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Market Arrivals and Price Behaviour of Potato: A Case Study of Bangalore Market

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ABSTRACT

The present study examined the trend, seasonal variations, cyclical variations, correlation in arrival and prices and to forecast future prices of potato in Bangalore market by using multiplicative trend model and Seasonal Autoregressive Integrated Moving Average (SARIMA) model. Bangalore market was selected based on the highest market arrivals of potato in Karnataka state and monthly time series data on arrivals and prices of potato for a period of 15 years from January, 2005 to December, 2019 was considered for analysis. The results revealed significant positive trend in both arrivals and prices with 259.86 quintal per annum and ₹ 4.08 per quintal per annum respectively. The highest seasonal arrival and price indices were observed in the months of September and November respectively, while the lowest were observed in the months of February and March respectively. The perfect price cycle of potato during the period of 2015 to 2019 was identified and while no such cycle was identified for the arrival. Significant correlation between arrival and prices of potato coupled with lowest variation in monthly mean arrival and monthly mean prices of potato was observed during February month only in Bangalore market. The SARIMA (0,1,1) (0,1,1) model selected as a best model based on the highest R-Square, lowest Mean Absolute Percent Error (MAPE), Root Means Square Error (RMSE) and Mean Absolute Error (MAE) values with 80.50, 12.12, 179.23 and 137.36 respectively. The per quintal predicted prices of potato during January 2020 to June 2020 would be ranging from ₹1437 per quintal in March 2020 to ₹1800 per quintal in June 2020.

Keywords: *Correlation coefficient***,** *Coefficient of Variation, Moving average, Monthly variability and Seasonal indices.*

Potato which is considered as one of the important non-cereal food crop occupied fourth position in agricultural crop production in the world after maize, wheat and rice. The world-wide potato production was estimated to be at 3881.91 lakh tonnes and India ranks second place in production with the 13.22 per cent (513.10 lakh tonnes) for the year 2017-18 (Anonymous, 2019). For the same study period Karnataka contribute 0.99 per cent (5.09 lakh tonnes) share of total potato production in all over India. Potato is predominantly grown in Bangalore, Belgaum and Chikmagalur districts of Karnataka. Potato is sown as a kharif crop in June and harvested in months of September and October and as rabi crop is sown in December and harvested in march and April months in Karnataka state (Anonymous, 2018). The present study aimed at the following objectives:

i) to examine trend, seasonal variations, cyclical variations, correlation in arrival and prices of potato in Bangalore market and

ii) to forecast prices of potato for Bangalore market

MATERIAL AND METHODS

For the present study Bangalore market was selected based on the highest market arrivals of potato in Karnataka state. Secondary monthly time series data on arrival and prices of potato in Bangalore market were collected from National Horticultural Research and Development Foundation (NHRDF), AGMARKNET and Horticulture Database for a period of 15 years from January, 2005 to December, 2019.

To analyse trend, seasonal and cyclical components of time series monthly data, a multiplicative model of the following type was used as elucidated in Areef *et al.*, (2019):

Monthly data $Y_t = T_t * S_t * C_t * I_t$

where,

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

T_t = Trend component in time period 't'

S_t = Seasonal variations in time period 't'

C_t = Cyclical movements in time period 't'

I_t = Irregular fluctuations at time period 't'

Trend Component

Ordinary least square method was employed to ascertain the trend in arrival and prices by estimating the intercept (a) and slope coefficient (b) in 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

Seasonal Variations

To estimate the seasonal index, a 12 month centered moving average was calculated as follows.

$M_1 = [Y_1 + Y_2 + Y_3 + ... + Y_{12}] / 12$
$M_2 = [Y_2 + Y_3 + Y_4 + ... + Y_{13}] / 12$
$M_3 = [Y_3 + Y_4 + Y_5 + ... + Y_{14}] / 12$ .....*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, which is expressed in terms of percentage.

$$S_t = \frac{Y}{(TC)_t} = \frac{T_t C_t S_t I_t}{T_t C_t}$$

In this process, there is no moving average for the first six months and the last six months. These seasonal components are next arranged month-wise for each year. In order to obtain a better estimate *i.e.*, stabilized seasonal indices, an iterative process of the following form is employed. The original observation (Y_t) is divided by corresponding (S_t) value and then obtained the residual $(TCI)_t$ corresponding to time point t.

$$(TCI)_t = \frac{Y_t}{S_t} = \frac{(TCSI)_t}{S_t}$$

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 to generate a revised set of seasonal indices by dividing each observation (Y_t) by the corresponding $(TC)_t$ value. This leads to revised estimates of seasonal indices (S_t) as second interactive ones.

