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Use of ARIMA modeling in forecasting coriander prices for Rajasthan

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Abstract

The present study aimed to forecast the coriander prices for Rajasthan by using the time series data of monthly wholesale prices for the period from May 2003 to June 2015 of Ramganj mandi Rajasthan. To forecast the coriander prices ARIMA models introduced by Box and Jenkins (1970) were used. To test the reliability of model R^2, Mean Absolute Percentage Error (MAPE), and Bayesian Information Criterion (BIC) were used. The best fitted model was ARIMA (0, 1, 1).On comparing the alternative models, it was observed that AIC (2141.14), SBC (2147.09) and MAPE (6.38) were least for ARIMA (0, 1, 1) model therefore it was considered the most representative model for the price of coriander in Ramganj mandi of Rajasthan. Based on ARIMA (0, 1, 1) results the estimated coriander prices for Rajasthan would be increasing from July 2015 to December 2015 *i.e.* ` 9677, ` 9724, ` 9770, ` 9816 ` 9863 and ` 9909 per quintal, respectively. Thus the study focus the estimated coriander prices during near future which help the farmers to take appropriate sowing and selling decisions.

Key words : ACF, ARIMA, auto regression, forecasting, moving average, PACF

Introduction

Efficient pricing of agricultural commodities assumes a crucial role in initiating and maintaining the development process. A system of efficient pricing is *sine-quonon* to maximize agricultural production. The objectives can be achieved only if the marketing system ensures prices, which are stable and remunerative to producers. Prices play a vital role in predominantly agricultural economies like India. It determines not only what shall be produced but also how much to be produced. The price system is a powerful tool to transmit essential economic information and stimulate appropriate decision by producers and consumers. Similarly, price is the most important determinant of profit or loss in the farm enterprise. In a farm enterprise, time factor is very important. While crops are grown in one period, these are harvested in another period. This long gestation period exercises significant influence on price determination. Therefore, the prices prevailing during the marketing period are of great significance.

Marketing information is a key function to take efficient marketing decisions, regulate the competitive marketing processes and to restrict the monopoly or profiteering individuals in the market. The future price information before the start of crop season helps the farmers to take appropriate sowing and input utilization decisions whereas before harvesting of crop it helps to take appropriate selling and storage decisions. The future prices information also useful to government to formulate price policies of agricultural commodities.

India is the foremost country in the production, consumption and export of spices, and popularly known as Spice Basket or Home of Spices. About 58.33 metric tonnes spices were produced from 31.45 lakh ha land in India during 2013-14 (anonymous, 2015a). The seed spices are mainly cultivated in Rajasthan and Gujarat. These states are called as seed spices bowl of India accounting for 72 per cent of the total seed spices production. Coriander is one of the most popular spices. In India, Coriander is an important commercial crop and has several medicinal uses as remedy. Its demand is worldwide. Coriander is the largest vegetable produced and consumed in India as well as in the world. India is a major Coriander producing country in the world with area of 5.16 lakh hectares land with a production of 4.96 lakh metric tonnes in 2013-14 (Anonymous, 2015a). The major coriander growing states in the country are Rajasthan, Madhya Pradesh, Assam, Gujarat, Andra Pradesh and Uttar Pradesh. Rajasthan ranks first in the area as well as production among the coriander growing states in the country. The area under coriander in the Rajasthan was 1.82 lakh ha with a production of 1.17 lakh metric tones in 2013-14 (Anonymous, 2015b). The main coriander growing districts of Rajasthan are Jhalawar, Baran, Kota,

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Bundi, and Chittorgarh. The prices of coriander showed fluctuations over a period of time. The prices of coriander 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 coriander is in between start of October to end of November in Rajasthan. The peak time for arrival is March but it starts in small quantity by February. Though gradual, arrivals continue round the year. Considering these points the present study has been undertaken with an objective to forecast the future prices of coriander before harvest to help the farmers to take appropriate selling and storage decisions.

