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Modeling and Forecasting the Sugarcane Yield of Pakistan

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ABSTRACT

The present study was planned to Model and forecast the sugarcane yield of Pakistan. The findings of present study are based on sugarcane yield data during the period (1947-2002). The most appropriate Model for the present study is ARIMA (2, 1, 2). Forecasting was also done up to 2008-2009. For comparison purposes, first three forecast values from 1999-2000 to 2001-2002 are compared with the actual values. Forecasts values are very close to the actual values.

Key Words: Sugarcane; ARIMA; Pakistan

INTRODUCTION

About 50 years ago, both in developed and developing countries, the agriculture sector was overlooked considering it traditional and outdated sector. During 1960s, realizing its importance, measures were taken for its development and since then the experts have been emphasizing the balanced growth between industrial and agriculture sector. Agriculture sector has a significant role for Pakistan where 67.5% of the population resides in villages out of which 55% are directly attached to the agriculture (Govt. of Pakistan, 2002). No doubt the urban population to a great extent also depends on the agro based industries and the major cultivated crops of Pakistan are wheat, rice, cotton and sugarcane etc. The yield per hectare in Pakistan is very low as compared to advanced countries. Sugarcane crop is considered a cash crop and serves as a major raw material for production of white sugar, gur and chipboard etc. Its shares in agriculture and GDP are 6.3 and 1.5%, respectively. Sugarcane was cultivated on an area of 1000 thousand hectares during the current fiscal year with an increase of 4.1% over the last year. The size of sugarcane crop is lower by an amount of 5.9% as compared to last year. The yield per hectare has also increased by 5.9%. Sugarcane, being the water intensive crop, suffered mainly due to the shortage of irrigation water in Punjab and Sindh but delay in payments by the sugar mills also discouraged farmers to grow more sugarcane. Sugarcane is the fourth largest cash crop grown in Pakistan which contributes to the agriculture economy a crop value of over Rs. 48 billion. Sugarcane industry's contribution to the Government exchequer in the Federal excise duty is 11.2%. Average yield of Sugarcane is 44 tons against the world average of 60 tons per hectare. Pakistan's sugar mills crushing capacity is 58 million tons of sugarcane and are capable of producing 5 million tons of refined sugar and 3 million tons of molasses. The mills still have 34% unutilized capacity (Rizvi, 2001). Furthermore, farmers often obtain less yield than researchers (Javed, 1996), although both use the same technology. This may be because of management differences. It is estimated that farmers get 10-20% less yield as compared to the experimental yield. Keeping in view the importance of sugarcane, present study was conducted for the sugarcane yield of Pakistan.

MATERIALS AND METHODS

The main objective of this research was to model and forecast the Sugarcane yield of Pakistan. The data used for the present study have been taken from Economic Survey (2002) for the periods 1947-2002. Different time series Model may be used for forecasting purposes with respect to the nature of the data like Univariate time series models, Multivariate time series models, purely judgment approaches, Structural econometric models. Univariate time series models may be used where casual models are inappropriate due to lack of data or incomplete knowledge regarding the casual structure. As our data are univariate time series, so Univariate time series Models have been tried to fit on the current data.

The general model introduced by Box and Jenkins (1976) includes autoregressive as well as moving average parameters, and explicitly includes differencing in the formation of the model. Notationally, the Box and Jenkins models are summarized as ARIMA (p, d, q): where p are the autoregressive parameters, d are the number of differencing passes, and q are the moving average parameters.

RESULTS AND DISCUSSION

Table I. Estimates of Parameters and their Testing

Type		Coefficient	Standard Deviation	T Value
AR	1	-0.0676	0.1159	-0.58
AR	2	-0.8850	0.1052	-8.41
MA	1	0.1814	0.1721	1.05
MA	2	-0.6372	0.1682	-3.79
Constant		0.5259	0.4881	1.08
Residuals: SS = 296.933 MS = 6.060 DF = 49 Modified Box-Pierce (Ljung-Box) Chi-Square statistic				
Lag	12	24	36	48
Chi-Square	8.5	19.3	34.7	44.3
DF	7	19	31	43

Table II. Forecasts of Sugarcane Yield, Pakistan (From 1999-2000 to 2008-2009)

Year	Forecast	95% Limits		Actual
		Lower	Upper	
1999-2000	46.2917	41.4659	51.1176	45.9000
2000-2001	47.7700	41.7347	53.8053	45.4000
2001-2002	49.5307	42.9944	56.0671	48.0000
2002-2003	48.6294	41.1436	56.1151	
2003-2004	47.6580	38.8939	56.4222	
2004-2005	49.0473	39.6143	58.4802	
2005-2006	50.3389	40.5114	60.1663	
2006-2007	49.5480	39.0287	60.0673	
2007-2008	48.9843	37.6077	60.3610	
2008-2009	50.2482	38.3708	62.1256	

