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PRICE FORECASTING OF BAJRA (PEARL MILLET) IN RAJASTHAN: ARIMA MODEL

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Abstract- The price behaviour of a commodity plays crucial role in farm level crop production planning. In this paper, an attempt has been made to forecast Pearl millet price using statistical time-series modelling techniques- Autoregressive Integrated Moving Average (ARIMA) Models. The forecasting performance of these models has been evaluated and compared by using common criteria such as: mean absolute percentage error, Akaike Information Criteria (AIC) and Schwarz's Bayesian Information criterion (SBC). The data used in this study include monthly wholesale price of bajra from January 2003 to December 2014. Among all the models tried, the Box-Jenkins ARIMA model (2, 1, 0) was best fit with least AIC (1557.22), SBC (1566.10) and MAPE (5.78). ARIMA (2, 1, 0) model is constructed based on autocorrelation and partial autocorrelation. Finally, forecasts were made based on the model developed. On validation of the forecasts from these models, ARIMA (2, 1, 0) model performed better than the others for bajra in Renwal market. The validation percentage ranged between 87.33 per cent in December 2015 to 96.67 per cent in July 2015. Thus, ARIMA model can be used to predict the future price of bajra in Renwal market of Rajasthan.

Keywords- Bajra, Price forecasting, ARIMA model, Rajasthan.

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Introduction

Pearl millet (*Pennistum glaucum)* is considered as the fifth important cereal crop, and most important millet (constitutes more than 55% of global millet production) and is grown in over 40 countries, predominantly in Africa and the Indian subcontinent. India produced 9.05 million tonnes of bajra in 2014-15[1]. The major producing countries are Senegal, Mali, niger, Nigeria, Sudan and India. The major producing states in India are Rajasthan, Uttar Pradesh, Maharashtra and Gujarat. Pearl millet (*Pennistum glaucum*) is one of the major coarse grain crops and is also one of the most drought resistant crops among cereals and millets. It is higher than sorghum in nutritive value but less in feeding value. Bajra grain contains about 12.4% moisture, 11.6% protein, 5% fat, 67% carbohydrates and about 2.7% minerals; Pearl millet production in India was characterized by subsistence cultivation during 1970s with a small marketable surplus. But in recent years, it is being geared to a more market oriented crop owing to the change in utilization from mainly food use to many alternative uses such as animal feed, potable alcohol, processed food, etc. Rajasthan has the highest area under pearl millet with the highest production in the country. The state occupies nearly 40.76 lakh ha area with average production of about 44.56 lakh tonnes and productivity of 1093 kg/ha in 2014- 15 [2]. The crop is grown as a sole crop as well as mixed crop or intercropped with legumes or sesame in the state. Considering the fact that pearl millet continues to be an important food grains crop for India and its productivity has shown upward trend, it is an ideal food crop to expand the food basket of the country. Also there is need to develop a strong market support system through market intelligence. The returns to the producer farmer are not only governed by production but prices at which the produce is marketed. The prices of bajra fluctuate to a great extent mainly because of its supply. Thus, the price forecast may help producers in acreage allocation and time of sale. Sowing time of bajra is in between start of June to end of July in Rajasthan. The peak time for arrival is November but it starts in small quantity by October. Though gradual, arrivals continue round the year. Thus, the present study was an attempt to identify the best suited model of price forecasting for bajra in Renwal (Jaipur) market of Rajasthan. Series analysis is the art of saying that what will happen in the future rather than why. Now days there are various forecasting models in use. Forecaster can choose his own method of forecasting based on his knowledge and available external information. As the process goes on, this procedure can be modified to meet the conditions and to satisfy the current situation. Different forecasting models may be fitted more or less equally well to the data, but they forecasts different future values. Thus, the present study was an attempt to identify the best suited model of price forecasting for bajra in Renwal (Jaipur) market of Rajasthan.

MaterialsandMethods

As the aim of the study was to forecast prices of bajra, various forecasting techniques were considered for use. ARIMA model, introduced by Box and Jenkins (1970), was frequently used for discovering the pattern and predicting the future values of the time series data. Renwal Market in Jaipur region was purposively selected for the price forecasting study of bajra (Pearl millet) on the basis of second highest bajra arrivals from the Jaipur region. The various price forecasting Autoregressive Integrated Moving Average (ARIMA) models were tried to identify the best-fit model for market price of bajra.

