Pak. J. Agri. Sci., Vol. 9, *No.* 1, 1992

FORECASTING SUGARCANE PRODUCTION IN PAKISTAN USING ARIMA MODELS

Faqir Muhammad*, Muhammad Siddique Javed & Mujahid Bashlr
**Department of Mathematics and Statistics,*
Department of Agri. Economics,
University of Agriculture, Faisalabad

The paper describes an empirical study of modelling and forecasting time series data of sugarcane production in Pakistan. The Box-Jenkins ARIMA methodology has been used for forecasting. The diagnostic checking has shown that ARIMA (3,2,2) is appropriate. The observed ami fitted values for years from 1947-48 to 1988-89 overlap to a large extent, The forecasts from 1989-90 to 1999-2000 arc calculated based on the selected model.. These forecasts would be helpful for the policy makers to foresee the future requirements of grain, import and/or export and adopt appropriate measures in this regard.

INTRODUCTION

Sugarcane *(Saccharum officinarum* L.) is a prominent member of the large family of grasses. It is originally a crop of tropics but its cultivation has been extended rapidly over the sub-tropics. It supplies over 60% of the world sugar and is also a major source of sugar in Pakistan. In sub-tropical regions of Pakistan its cultivation proves successful only under irrigation. It being a cash crop plays a remarkable role in balancing the economy of Pakistan. It provides basic raw material for sugar industry which is second to textile. Its contribution to all other major crops is 14.96% in 1988-89.

Forecasts have traditionally been made using structural econometric models. We have mainly concentrated on the univariate time series models, known as auiorcgrcssivc integrated moving average (ARIMA) models which arc primarily due to the work of Box and Jcnkins (1970). These models have been extensively used in practice for forecasting economic time series, inventory and sales modeling (Brown, 1959; Holt *et al.,* 1960) and arc generalization of the exponcntially weighted moving average process. Several methods for identifying special cases of ARIMA models have been suggested by Box-Jcnkins and others. Makridakis *et al.* (1982) and Mcesc and Gewcke (1982) have discussed the methods of identifying univariate models. Among others Jenkins and Walls (1968), Ljunge and Box (1978) and Pindyck and Rubinfeld (1981) have also emphasised the use of ARIMA models.

In this study these models have been applied to forecast the production of sugarcane crop in Pakistan. This would enable us to predict expected sugarcane production for the years from 1989-90 onward. Such an exercise would enable the policy makers to foresee the future requirements of sugarcane, import and/or export of sugarcane thereby enabling them to take appropriate measures in this regard. The forecasts would thus help save much of the precious resources of our country which otherwisct may be wasted.

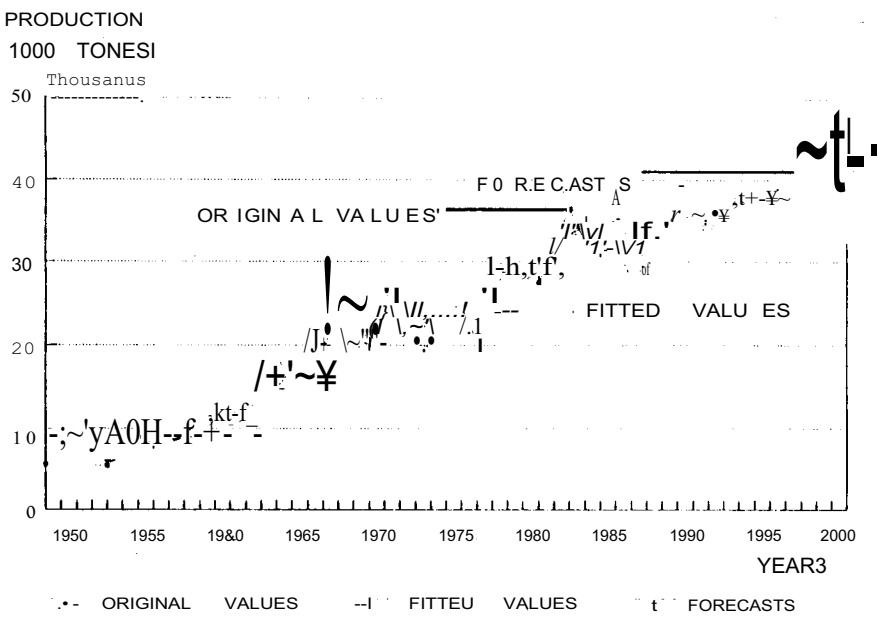

Fig. 2. Time series plot of the original, fitted and forecasts.

Final estimate of parameters

Type	Estimate	SI, Dcv,	t-ratio
AR1	-0.7393	0.5200	-1,42
AR2	-0.5760	0.1834	-3.14
AR3	-0,4826	0.2543	-1,90
MA1	0.3516	0.5626	0.62
MA2	0.6146	0.5578	1,10

Differencing: 2 regular differences
No. of obs.: Original series 42, after differencing 40
Rcsiduals: SS = 222887296 (backforecasts excluded)
MS = 6368209, OF = 35

Modified Box-Pierce Chisquure statistic

Lag	12	24	36	48
Chisquare	15,4 (OF = 7)	23.5 (OF = 19)	28.9 (OF 31)	* (OF = *)