Fig. 1, 2 and 3 are the time series plot, autocorrelation function, and partial autocorrelation function respectively of Sugarcane Yield, indicate that the given time series is not stationary (Gujrati, 2003). Since the Pakistan Sugarcane Yield time series is not stationary, given time series may be made stationary by taking differences. After taking first differences the Time Series Plot, ACF, and PACF are plotted in Fig. 4, 5 and 6, respectively. These figures reveal that the first differenced time series is stationary. Fig. 5 and 6 suggest the tentative model ARIMA (2, 1, 2). Estimates of the ARIMA (2, 1, 2) are given in Table I.

After model fitting the next step is the diagnostic checking of the fitted Model. Different diagnostic checks are applied on the estimated model. The most important technique is the residual plot. Fig. 7 and 8 are the residuals plot. It is clear that all the autocorrelations and partial autocorrelations lie between the 95% confidence interval. Thus, the model specification is appropriate. Normal probability plot is also constructed in Fig. 9 revealing that the residuals lie along a straight line and the histogram of residuals is also constructed in Fig. 10 indicating that the residuals are approximately symmetric, confirming that the model specification is accurate Pindyck (1991).

After the model is fitted adequately, the next step is to predict the future values. Our objective in forecasting is to predict future values of a time series subject to minimum error as less as possible. For this reason, we consider the optimum forecast to be that forecast which has the minimum mean square forecast error. Since the forecast error is a random variable, we minimize the expected value. Table II reveals that the forecasts, from 1999-2000 to 2008-

Fig. 1. Plot of Sugarcane Yield of Pakistan 1947-2002 (Yearly)

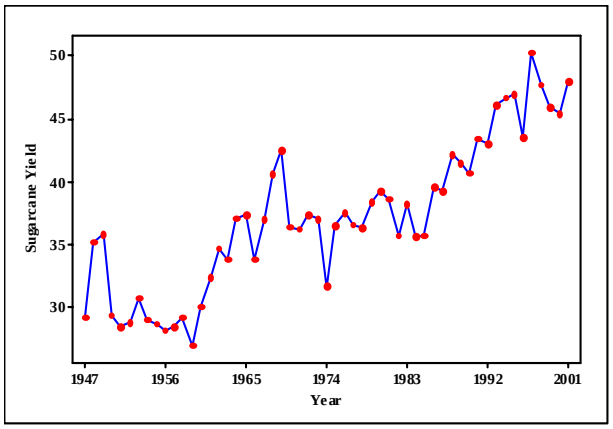


Fig. 2. ACF plot for Sugarcane Yield

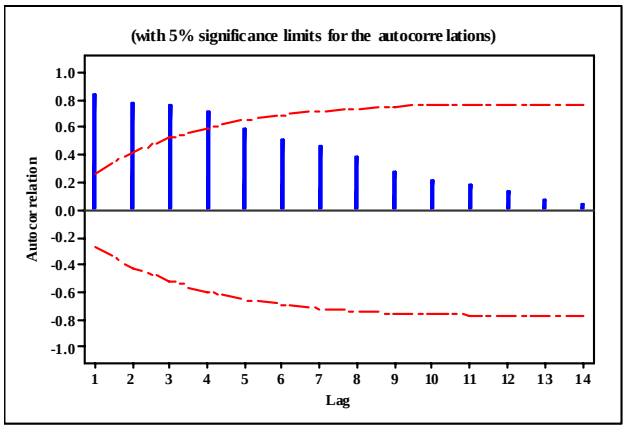


Fig. 3. PACF plot for Sugarcane Yield

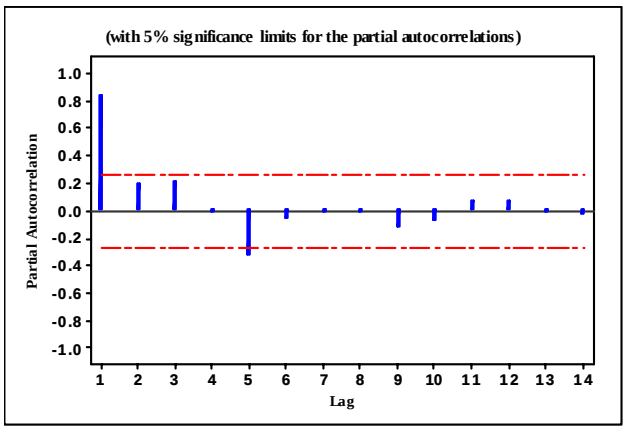


Fig. 4. Plot of first difference of Sugarcane Yield of Pakistan, 1947-2002 (Yearly)