The secondary data of monthly wholesale bajra prices were collected for the study from the Renwal market. The data of bajra price in Renwal regulated market for the period from January 2003 to December 2014 was utilized for model fitting and data for subsequent period i.e. from January 2015 to December 2015 were used for validation. The details of various price forecasting ARIMA models are as follows:

ARIMA Models

Box-Jenkins (ARIMA) model was used to measure the relationships existing among the observations within the series. Box-Jenkins time series model written as ARIMA (p, d, q) was first popularized by Box-Jenkins (1976). The acronym ARIMA stands for "Auto-Regressive Integrated Moving Average". Lags of the differenced series appearing in the forecasting equation are called "auto-regressive (AR)" terms, lags of the forecast errors are called "moving average (MA)" terms and a time series, which need to be differenced to make the data stationary, is said to be an "integrated" version of a stationary series. This model amalgamates three types of processes, namely, auto-regressive of order p, d is differencing to make to the series stationary of order d and moving average of order q [3].

This method applied only to a stationary time series data and if the data are non-stationary, it has to be brought into stationary by method of differencing i.e.

$$W = Y_t - Y_{t-1}$$

The series Wt is called the first difference of Yt and the second difference of the series is $V_t = W_t - W_{t-1}$. The ARIMA modeling consists of following four operational steps.

Identification of the model is concerned with deciding appropriate value of p, d, q, P, D and Q, where,

p= order of the non-seasonal AR terms

d= non-seasonal differencing

q= order of the non- seasonal MA terms

P= order of the seasonal AR term

D= seasonal differencing

Q= order of the seasonal MA term

Before identifying the model, identify the characteristics of time series for stationarity and seasonality as said above and the same must be removed. After the time series has been stationarized by differencing, the next step in fitting an ARIMA model is to determine whether auto regressive (AR) or moving average (MA) terms are needed to correct any autocorrelation that remains in the differenced series. Of course, with software like Stat graphics you could just try same different combinations of terms and see what works the best. But there is a more systematic way to do this. By looking at the autocorrelation function (ACF) and partial autocorrelation (PACF) plots of the differenced series, we can tentatively identify the numbers of AR and Ma terms that are needed. ACF plot is merely a bar chart of the coefficients of correlation between a time series and lag of itself. The PACF plot is a plot of the partial correlation coefficients between the series and lags of itself. After identifying the suitable model, the next step is to obtain the minimum the squares. Estimating the parameters of the Box-Jenkins model is a quite complicated non-linear estimation problem. [3]. For this reason, using much commercial statistical software like SAS, SPSS, Minitab, etc. was used for the estimation of parameters. After having estimated the parameters of a tentatively identified ARIMA model, it is necessary to do diagnostic checking to verify that the chosen model is adequate. Considerable skills are required to choose the right ARIMA model. Diagnostic checking helps us to identify the differences in the model, so that the model could be subjected to the modification if needed. After satisfying about the adequacy of the model, it can be used for forecasting. One of the reasons for the popularity of ARIMA modeling is its success in forecasting. In many cases, forecasting's obtained by Box-Jenkins method are reliable than those obtained from traditional econometrics modeling.

Result and Discussions

ARIMA model forecasting

Model Identification: ARIMA model is estimated only 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. There are several ways to ascertain this. The most common method is to check stationarity through examining the graph or time plot of the data [Fig-1]. revealed that the data were nonstationary. Non-stationarity in mean is corrected through appropriate differencing of the data. The newly constructed variable Yt was stationary in mean, the next step is to identify the values of p and q. For this Autocorrelation (ACF) and Partial Autocorrelation (PACF) of various orders of Yt were computed and presented in [Table-1] and [Fig-2]. It can be seen from [Table-1] that the auto correlation function (ACF) declined very slowly from 0.961 to 0.489 and as many ACFs were significantly different from zero and fell outside the 95 per cent confidence interval, the price of bajra was non-stationary [4].

