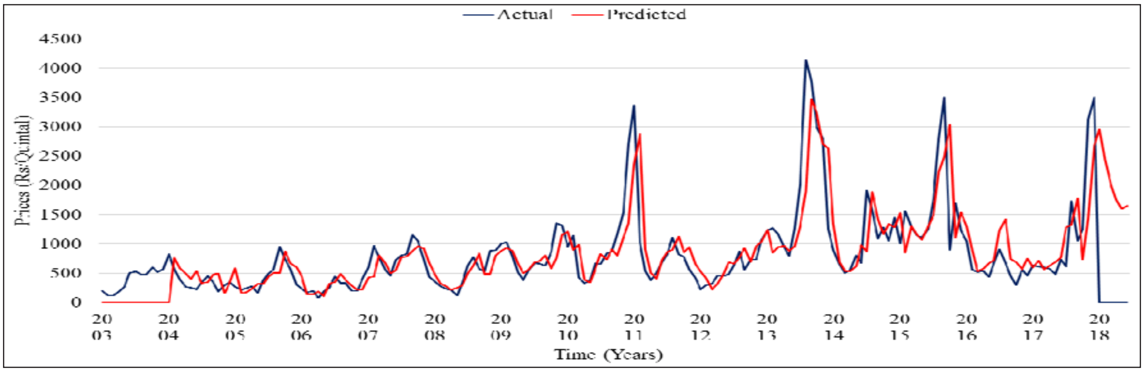

Fig. 7: Ex-ante and Ex-post forecast of monthly prices of onion in Kurnool market

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