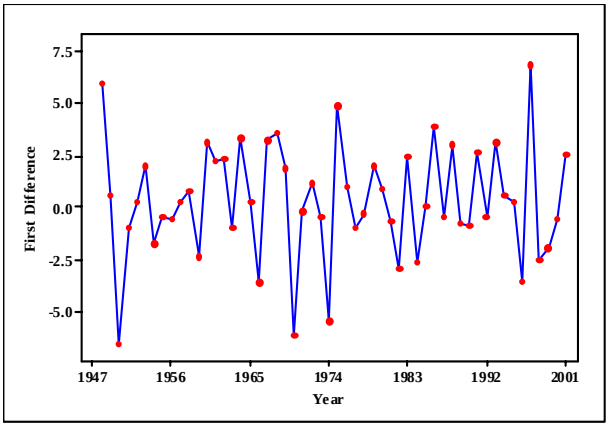


Fig. 5. ACF plot for first difference of Sugarcane Yield

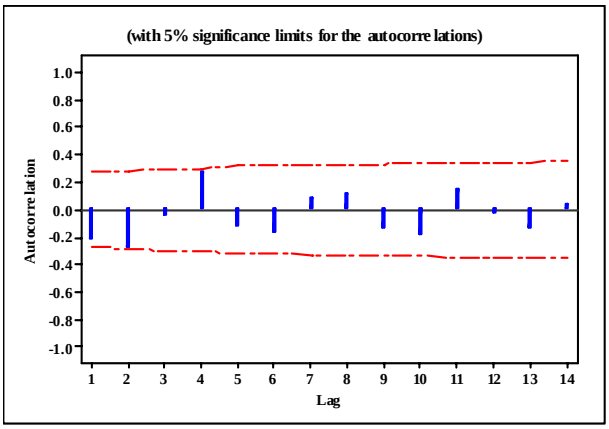
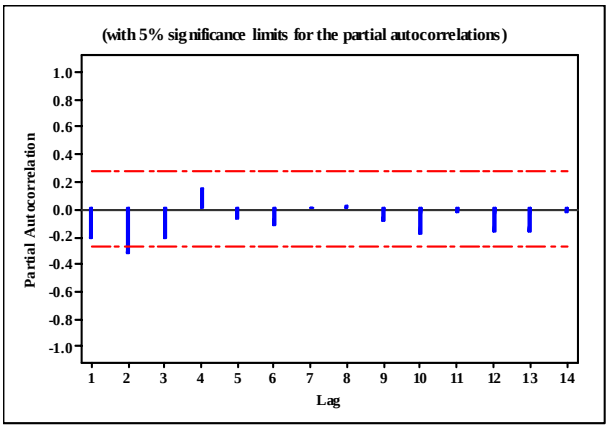


Fig. 6. PACF plot for first difference of Sugarcane Yield



2009, along with 95% Confidence Limits. The first three forecasts are just to compare with the observed series to get an idea of the quality of the forecast. The residuals are very small. The forecasts are very close to the actual data. This implies that the model specification is adequate Cryer (1986).

Fig. 7. ACF plot for Residuals

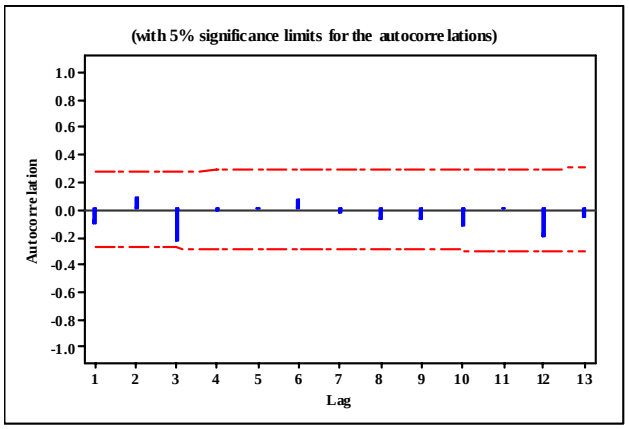


Fig. 8. PACF plot for Residuals

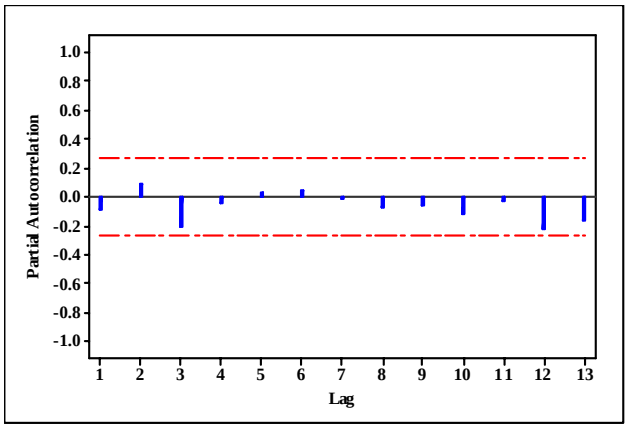


Fig. 9. Normal Probability Plot of the Residuals (response is Sugarcane)