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

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

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

Where,

$$\text{Correction factor} = \frac{1200}{\text{sum of seasonal indices}}$$

Cyclical movements

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'

$$\text{Symbolically, } \frac{T.C.S.I}{S} = T.C.I. \text{ and } \frac{T.C.I}{T} = C.I.$$

Correlation coefficient (r)

Singh *et al.*, (2017) used the correlation coefficient (r) to examine the correlation between monthly arrival and monthly price of potato, with the help of following formula given as below

$$r = \frac{\{\Sigma_{XY} - [(\Sigma_X)(\Sigma_Y)/N]\}}{\sqrt{\{(\Sigma_X^2) - [(\Sigma_X)^2/N]\}\{(\Sigma_Y^2) - [(\Sigma_Y)^2/N]\}}}$$

Where,

X= Monthly prices of potato in ₹/quintal
Y= Monthly arrival of potato in quintals
N= Number of observation i.e. 180 (From January, 2005 to December, 2019)

Seasonal Auto Regressive Integrated Moving Average (SARIMA)

Introduced by Box and Jenkins (1976), the ARIMA 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

$$Y_t = \theta_0 + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + ... + \phi_p Y_{t-p} + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} - ... - \theta_q e_{t-q}$$

where, Y_t and e_t are the actual values and random error at time t, respectively, f_i (i = 1,2,……., p) and q_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) x (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 (Chandran and Pandey, 2007 and Mithiya *et al*., 2019). Basically this method has four steps: identification of the model, estimating the parameters, diagnostic checking and forecasting.

RESULTS AND DISCUSSION

The movements in area and production of potato crop in Karnataka state are illustrated in the Fig. 1 and it showed that from 2010-11 to 2017-18 the area allocated for potato crop cultivation was less but production was very high over the initial period from 2004-05 to 2009-10. It could be concluded that productivity and production of potato increased irrespective of area expansion. The trend in market arrival and prices of potato in the Bangalore market was obtained by using the equations Y_t = 193678 + 259.86*t and Y_t = 776.738 + 4.08*t respectively and is graphically shown in Fig. 2. The linear equation coefficient values were significant indicating a positive trend in both arrivals and prices with 259.86 quintal per annum and ₹4.08 per quintal per annum respectively.

Seasonal Indices of arrival and prices of potato in Bangalore market was calculated and presented in Table 1. The results revealed that arrival was higher for the months of September (127.54), August (117.64) and March (105.18), whereas prices were higher for the months of November (119.01), July (111.94) and December (109.21). The lowest seasonal indices for arrival and prices were observed for the month of February (86.96) and March (80.53) respectively. Finally the results concluded that there is inverse relationship between the arrival and prices of potato in Bangalore market. During harvesting period of September and October months for kharif potato, the market arrival was high and prices were low while for *rabi* March and April months were observed with high arrivals and lower prices. Singh *et al*., (2017) and Dhakre and Bhattacharya (2014) obtained similar results of inverse relation of arrival and prices in their study of price behaviour of potato in Agra market.

The results of cyclical variations in arrival and prices of potato in the Bangalore market is graphically presented in Fig. 4. From the results a perfect price cycle of potato was identified for the period of 2015 to 2019 and for the arrival no cycle was identified for potato in Bangalore market for the study period from January, 2005 to December, 2019

The correlation coefficient (r) and Monthly variability in market arrivals and prices of potato in the Bangalore market for the time period January, 2005 to December, 2019 was calculated and presented in Table 2. The significant correlation coefficient (r) value explains the strength of the linear relationship between arrivals and prices. From the results, it is concluded that February month only showed significant correlation and for other months of the year there was no significant correlation between arrival and prices of potato in Bangalore market for the study period. It might be due to the reason that in month of February, early sown *rabi* crop harvested produce arrivals was started in Karnataka state. The mean monthly arrival was high for the month of August (2.65 lakh quintals) and low for the month of February (1.85 lakh quintals), whereas variation in arrival was high for the month of July with 31.98 per cent and low for the month of February with 16.64 per cent. The finding also indicated that highest mean monthly prices was observed for the month of November (₹.365 per quintal) and lowest mean prices for the month of March ([1] 880 per quintal). The variation in prices was highest in September (45.47 per cent) and lowest in February (26.41 per cent). Finally it could be concluded that February month only showed lowest variation in mean arrival and mean prices of potato for Bangalore market.