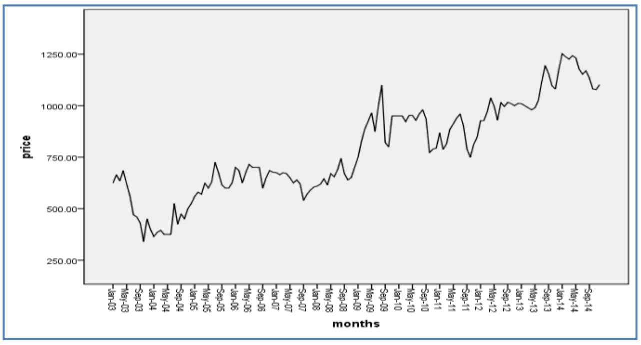
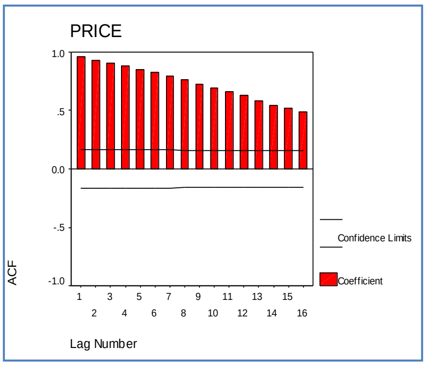


Fig-1 Monthly wholesale prices (January- 2003 to December- 2014) of bajra at Renwal Mandi

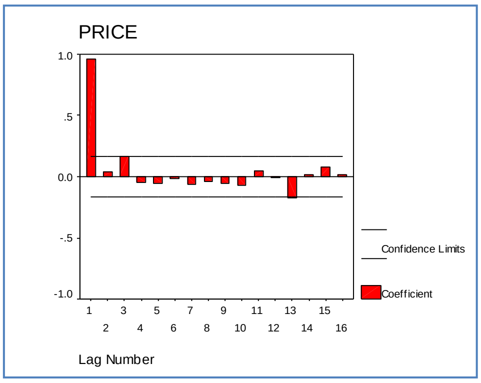
The analyses of partial autocorrelation coefficient and bajra prices are depicted in [Table-1]. The graphical presentation of ACF and PACF of [Table-1] are given in [Fig-2]. It is seen from [Table-1] that the value of partial autocorrelation function (PACF) declined rapidly after the first lag period from 0.962 to 0.076, which also indicated the non-stationarity of the price series. These tables showed that the autocorrelation and partial autocorrelation functions at lag 16 were significantly different from zero and fell outside the 95 % confidence interval. Differencing of bajra price data was done to make the series stationary. The value of d in the ARIMA model was unity (1) because the differencing was carried out only once to arrive at stationary series.

Table-1 *Auto-correlation and partial autocorrelation coefficient of bajra price*

Lag	Aut. Correlation		Box-Ljung	Partial autocorrelation	
	Value	Standard Error		Value	Standard error
1	0.961	0.082	135.829	0.0961	0.083
2	0.927	0.082	263.071	0.042	0.083
3	0.907	0.082	385.644	0.167	0.083
4	0.887	0.082	502.473	-0.045	0.083
5	0.852	0.081	612.394	-0.052	0.083
6	0.824	0.081	715.954	-0.018	0.083
7	0.794	0.081	812.688	-0.065	0.083
8	0.762	0.080	902.335	-0.041	0.083
9	0.728	0.080	984.815	-0.052	0.083
10	0.691	0.080	1059.716	-0.070	0.083
11	0.660	0.080	1128.514	0.046	0.083
12	0.630	0.079	1191.672	-0.005	0.083
13	0.586	0.079	1246.770	-0.174	0.083
14	0.546	0.079	1295.031	0.014	0.083
15	0.518	0.078	1338.796	0.078	0.083
16	0.489	0.078	1378.119	0.018	0.083



Autocorrelation



Partial Autocorrelation

Fig-2 Autocorrelation and partial autocorrelation coefficients

Model estimation: The models as identified above were estimated through the marquardt procedure using SPSS 7.5 version of the SPSS package. From the various forms of following ARIMA models *viz:* ARIMA (1, 1, 1); ARIMA (1, 1, 0); ARIMA (0, 1, 1); ARIMA (2, 1,1); ARIMA (2, 1, 0) and ARIMA (0, 1, 2); the best model was chosen on the basis of lowest value of Akaike Information Criteria (AIC) and Schwarz Bayesian Criteria (SBC) [Table-2]. On comparing the alternative models on the basis of statistics such as Akaike Information Criteria and Schwarz Bayesian Criteria, Mean absolute Percentage Error and t- value, it was observed that both AIC (1557.22),SBC (1566.10) and MAPE (5.78) were the lowest value for ARIMA (2, 1, 0) model from [Table-2]. Hence, ARIMA (2, 1, 0) was the most representative model for the price of bajra.

