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Applicability of ARIMA Models in Wholesale Wheat Market of Rajasthan: An Investigation

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Abstract

Wheat is a dominant product in the consumption basket of Indian households and can be considered as a strategic commodity. In this paper different ARIMA time series models were specified and estimated. Forecasting performance of these models were evaluated and compared by using common criteria such as: root mean square error, mean absolute deviation and mean absolute percentage error. The data used in this study include wholesale prices of wheat for year 2002 to 2012. Empirical results showed that ARIMA (1,1,1) price forecast time series model fitted the price series well and they have correctly predicted the future trend of the price series within the sample period of the study. Thus, ARIMA (1,1,1) was the most representative model for the price forecast of wheat in Sriganganagar market of Rajasthan. This model can facilitate the farmers and wholesalers in effective decision making.

Keywords: Forecasting, prices, Wheat, Sriganganagar, ARIMA

Price forecasts are critical to market participants who make production and marketing decisions, and to policymakers who administer commodity programs and assess the market impacts of domestic or international events. Price forecasting is very essential for planning and development and therefore it becomes pertinent to develop methods which helps the policy makers to have some idea about the prices of commodities in the future. One approach is to consider causes and their effects and the other approach is to forecast prices without taking in to consideration the causes. The time series approach to forecasting is one such approach which relies on the past pattern in a time series to forecast prices in the future. De Gooijer and Hyndman (2006) have provided an excellent review of time series methods in forecasting. There are many methods for analyzing a time series like exponential smoothing with a damped multiplicative trend Taylor (2003) etc., but one of the most simple and bench mark method is that of Box and Jenkins which is popularly known as ARIMA methodology. The time series approach to forecasting is one such approach which relies on the past pattern in a time series to forecast prices in the future. Burark and Sharma (2012) confirmed the suitability of Box-Jenkins univariate ARIMA models in agricultural price forecasting. Paul and Das (2010) have attempted forecasting of inland fish production in India by using ARIMA approach. Paul (2010) has also studied the application of stochastic modelling for forecasting of wholesale price of Rohu in West Bengal, India. Saz (2011) has used seasonal autoregressive moving average (SARIMA) model to forecast inflation rates. Food grain production is likely to touch a record 263.2 million tonnes (mt) this year, this would be about 4 mt higher than the record of 259 mt achieved two years ago. Wheat production in India, the world's second-largest grower, will probably climb to a record as all-time high domestic prices motivated. planting, adding to global grain surpluses. India's wheat production in marketing year 2014-15 is expected to rise by 4% to 96.0 mt from the 92.5 mt produced in the current year. Exports

are seen at 3.0 mt and domestic use at 91.5 mt. This should lead to higher ending stocks of 20.5 mt. In Rajasthan, major wheat growing districts are Kota, Jaipur, Sri Ganganagar, Hanumangarh, Alwar, Tonk, S.Madhopur, Pratapgarh, Bundi, Dousa, Bhilwara, and Bharatpur. The price of wheat also fluctuates a lot depending upon the demand and supply situation which in turn affect the income of the wheat growers.

In this paper time series of prices of wheat in Sriganganagar has been analyzed with the ARIMA methodology and the forecasting abilities of various ARIMA models has been compared. Rest of the paper is organized as follows the traditional univariate time series approach to forecasting is designed for this study is discussed. It also discusses the evaluation methods for comparing the forecasting approaches. Data and forecast procedure are discussed and shows the results obtained from the ARIMA estimations and last shows conclusion.

Database andMethodology

Sriganganagar market was purposively selected for the price data as the market arrivals of wheat were maximum in the state of Rajasthan. The various price forecasting ARIMA models were tried to identify the most suitable model which suits to actual market price of wheat. The monthly wholesale prices data of wheat in Sriganganagar regulated market for the period Jan. 2002 to Dec, 2011 were utilized for model fitting and data for subsequent period i.e. from Jan 2012 to June 2012 were used for validation. The details of forecasting models are as follows:

Introduced by Box and Jenkins (1976), the ARIMA model has been one of the most popular approaches for forecasting. 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 non seasonal 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:

$$Xt = \theta 0 + \Phi 1 X_{t-1} + \Phi 2\, X_{t-2} + \ldots + \Phi p\, X_{t-p} + et - \theta 1 e_{t-1} - \theta 2 e_{t-2} - \ldots - \theta\, e_{t-q} \quad (1)$$

Where Xt and et are the actual values and random error at time t, respectively, Φi (i = 1,2,……., p) and θj (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 et are assumed to be independently and identically distributed with mean zero and the constant variance, σe 2. Similarly a seasonal model is represented by ARIMA (p, d, q) x (P, D, Q) model, where P = number of seasonal autoregressive (SAR) terms, D = number of seasonal differences, Q = number of seasonal moving average (SMA) terms. Basically this method has three phases: model identification, parameters estimation and diagnostic checking. The ARIMA model is basically a data oriented approach that is adapted from the structure of the data itself. The forecasting performance of these models are evaluated and compared by using common criteria such as: root mean square error, mean absolute deviation and mean absolute percentage error.