An application of SARIMA technique, identification of the model was concerned with deciding the (p,d,q) (P,D,Q) values by observing Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) values as illustrated in 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). Based on the maximum R-Square (80.50), minimum MAPE (12.12), minimum RMSE (179.23) and minimum MAE (137.36) values, the SARIMA (0,1,1) (0,1,1) model was selected as best model compared with all possible models and among all models only few appropriate models are presented in Table 3.

The parameters of the tentatively identified (0,1,1) (0,1,1) model were estimated and are presented in Table 4, the parameters were statistically significant. Among the selected models, only in the case of SARIMA (0,1,1) (0,1,1) up to 36 lags autocorrelation and partial autocorrelations of various orders of the residuals are within the confidence interval limits, which indicated the absence of white noise error in the

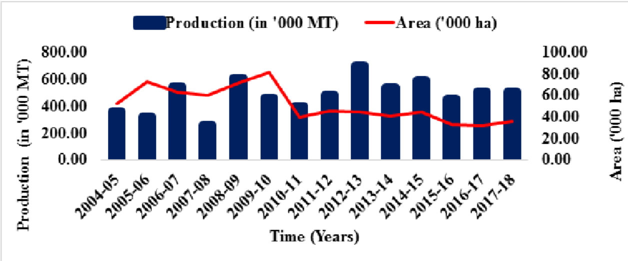

Fig. 1 Area and production of potato in Karnataka State during 2004-05 to 2017-18

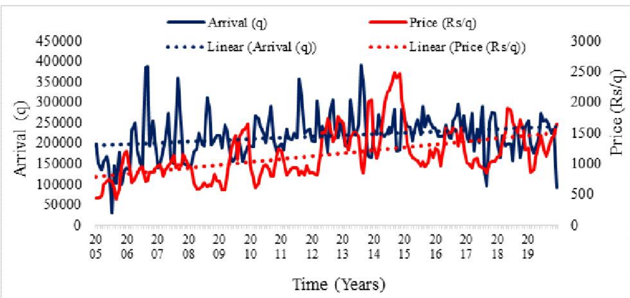

Fig. 2 Actual arrival and prices of potato in Bangalore market of Karnataka State