Table-2 *AIC and SBC values of ARIMA*

ARIMA (p, d, q)	Akaike Information Criteria (AIC)	Schwarz Bayesian Criteria (SBC)
1,1,1	1557.60	1566.49
1,1,0	1564.00	1569.92
0,1,1	1563.68	1569.60
2,1,1	1559.14	1570.99
2,1,0	**1557.22**	**1566.10**
0,1,2	1558.32	1568.21

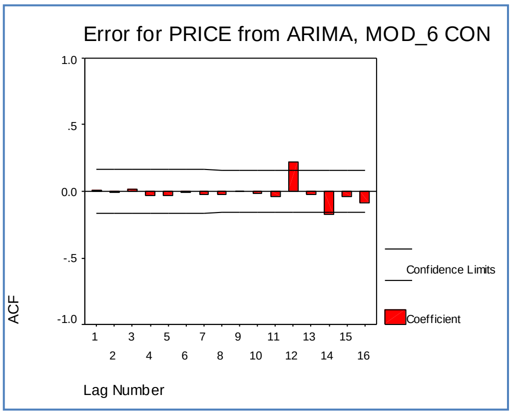
AIC=1557.22, SBC=1566.10 and MAPE=5.78

Diagnostic checking: The model verification is concerned with checking the residuals of the model to see if they contained any systematic pattern, which still could be removed to improve the chosen ARIMA, which has been done through examining the autocorrelations and partial autocorrelations of the residuals of various orders. For this purpose, various autocorrelations up to 16 lags were computed and the same along with their significance tested by Box-Ljung statistic are provided in [Table-3]. As the results indicate, none of these autocorrelations was significantly different from zero at any reasonable level [5]. This proved that the selected ARIMA model was an appropriate model for forecasting bajra price of the renwal market. The ACF and PACF varied from 0.004 to -0.083 which showed that the autocorrelation and partial correlation functions at lag 16 were significantly different from zero and fell within the 95% confidence interval of the residuals are given in [Fig-3], which also indicated the 'good fit' of the model.

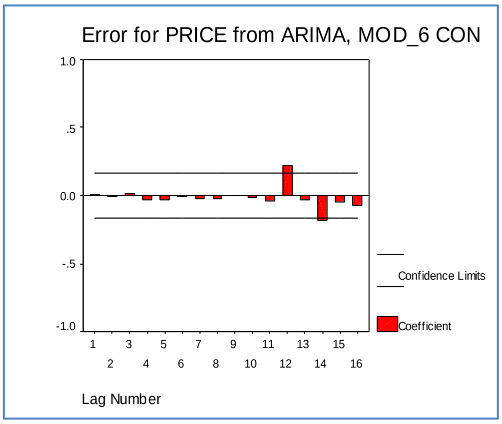
Post sample forecasts: The principal objective of developing an ARIMA model for a variable is to generate post sample period forecasts for that variable. This is done through using equation (1). The figures depicted the absence of autocorrelation as the autocorrelation and partial autocorrelation functions up to lag fell within the 95 per cent confidence interval. This proved that the selected ARIMA (2, 1, 0) model was appropriate for forecasting the price of bajra during the period under study.

Table-3 *Autocorrelation and partial autocorrelation coefficients of residuals of ARIMA (2, 1, 0) model for the bajra price*

Lag	Auto Correlation		Box-Ljung	Prob	Partial autocorrelation	
	Value	Standard Error			Value	Standard error
1	0.004	0.083	0.003	0.957	0.004	0.084
2	-0.008	0.082	0.012	0.994	-0.008	0.084
3	0.014	0.082	0.042	0.998	0.014	0.084
4	-0.031	0.082	0.186	0.996	-0.031	0.084
5	-0.035	0.082	0.365	0.996	-0.034	0.084
6	-0.011	0.081	0.383	0.999	-0.011	0.084
7	-0.023	0.081	0.463	1.000	-0.022	0.084
8	-0.022	0.081	0.536	1.000	-0.022	0.084
9	0.003	0.080	0.538	1.000	0.001	0.084
10	-0.012	0.080	0.560	1.000	-0.014	0.084
11	-0.040	0.080	0.805	1.000	-0.041	0.084
12	0.221	0.079	8.562	0.740	0.219	0.084
13	-0.022	0.079	8.640	0.800	-0.029	0.084
14	-0.173	0.079	13.431	0.493	-0.179	0.084
15	-0.040	0.079	13.691	0.549	-0.049	0.084
16	-0.083	0.078	14.824	0.538	-0.074	0.084