Table 1. Observed and estimated values of sugarcane production

Row	Years	)Production (000 lonnes)	Rcsiduals	Estimated values
1	1947	5529	*	*
2	1948	6947	*	*
3	1949	7849	399.38	7449.6
4	1950	5506	-2274.82	7780.6
5	1951	5399	-605.84	6004.8
6	1952	7266	-102.26	7368.3
7	1953	895	595.83	8360.2
8	1954	8836	421.93	8414.1
9	1955	8200	-488.79	8688.8
10	1956	8947	-38.97	8986.0
11	1957	11294	1137.56	10156.4
12	1958	12489	954.47	11534.5
13	1959	10662	-1249.82	11911.8
14	19()()	11641	827.70	10813.3
15	1961	14357	1037.71	13319.3
16	1962	18439	3681.50	14757.5
17	1963	16140	-1084.07	17224.1
18	1964	18668	3616.28	15051.7
19	1965	22309	2270.75	20038.2
20	1966	21982	-423.34	22405.3
21	1967	18660	-1711.00	20371.0
22	1968	21971	1808.64	20162.4
23	1969	26370	1935.94	24434.1
24	1970	23167	-2630.21	25797.2
25	1971	19963	-1528.17	21491.2
26	1972	19947	-2820.24	22767.2
27	1973	23911	736.46	23174.5
28	1974	21242	-3329.33	24571.3
29	1975	25547	5183.24	20363.8
30	1976	29523	2703.41	26819.6
31	1977	30077	1286.87	28790.1
32	1978	27326	-544.45	27870.4
33	1979	27498	-1050.64	28548.6
34	1980	32359	2590.72	29768.3
35	1981	36580	3180.29	33399.7
36	1982	32534	-1918.02	34452.0
37	1983	34287	2861.94	31425.1
38	1984	32140	-4855.92	36995.9
39	1985	27856	-5618.37	33474.4
40	1986	29926	366.30	29559.7
41	1987	33029	-707.08	33736.1
42	1988	36916	4152.63	32763.4

lSource: Economic Survey, 1989-90.

of sugar cane crop has been used for modelling purposes. The used data associated with this crop are for the year from 1947-48 to 1988-89, given in Table 1. The plot of the original time series is given in Figure 1. The modelling of the time series involved the steps of model specification, model estimation, diagnostic checking and forecasts. The model specification included the plot of the autocorrclation function, partial autocorrelation function and plot of the differenced series. The plot of the second differenced series showed that the parameter d is 2; the correllogram of autocorrclation function of the second differenced series falls off quickly after lag 2, so q = 2. The correllogram for the partial autocorrclation function of the second differenced series falls off quickly after lag 3, so p = 3. This suggested that ARIMA (3,2,2) is appropriate for these data.

The model ARIMA (3,2,2) is estimated using the Minitab computer package.

The modified Box-Pierce statistic for the sugarcane production, calculated in step 2, for lag 12 is 15.4 at 7 degrees of freedom which has the observed significance level 0.0312 indicating that it is non-significant at 1% (0.01) significance level. Hence the fit is good.

Using ARIMA (3,2,2) 11 years ahead forecasts and their 95% confidence interval arc calculated and arc given in Table 2. The graph of the original, filled and forecasts is shown in Figure 2. H is apparent from the graph and Table 2 that the forecasts arc reasonable as observed and filled values overlap to a greater extent.

Table 2. Forecasts I'or sugurcane production

		95% limits	
Period	Forecast	Lower	Upper
1989-90	35536.2	30589.1	40483.4
1990-91	34547.7	27861.9	41233.5
1991-92	35925.1	28902.9	42947.2
1992-93	37869.9	30589.2	45150.6
1993-94	37843'()	2%18.7	46068.6
1994-95	37805.9	28724.7	46887.1
1995-96	38638.1	29070.7	48205.5
1996-97	39785.1	29797.6	49772.5
1997-98	40203.8	29583.3	50824.3
1998-99	40559.8	29308.1	51811.4
1999-2DW	4J229.7	29462.J	52997.3

REFERENCES

Box, G.E.P. and G.M. Jenkins. 1970. Time Series Analysis: Forecasting and Control.. Holden-Day, San Francisco, California, USA.

Brown, R.G. 1959. Statistical Forecasting for Investory Control.. McGraw Hill Book Co. Inc., NY, USA.

Holt, C.C., F. Modigliani, J.F. Muth and HA. Simon. 1960. Planning, Production, Inventories and Work Force. Prentice-Hall, Englcwood Cliffs, New Jersey, USA.

Jenkins, G.M. and D.G. WaLLs. *19G8. Spec/raj A1JaJysjs and hs AppJh'JJjon.* Holden-Day, San Francisco, California, USA,

Ljunge, G.M. and G.E.P. Box. 1978. On a measure of lack of fit in time series models. Biometrika, 65: 67-72.

Makridakis, S., A. Anderson, R. Fildes, M. Hibon, R. Lewandowski, J. Newton, E. Parzen and R. Winklcr.. 1982. The accuracy of extrapolation (time series) methods: Results of a forecasting competition. J. Forecasting, 1: 111-153.

Meese, R. and J. Gcwckc, 1982. A comparison of autoregrcssive univariate forecasting procedures for macroeconomic time series. Unpublished Manuscript, Univ. Calif., Berkeley, California, USA.

Pindyck, R.S. and D.L. Rubinfeld. 1981. *Econometric ModcJs and Economic* Forecasts. McGraw Hill Book Co, Inc., NY, USA..