Material and methods

As the aim of the study was to forecast prices of coriander, 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. Ansari and Ahamed (2001) applied ARIMA modeling for time series analysis of world tea prices and industrialized countries export prices. Nochai and Titida (2006) used ARIMA model for forecasting oil palm prices. Moghaddsi and Bita (2008) Applied econometric model for wheat price forecasting in Iran. The study revealed that ARIMA (3, 2, 1) was the superior model in wheat price forecasting. Rabbani *et.al.* (2009) forecasted wheat prices in Bangladesh. They found ARIMA (1, 1, 0) and (2, 1, 1) was the best fitted model to forecast the wheat prices. Shankar and Prabhakaran (2012) used the ARIMA model for forecasting the milk production in Tamil Nadu. Chaudhari and Tingre (2013) found that ARIMA (1, 1, 0) was the best fitted model for forecasting of milk production in India. Stochastic time-series ARIMA models were widely used in time series data having the characteristics of parsimonious, stationary, invertible, significant estimated coefficients and statistically independent and normally distributed residuals. When a time series is non-stationary, it can often be made stationary by taking first differences of the series i.e., creating a new time series of successive differences (Yt-Yt-1). If first differences do not convert the series to stationary form, then second differences can be created. This is called second-order differencing. A distinction is made between a second-order differences (Yt-Yt-2). ARIMA process is mathematical models used for forecasting. As it was popularized by Box and Jenkins, it is also known as Box –Jenkins model. The ARIMA approach is based on the two ideas 1) the forecast are based on linear functions of the sample observations and 2) the aim is to find out the simplest models that provide an adequate description of the observed data. This is also called principle of parsimony. The time series when differenced follows both AR and MA models and is known as Autoregressive Integrated Moving Averages (ARIMA) model. The model are often written in short hand as ARIMA (p,d,q) where 'p' describes the AR part, 'd' describes the integrated part and 'q' describe the MA part. ARIMA model was used in this study, which required a sufficiently large data set and involved four steps: identification, estimation, diagnostic checking and forecasting. Model parameters were estimated using the Statistical Package for Social Sciences (SPSS) package and to fit the ARIMA models.

Autoregressive process of order (p) is,

$$Yt = \text{«} + \varnothing_1\ Y\ t\text{-}1 + \varnothing_2\ Y\ t\text{-}2 + \ldots\ldots\ldots\ldots + \varnothing_p\ Y_{t-p} + et$$

Moving Average process of order (q) is,

$$Yt = \text{«} - \theta_1\ e_{t-1} - \theta_2\ e_{t-2} - \ldots\ldots - \theta_q\ e_{t-q} + e_t$$

and the general form of ARIMA model of order (p, d, q) is

$$Yt = \varnothing_1\ Y_{t-1} + \varnothing_2\ Y_{t-2} + \ldots + \varnothing_p\ Y_{t-p} + \text{«} - \bar{\ }_1 e_{t-1} - \bar{\ }_2\ e_{t-2} - \ldots - \bar{\ }_q\ e_{t-q} + e_t$$

Where

Yt is coriander prices, et's are independently and normally distributed with zero mean and constant variance for t = 1, 2,..., n; d is the fraction differenced while interpreting AR and MA and $\varnothing_p$ and θ_q are coefficients to be estimated. The best model is obtained with the following diagnostics, by lowest values of Akaike's Information Criteria (AIC) and Schwartz Bayesian Criteria (SBC or BIC). To check the adequacy for the residuals using Q statistic. A modified Q statistic is the Box-Ljung Q statistic as given below:

$$Q = \frac{N(n+2)\sum rk2}{(n-k)}$$

Where rk is the residual autocorrelation at lag k n : the number of residuals

The Q statistic is compared to critical value of Chi Squre distribution. If the p-value associated with Q statistic is small, the model is considered in adequate. Forecasting the future periods using the parameters for the tentative model has been selected.

***Trend fitting*:** For evaluating the adequacy of AR, MA and ARIMA processes, various reliable statistics like R^2, Mean Absolute Percentage Error (MAPE), and Bayesian Information Criterion (BIC) were used. Lesser the various reliability statistics better will be the efficiency of the model in predicting the future production. Kota region is the main producer of coriander in the state of Rajasthan. Ramganj Mandi is one of the largest arrival centers of coriander in Rajasthan. As per availability the time series data related to monthly average prices of coriander was collected from Agricultural Produce Market Committee, Ramganj mandi for the period from May -2003 to June -2015. Using the data forecasting of coriander prices was done for next six months.