Results and Discussion

The whole sale prices prevailed in past for wheat in Sriganganagar regulated market were considered for the selection of appropriate model for price forecast. The monthly wholesale prices from Jan. 2002 to Dec.2011 were used to estimate the ACF and PACF (Appendix I). The price data were tested for stationarity. It can be seen from Table 1 and Fig.1 that the auto correlation function (ACF) declined very slowly and as many ACFs were significantly different from zero and fell outside the 95 per cent confidence interval, the price of wheat was non-stationary. The partial auto correlation function (PACF) dropped steeply after the first lag period, which also indicated the non-stationarity of the price series.

The problem of non-stationarity was solved through appropriate differencing of the data. Since differencing was carried out only once to arrive at stationary series, the value of ***d*** in the ARIMA model was unity (1).

Table 1: Autocorrelation and partial autocorrelation coefficients of the wheat price

Lag	Auto- Corr.	Par-Auto- Corr.
1	0.974	0.974
2	0.949	0.011
3	0.923	-0.017
4	0.895	-0.070
5	0.875	0.145
6	0.859	0.063
7	0.837	-0.103
8	0.817	-0.003
9	0.800	0.063
10	0.779	-0.044
11	0.764	0.058
12	0.744	-0.096
13	0.719	-0.110
14	0.697	0.047
15	0.677	0.061
16	0.659	0.035

From the following ARIMA models *viz.* ARIMA (1, 1, 0); ARIMA (1, 1, 1); ARIMA (0, 1, 1); ARIMA (2, 1, 1); ARIMA (1, 1, 2); ARIMA (0, 1, 2) and ARIMA (2, 1, 0) the best model was chosen on the basis of least AIC and SBC. The details of AIC and SBC values for different ARIMA models are presented in Table 2.

The models as identified above were estimated through the Marquardt procedure using SPSS 7.5 version of the SPSS package. On comparing the alternative models on the basis of statistics such as Akaike Information Criteria (AIC) and Schwarz Bayesian Criteria (SBC), it was observed that both AIC (1224.17) and SBC (1232.51) were least for ARIMA (1,1,1) model (Table 2). Hence, ARIMA (1, 1, 1) model was the most representative model for the price of wheat in Sriganganagar market.

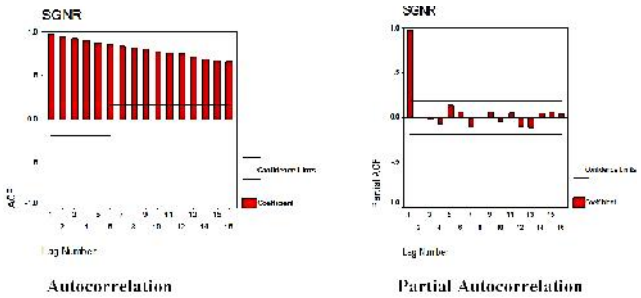

Fig. 1: Autocorrelation and partial autocorrelation coefficients of the wheat price

Table 2: ARIMA model for the price of wheat

Model	AIC	SBC
1,1,0	1225.92	1231.47
1,1,1	1224.17	1232.51
0,1,1	1225.90	1231.46
2,1,1	1228.68	1239.80
1,1,2	1228.71	1239.83
0,1,2	1227.84	1236.18
2,1,0	1227.86	1236.20

Table 3: Autocorrelation and partial autocorrelation coefficients of residuals of ARIMA (1, 1, 1) model for the wheat price

Lag	Auto- Corr.	Par-Auto- Corr.
1	0.002	0.002
2	0.029	0.029
3	0.095	0.095
4	-0.185	-0.188
5	-0.064	-0.07
6	0.13	0.142
7	-0.052	-0.015
8	-0.057	-0.099
9	0.054	0.012
10	-0.114	-0.055
11	0.118	0.145
12	0.169	0.131
13	-0.043	-0.046
14	-0.044	-0.108
15	-0.049	-0.046
16	0.05	0.187

The autocorrelation and partial autocorrelations of various orders of the residuals of ARIMA (1, 1, 1) up to 16 lags were computed and are shown in Table 3 and Fig. 2. The figures showed that, the autocorrelation at lag 4 and 12 and partial autocorrelation functions at lag 16 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. Hence, except for lag 4, 12 and 16 autocorrelation was absent in the residuals. This showed that the selected ARIMA model was appropriate for forecasting the price of wheat during the period under study.