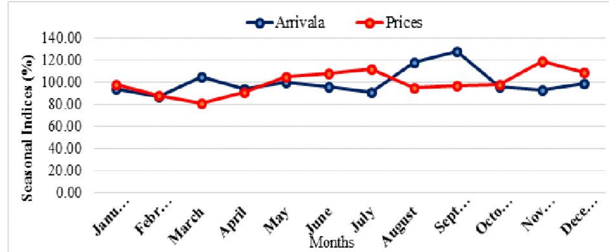

Fig. 3 Seasonality in arrival and prices of potato in Bangalore market

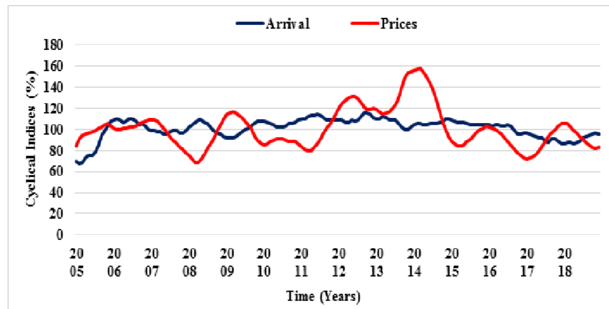

Fig. 4. Cyclical indices of arrival and prices of potato in Bangalore market

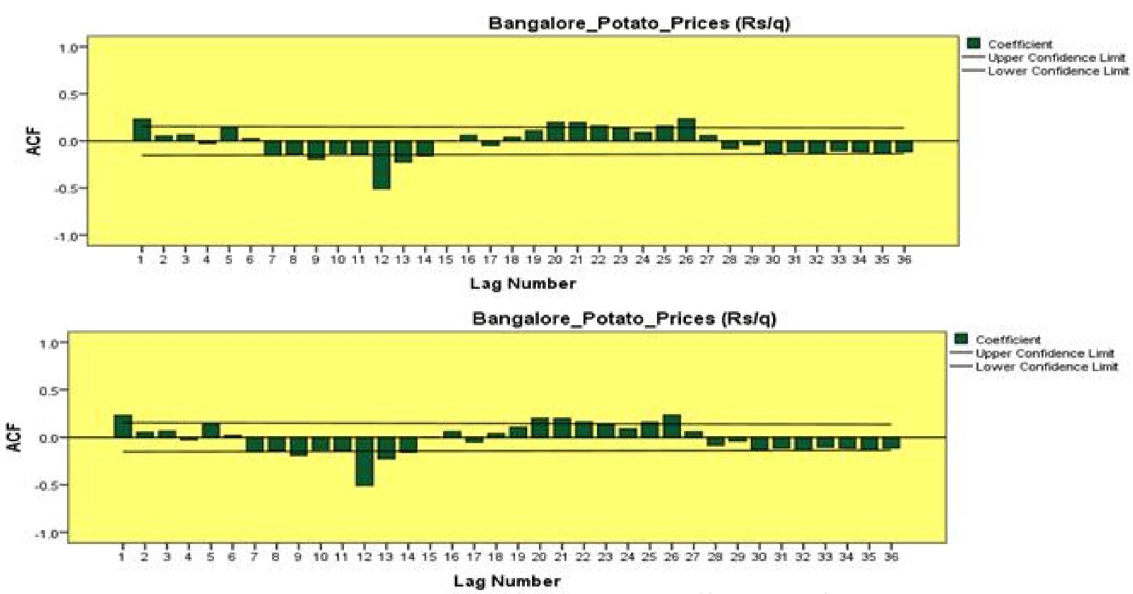

Fig. 5 Autocorrelation and Partial Autocorrelation Coefficients of potato prices in Bangalore market

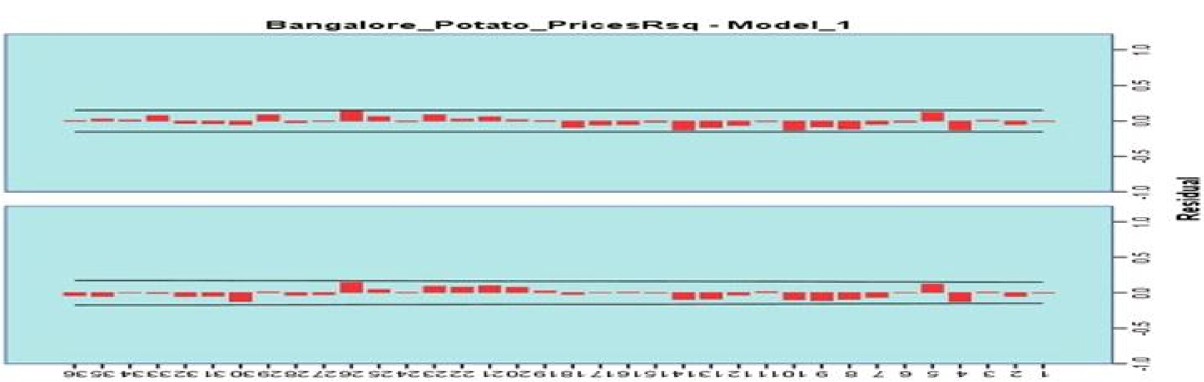

Fig. 6 Autocorrelation and Partial Autocorrelation Coefficients of residual of ARIMA (0,1,1) (0,1,1) model for the potato prices in Bangalore market

Table 1. Seasonal Indices (%) of arrival and prices of potato in Bangalore market

Months	Arrival indices	Price indices
January	94.23	97.68
February	86.96	87.82
March	105.18	80.53
April	94.38	91.22
May	99.88	105.00
June	95.75	108.00
July	90.78	111.94
August	117.64	94.90
September	127.54	97.15
October	95.98	97.55
November	93.10	119.01
December	98.59	109.21