Results and discussion

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 stationary through examining the graph or time plot of the data. Fig1 revealed that the data were non stationary. Non-stationary 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, Buarak *et. al.,(2011).*

It can be seen from table 1 that the auto correlation function (ACF) declined very slowly from 0.995 to 0.330 and as many ACFs were significantly different from zero

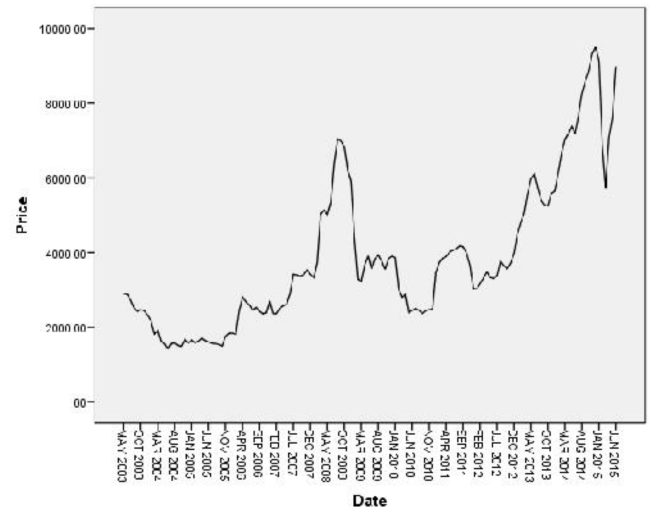


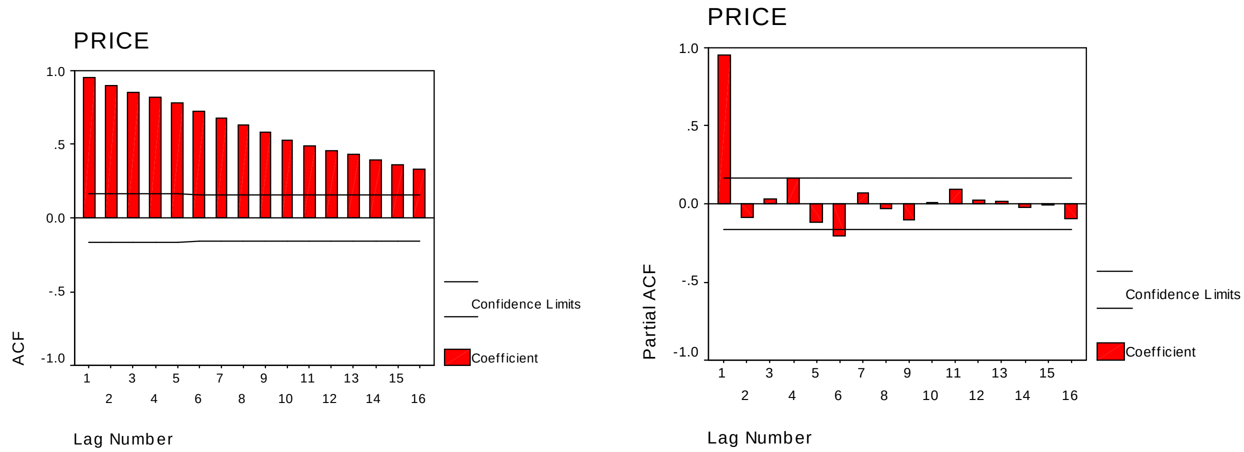
Fig 1: Monthly wholesale prices (May 2003 to June 2015) of coriander at Ramganj Mandi

Table 1. ACF and PACF of coriander prices in Rajasthan

Lag	Auto Correlation		Box-Ljung	Partial auto Correlation	
	Value	SE (±)		Value	SE (±)
1	0.953	0.082	135.221	0.953	0.083
2	0.899	0.082	256.522	-0.090	0.083
3	0.851	0.081	365.837	0.030	0.083
4	0.820	0.081	468.212	0.165	0.083
5	0.783	0.081	562.140	-0.119	0.083
6	0.727	0.080	643.667	-0.204	0.083
7	0.674	0.080	714.383	0.071	0.083
8	0.627	0.080	775.916	-0.028	0.083
9	0.580	0.080	828.914	-0.101	0.083
10	0.530	0.079	873.601	0.011	0.083
11	0.488	0.079	911.794	0.098	0.083
12	0.457	0.079	945.427	0.027	0.083
13	0.430	0.078	975.423	0.020	0.083
14	0.397	0.078	1001.267	-0.027	0.083
15	0.365	0.078	1023.198	-0.006	0.083
16	0.330	0.078	1041.254	-0.095	0.083

a. The underlying process assumed is independence (white noise).

b. Based on the asymptotic Chi-Square approximation.