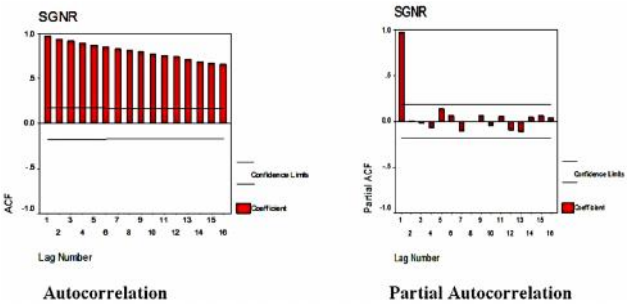

Fig. 2: Autocorrelation and partial autocorrelation coefficients of residuals of ARIMA (1, 1, 1) model for the wheat price

It can be inferred from the Table 4 that the ARIMA (1, 1, 1) model was the preferred model for forecasting wheat price due to the minimum value of MAD (57.15), MSE (5105.89) and MAPE (4.56) when compared to other ARIMA forecasting models.

In order to check the validity of these forecasted values, they were compared with the actual values of price of wheat during the post sample forecast period i.e. from Jan.-2012 to June-2012 (Six months). The accuracy percentages vary from 92.68% to 98.01 per cent in ARIMA (1, 1, 1) model for the predicted period of six months. It was observed that the accuracy percentage out of different forecasting models, the prevailing market price of wheat and predicted through ARIMA (1,1,1)

model was very close to other predicted model prices (Fig.3). This proved that the ARIMA (1,1,1) model was the best fit model for forecasting the price of wheat for Sriganganagar market during the period under study.

Kumar *et al.* (2002) also obtained same results while studying the ARIMA (0,1,2) model for forecasting the wheat productivity in the alluvial plains of Bihar, India for 45 years between 1950-51 to 1996-97.

Table 4: Extent of accuracy through different criterion

Criteria	ARIMA						
	1,1,0	**1,1,1**	**0,1,1**	**2,1,1**	**1,1,2**	**0,1,2**	**2,1,0**
MAD	69.56	**57.15**	65.55	70.52	66.53	60.82	62.25
MSE	9635 .09	**5105 .89**	8635 .09	7562 .49	6655 .86	6958 .22	6565 .53
MAPE	10.59	**4.56**	8.59	8.03	7.23	6.72	6.89

Table 4: Forecast price of wheat by different models (₹/quintal)

Month	Actual	ARIMA (1,1,1)
Jan-12	1155	1131.99(98.01)
Feb-12	1166	1147.61(98.42)
Mar-12	1200	1162.02(96.84)
Apr-12	1260	1175.37(93.28)
May-12	1272	1187.77(93.38)
Jun-12	1294	1199.33(92.68)

Figure in parentheses are the percentages of respective actual prices.

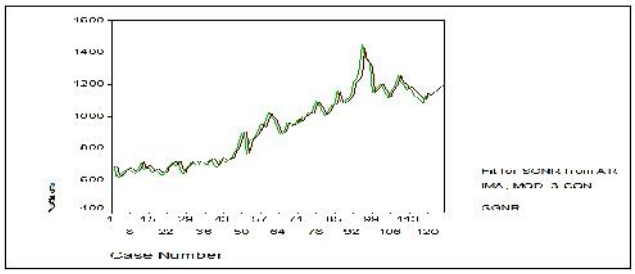

Fig. 3: Forecast price accuracy of wheat in ARIMA (1, 1, 1) model

Thus, in present investigation a large scale comparison of different models has been done in order to know the best model for forecasting wheat price. The comparison of all the ARIMA models was carried out in the process based on the MAD, MSE and MAPE values which were considered to be least. ARIMA (1, 1, 1) model for wheat were found to be the most appropriate model with MAD (57.15), MSE (5105.89) and MAPE (4.56). The validity of the forecasted price values of wheat was checked by comparing them with their actual market price values during the post sample forecast period i.e. Jan. 2012 to June 2012 for wheat crops. The accuracy percentage between the forecasted and actual price value of wheat were found to be 92 to 98 per cent. It was observed that the ARIMA (1,1,1) model was found to be the most suitable for forecasting the prices of wheat commodity. These projections help the government to make policies with regard to relative price structure, production and consumption and also to establish relation with other state of the countries.

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Appendix-I

Monthly Wholesale Price of Wheat in Sriganganagar Regulated market of Rajasthan during 2002 to 2012

(₹/quintal)

Month	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
	Price	Price	Price	Price	Price	Price	Price	Price	Price	Price	Price
Jan	680	666	689	703	849	1002	1004	1081	1359	1254	1155
Feb	685	690	715	729	891	982	1006	1165	1329	1210	1166
Mar	625	679	661	713	898	941	1031	1097	1149	1204	1200
Apr	619	649	640	684	760	893	1015	1083	1172	1164	1260
May	642	663	673	690	846	887	1065	1093	1186	1182	1272
Jun	661	659	683	731	865	908	1095	1114	1207	1162	1294
Jul	672	641	707	721	872	959	1063	1127	1169	1130	1406
Aug	668	637	710	712	913	944	1035	1216	1142	1111	1531
Sep	652	639	696	725	953	938	1005	1230	1114	1093	1478
Oct	647	680	709	724	935	953	1024	1267	1151	1082	1436
Nov	665	691	711	772	990	980	1052	1453	1177	1133	1517
Dec	711	712	704	792	1029	964	1072	1367	1206	1115	1490