Table 2. Correlation coefficient (r) and Monthly variability in arrivals and prices of potato in Bangalore market during 2005 to 2019

Months	Correlation coefficient (r)	Arrivals		Prices	
		Mean arrival (q)	C.V. (%)	Mean price (Rs./q)	C.V. (%)
January	0.38	203681	18.44	1108	29.44
February	0.44*	185909	16.64	962	26.41
March	0.23	225543	19.79	880	29.73
April	0.22	215554	16.92	1033	30.86
May	0.1	219713	13.44	1194	34.73
June	0.34	204718	18.69	1239	34.7
July	0.25	193026	31.98	1238	34.25
August	-0.16	265367	28.32	1121	41.32
September	0.08	264532	31.76	1111	45.47
October	-0.22	216367	18.21	1188	40.26
November	-0.17	202846	22.64	1365	33.96
December	-0.06	209100	26.46	1313	31.65

Note : C.V. means Coefficient of Variation

* indicate significant at 5% level of significance

Table 3. Residual analysis of monthly prices of potato in Bangalore market

S.NO	Model	R-square	MAPE	RMSE	MAE
1	(1,1,0) (1,1,0)	75.1	13.42	202.9	152.35
2	(0,1,0) (0,1,0)	64.7	16.1	240.19	184.21
3	(1,1,0) (0,1,0)	66.7	15.49	233.99	176.53
4	(0,1,1) (0,1,1)	80.5	12.12	179.23	137.36
5	(0,1,1) (0,1,0)	66.7	15.55	234.15	177.03
6	(0,1,1) (1,1,0)	75.3	13.41	202.23	151.94

Table 4. Conditional least square estimates of potato prices in Bangalore market

	Estimate	SE	t	Sig.
MA (1)	-0.18	0.08	-2.29	0.023
Seasonal MA (1)	0.95	0.2	4.706	0

Table 5. Actual and predicted prices of potato in Bangalore market

Years	2005		2006		2007		2008		2009	
Month	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted
Jan	436	*	1200	*	971	948	963	1052	707	701
Feb	429	*	919	1193	980	830	930	856	575	630
Mar	473	*	694	915	787	916	689	818	576	411
Apr	658	*	761	839	897	890	586	786	820	670
May	718	*	844	807	961	970	594	619	1142	901
Jun	736	*	937	869	1022	1015	625	647	1308	1236
Jul	706	*	954	919	1135	1017	687	655	1452	1362
Aug	588	*	706	842	935	973	629	504	1074	1313
Sep	414	*	724	507	976	850	661	613	1435	1010
Oct	584	*	857	933	964	1150	639	766	1545	1579
Nov	945	*	869	1204	1148	1117	827	802	1561	1725
Dec	1164	*	912	1027	1043	1285	723	884	1651	1544
Years	2010		2011		2012		2013		2014	
Month	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted
Jan	989	1672	1209	1123	868	700	1665	1610	1289	1943
Feb	763	781	1048	1112	825	778	1330	1565	1090	1036
Mar	614	637	811	909	816	690	1216	1162	1227	975
Apr	673	711	866	887	1123	927	1428	1342	1600	1400
May	832	774	932	979	1511	1268	1505	1589	1942	1774
Jun	959	917	937	1007	1519	1627	1515	1553	2163	2030
Jul	989	1028	931	981	1739	1547	1424	1578	2192	2238
Aug	908	781	810	742	1644	1602	1003	1235	2293	1992
Sep	799	988	882	851	1356	1687	853	954	2480	2324
Oct	796	840	810	950	1414	1339	1347	879	2403	2605
Nov	1096	940	960	962	1761	1601	2002	1627	2459	2616
Dec	1239	1153	844	1008	1721	1814	2040	2085	2045	2449
Years	2015		2016		2017		2018		2019	
Month	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted
Jan	1704	1806	1250	901	1014	1096	1110	891	1252	1043
Feb	1343	1543	1204	1149	997	846	1143	1008	855	1162
Mar	1173	1210	968	1110	926	908	1341	1055	896	713
Apr	1096	1320	1294	1073	1075	1078	1503	1542	1117	1079
May	1071	1215	1575	1475	1086	1228	1904	1638	1299	1287
Jun	1044	1120	1517	1658	968	1114	1868	1991	1467	1334
Jul	965	1079	1512	1528	930	974	1680	1872	1272	1500
Aug	1035	784	1579	1371	914	803	1575	1535	1124	1121
Sep	942	1079	1542	1606	848	921	1513	1565	1247	1104
Oct	1025	996	1282	1609	1018	883	1721	1562	1411	1343
Nov	1226	1259	1573	1449	1040	1274	1565	1964	1438	1607
Dec	1102	1192	1295	1558	1037	938	1225	1438	1721	1330
Years	2020									
Month	Actual	Predicted								
Jan	*	1662								
Feb	*	1514								
Mar	*	1437								
Apr	*	1592								
May	*	1756								
Jun	*	1800								