Autocorrelation



Partial Autocorrelation

Fig-3 Autocorrelation and partial autocorrelation coefficients of residuals of ARIMA (2, 1, 0) model for the bajra price

Table-4 *Estimates of the fitted ARIMA model (2, 1, 0) for the price of bajra*

Parameters	B	Standard error	T Value	P value
AR1	-.0608248	0.08119680	-.7420548	0.45929727
AR2	-.2432097	0.0819137	-2.9690980	.00351497
Constant	3.2936893	3.5645329	0.9240171	3.576729

Standard Error=55.421, DF=16, Log likelihood=-775.61

Table-5 *Post-sample periods forecasting for the bajra price of Renwal market based on ARIMA (2, 1, 0) models*

(`/q)

Months	Bajra price		Difference (Forecasted-Actual)	Difference in per cent
	Actual price	Forecasted price		
Jan 2015	1198	1105.56(92.28%)	-92.44	-7.72
Feb 2015	1143	1103.81(96.57%)	-39.19	-3.43
Mar 2015	1158	1107.34(95.63%)	-50.66	-4.37
Apr 2015	1152	1111.85(96.51%)	-40.15	-3.49
May 2015	1172	1115.01(95.14%)	-56.99	-4.86
Jun 2015	1180	1118.02(94.75%)	-61.98	-5.25
Jul 2015	1160	1121.36(96.67%)	-38.64	-3.33
Aug 2015	1172	1124.72(95.97%)	-47.28	-4.03
Sep 2015	1210	1128.00(93.22%)	-82.00	-6.78
Oct 20015	1215	1131.28(93.11%)	-83.72	-6.89
Nov 2015	1289	1134.58(88.02%)	-154.42	-11.98
Dec 2015	1303	1137.87(87.33%)	-169.13	-12.94

Note - Figures in parentheses are percentage of accuracy.

The actual prices of bajra in Renwal market and the predicted values for these months through ARIMA models are presented in [Table-5]. In order to check the validity of these forecasted values, they were compared with the actual values of price of bajra during the post sample forecast period i.e. from January-2015 to December-2015 (twelve months) which is shown in [Table-5]. The accuracy percentages vary from 87.33 per cent to 96.67 per cent. It was observed that the accuracy percentage out of different ARIMA models the prevailing market price of bajra and based on ARIMA (2, 1, 0) model was very close to actual value as compared to other predicted model prices. This proved that the ARIMA (2, 1, 0,) model was the best fit model for forecasting the price of bajra for Renwal market during the period under study.

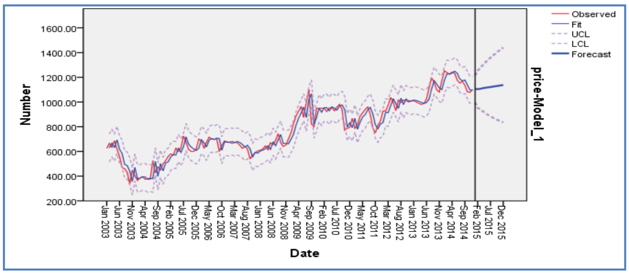


Fig-4 Validity of forecasted price and actual price of bajra

Conclusion

In the present study the best fitted model was ARIMA (2,1,0).On comparing the alternative models, it was observed that AIC (1557.22), SBC (1566.10) and (5.78) were least for ARIMA (2, 1, 0) model was considered the most representative model for the price of bajra in Renwal market of Rajasthan. The validity of the forecasted values can be checked when the data for the lead periods become available. The developed model can be used as a policy instrument of the producers and sellers. The limitation of the ARIMA model is that it requires a long time series data. Like any other method, this technique also does not guarantee perfect forecasts. Nevertheless, it can be successfully used for forecasting long time series data.

Conflict of Interest: None declared

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