Auto correlation **Partial Auto correlation**

Fig 2: ACF and PACF of differenced data of coriander prices

and fell outside the 95 per cent confidence interval, the price of coriander was non-stationary. The analysis of partial auto correlation coefficient and coriander prices are depicted in table 1. The graphical presentation of ACF and PACF of table 1 are given in fig 2. It can be seen from table 1 that the value of partial autocorrelation function (PACF) declined rapidly after the first lag period from 0.995 to- 0.095, 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 coriander price data was done to make the series stationary (Sharma and Burark, 2012). The value of d in the ARIMA model was unity (1) because the differencing was carried out only once to arrive at stationary series.

The various ARIMA models were fitted. The model which had minimum normalized BIC value was chosen. The various ARIMA models and their AIC and normalized BIC values are presented in table 2 showed that ARIMA (0,1,1) had the lowest normalized BIC value

Model estimation: By using SPSS package the model parameter were estimated and presented in table 3. From table it was observed that the R^2 was 0.962. The value of the normalized BIC was lowest and worked out to 2147.09 for the ARIMA (0,1,1) and the MAPE value recorded to 6.389, indicated that ARIMA (0,1,1) was the most suitable model for forecasting coriander prices.

Table 2. AIC and SBC values of ARIMA

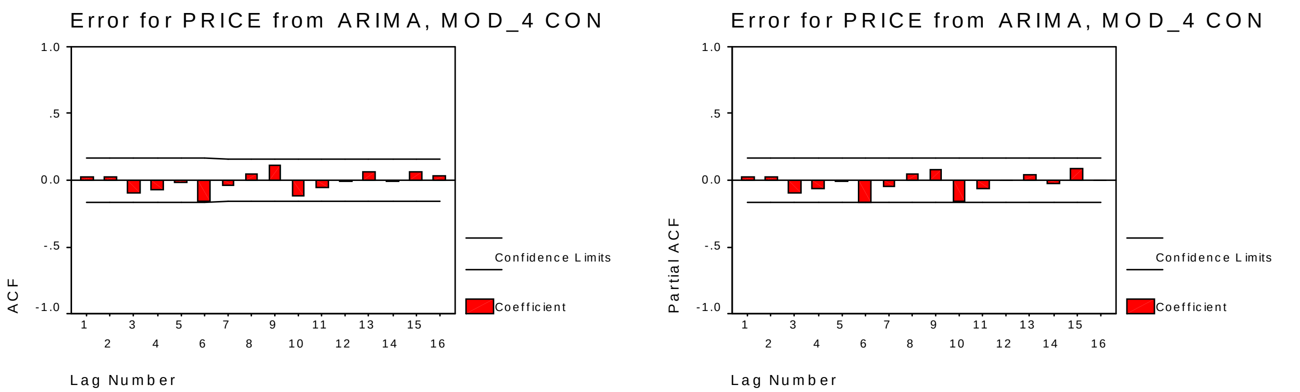
ARIMA (p, d, q)	AIC	SBC (BIC)
ARIMA (1,1,1)	2142.74	2151.67
ARIMA (1,1,0)	2145.44	2151.39
ARIMA (0,1,1)	**2141.14**	**2147.09**
ARIMA (2,1,1)	2142.39	2154.29
ARIMA (1,1,2)	2142.73	2154.63
ARIMA (0,1,2)	2142.62	2151.54

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.

Table 3. Estimates of the ARIMA model fitted for coriander prices in Rajasthan

Parameters	Estimates	SE	T value	Sig.
Constant	46.382	47.136	0.984	0.327
Number of residuals	145			
Log likelihood	-1068.57			
D F	17			
R^2	0.962			
MAPE	6.389			
Normalized BIC	2147.09			

As the results indicate, none of these autocorrelations was significantly different from zero at any reasonable level. This proved that the selected ARIMA model was an appropriate model for forecasting coriander price for Ramganj mandi in Rajasthan. The ACF and PACF of the residuals are given in fig 3, which also indicated the 'good fit' of the model. Hence, the fitted ARIMA model for the coriander price data was



Autocorrelation **Partial Autocorrelation**

Fig 3: Auto correlation and partial autocorrelation coefficients of residuals of ARIMA (0, 1, 1) model for the coriander price

$$Yt = 46.382\text{-}Y_{t-1} - e_t - e_{t-1} \ldots\ldots\ldots\ldots.1$$

Forecasting: ARIMA models are developed basically to forecast the corresponding variable. There are two kinds of forecasts: sample period forecasts and post-sample period forecasts. The former are used to develop confidence in the model and the latter to generate genuine forecasts for use in planning and other purposes. The ARIMA model can be used to yield both these kinds of forecasts.