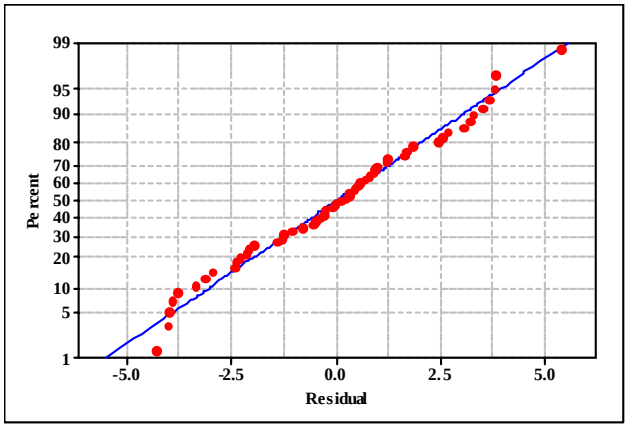
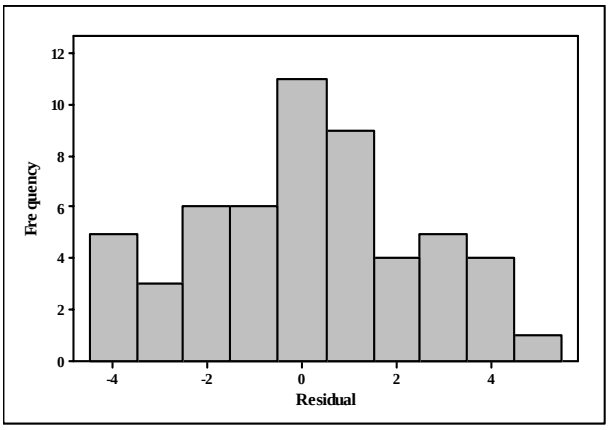


Fig. 10. Histogram of the Residuals (response is Sugarcane)



CONCLUSIONS AND SUGGESTIONS

The parsimonious model for given time series data is ARIMA (2, 1, 2) (Autoregressive Integrated Moving Average model of autoregressive order 2, differencing 1, and moving order 2). Further to increase the yield of sugarcane, following measures may help:

Balanced policy for cultivation of four major crops wheat, cotton, rice, and sugarcane should be chalked out by the Government. An incentive should be provided to the growers for cultivation of sugarcane on 1.15 million hectares. Also the Government should import high-yielding varieties of sugarcane from other countries for averting any sugar crisis in the future. The Government should make a publicity campaign for minimizing use of gur so that a substantial quantity of cane becomes available for crushing and making white spoon sugar.

The support prices of sugarcane can not work at all through the free market forces due to the simple reason that retail price of sugar is controlled by the Government and further, the support price of other cash crops such as wheat, rice and cotton are also fixed by the Government.

The provincial Governments should fix the support price in the range of from Rs. 40 (forty) to Rs. 45 (forty five) per 40 kg for purchase of sugarcane at the factory gate as well as at the cane purchase centers under section 16 of the Sugar Factories Control Act, 1950 (Rizvi, 2001). A master plan to check water logging and salinity should be launched through out the country. The departments of agriculture and other agencies should ensure a regular supply of quality seeds to the farmers. The price of quality seeds should be reasonable.

The Government should supply fertilizers to tenants and small farmers at lowest possible price. The canal irrigation system should be improved to check the wastage of water. Supply of water to small farmers should be ensured. The persons involved in water theft should be punished. Financial aid for installation of tube wells should be provided to farmers. The department of agriculture should arrange special training courses for farmers at union level. The experts should demonstrate the use of modern implements, seeds, fertilizers and pesticides. The experts should use the trainees' native language. The commercial banks and other agencies should be directed by the Government to supply more loans to tenants and small farmers for the purchase of inputs.

The Government should enhance the purchase price of products to give incentive to the farmers for more output. The Government should make easy access of farmers to the market, reduce the role of middleman and make early payment to the farmers.

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