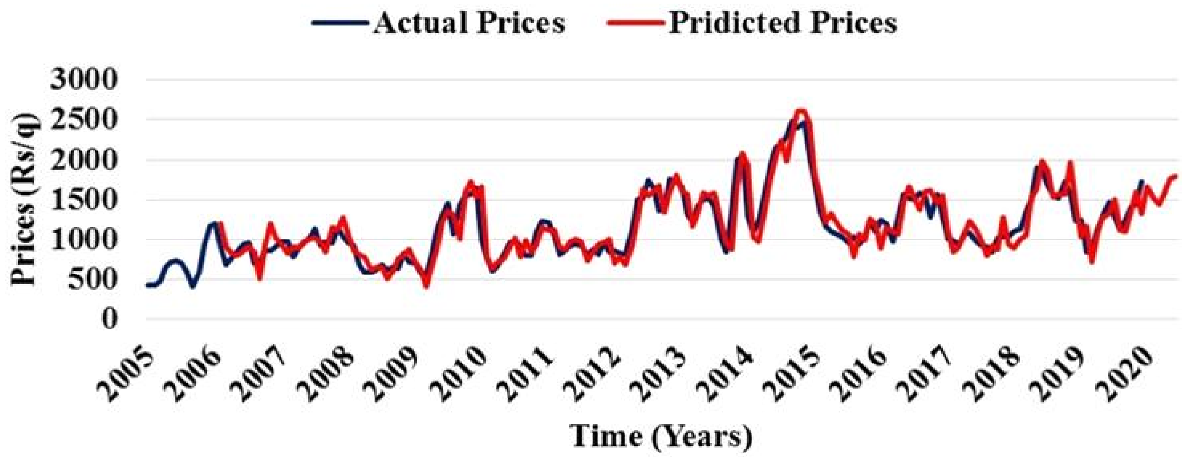

Fig. 7 Actual and predicted prices of Bangalore potato market using SARIMA technique

residuals as shown in Fig. 6. The results concluded that the selected SARIMA model was appropriate for forecasting the price of potato for short term time period up to next six months. The prices were forecasted up to June, 2020 are shown in Table 5 and illustrated in Fig. 7. The forecast values also indicated that there was narrow variation in between the actual and forecasted values of prices of potato in Bangalore market. According to the predicted values the price of potato showed decreasing trend up to month of March and then start rising from April to June, prices would be ranging from ₹.662 to ₹1437 per quintal for the first three months and for next three months ranging from ₹ 1592 to ₹1800 per quintal during the months of January to June 2020.

CONCLUSION

The findings of the present study concluded the existence of positive trend in both arrivals and prices with 259.86 quintal per annum and ₹4.08 per quintal per annum respectively in Bangalore market. The seasonal indices values for arrival and prices revealed that the highest indices were observed in the months of September and November and the lowest indices were observed in the months of February and March respectively. During the months of September, August and March glut condition was noticed in the market arrival due to harvesting of produce and eventually prices started declining. Perfect price cycle of potato for the period of 2015 to 2019 was identified and no such pattern was identified for the arrival of potato. Significant correlation between arrival and prices of potato was documented for February month only, which also showed lowest variation in monthly mean arrival and monthly mean prices of potato in Bangalore market. To overcome the price fluctuation price transmission should be allowed by integrating the spatially separated markets in India, besides adopting new technologies and accessing the market intelligence centres to identify the markets and sell their surplus produce at remunerative prices. Predicted future prices help the farmers to plan in advance for sowing and harvesting of potato, so as to get a better price for the produce.

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