Sample period forecasts: The sample period forecasts are obtained simply by plugging the actual values of the explanatory variables in the estimated equation (1).The explanatory variables here are the lagged values of Yt and the estimated lagged errors. So obtained values for Yt together with the actual values of Yt are shown in fig 4. To judge the forecasting ability of the fitted ARIMA model, important measures of the sample period forecasts' accuracy were computed. The Mean Absolute Percentage Error (MAPE) for coriander prices worked out to be 6.38. This measure indicates that the forecasting inaccuracy is low.

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). Based on the fitted model forecasting of coriander prices for Rajasthan was done for the period from July 2015 to December 2015 are presented in Table 4 and Fig.4. From the table it was observed that the forecasted prices of coriander for the period from July 2015 to December 2015 were ` 9677, ` 9724, ` 9770, ` 9816 ` 9863 and ` 9909 per quintal,

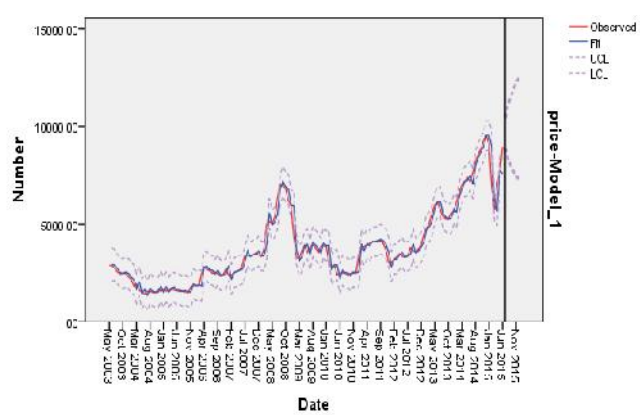


Fig 4: Validity of forecasted price and actual price of coriander

Table 4. Price forecast of coriander for Rajasthan (` q^{-1})

Months	Coriander price		Residuals	Lower limit (LCL)	Upper limit (UCL)
	Actual price	Forecasted price			
Jul 2015	8798	9677.69	879.69	8914.13	10441.25
Aug 2015	8568	9724.07	1156.07	8365.08	11083.06
Sep 2015	8798	9770.45	972.45	8006.74	11534.17
Oct 20015	8838	9816.84	978.84	7725.30	11908.37
Nov 2015	8679	9863.22	1184.22	7488.70	12237.74
Dec 2015	8815	9909.60	1094.60	7282.40	12536.80

respectively. In the present study the best fitted model was ARIMA (0, 1, 1).

The forecast values of coriander prices increasing from ` 9677 per quintal during July 2015 to ` 9909 per quintal during December 2015. Thus the study focus the estimated coriander prices during near future which help the farmers to take appropriate sowing and selling decisions. The validity of the forecasted values can be checked when the data for the lead periods become available. The limitation of the ARIMA model is that it requires a long time series data. This method can be successfully used for forecasting longtime series data.

Conclusion

In the present study the best fitted model was ARIMA (0, 1, 1). On comparing the alternative models, it was observed that AIC (2141.14), SBC (2147.09) and MAPE (6.38) were least for ARIMA (0, 1, 1) model was considered the most representative model for the price of coriander in Ramganj mandi of Rajasthan. Based on ARIMA (0, 1, 1) results the estimated coriander prices for Rajasthan would increasing from July 2015 to December 2015 were ` 9677, ` 9724, ` 9770, ` 9816, ` 9863 and ` 9909 per quintal, respectively. Thus, the study focus the estimated coriander prices during near future which help the farmers to take appropriate sowing and selling decisions. 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 accurate forecasts. Nevertheless, it can be successfully used for forecasting long time series data.

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