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Forecasting Kinnow Production in Pakistan: An Econometric Analysis

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ABSTRACT

The production of Kinnow has considerably increased during the past years due mainly to an increased demand for the fruit both in the domestic and international markets. Despite greater demand, the potential of Kinnow export has not been fully reaped. Pakistan has comparative advantage in the production of Kinnow and enormous potential exists for its export in the vast Middle East market. The present study was undertaken to estimate the trend in the production of Kinnow and to forecast production of Kinnow. The log lin. model was applied to estimate the past trend in production. ARIMA model was used to forecast the production of Kinnow for twenty years. The forecast value of production of Kinnow for 2022 - 23 worked out to be 2617.45 thousand tons, which suggest that an increased output of Kinnow would be available for consumption. The paper suggests the need for taking measure to increase export of Kinnow to potential international markets by improving quality, packaging and following the international standards required under various agreements of World Trade Organization (WTO).

Key Words: Kinnow; Production; ARIMA; Forecast; Pakistan

INTRODUCTION

Kinnow is grown primarily in the plains of Punjab province of Pakistan. Out of the total area under fruits, 29.55% is under citrus and out of the total area under citrus, 60% is under Kinnow (GOP, 2003 - 04). The total production of Kinnow increased from 1609 thousand tons in 1990 - 91 to 1830 thousand tons in 2001 - 2002, due mainly to cultivation of better/improved varieties and management. There are 28 Kinnow processing plants with a processing capacity of 5 - 10 metric tons per hour, located in Sargodha and Karachi. Chronological sequence of citrus development in Pakistan indicates appreciable growth of citrus industry in this country (Table I).

The present study was undertaken with the following objectives:

1. To estimate the growth trend in the Production of Kinnow.
2. To forecast production of Kinnow.
3. To suggest policy measures for boosting production of Kinnow and improving its marketing system.

METHODOLOGY

Time series data were used for the present study. The data were collected from various government publications and institutions such as Federal Bureau of Statistics, Ministry of Food, Agriculture and Livestock (MINFAL) and Ministry of Commerce. The data collected, were processed and analysed by using various statistical techniques. Some of the techniques employed for analysis of data, are summarized below:

Growth trend. The growth trend for Production of Kinnow was estimated using log-lin model. The variables employed in the model were:

Suppose:

X_t = Production of kinnow

X_o = Initial value of production.

The compound interest formula used was:

$X_t = X(1+r)^t$

Where

r is the compound (i.e., over time) rate of growth of X.

Taking the natural logrithm, the equation was reframed:

Now letting:

β_0 = lnXo

β_1 = ln (1 + r).

The equation was re-written as:

$LnX_t = \beta_0 + \beta_1 t.$

Adding the disturbance term to above equation we obtained:

$Log\ X_I = \beta_0 + \beta_1 t + u_t.$

This equation is known as log-line model. It is a linear regression model like other linear regression models, because the parameters β_1 and β_2 are linear. The only difference is that regressand is the logarithm of X and the regressor is "time". This model is also called semi log model, because only one variable (in this case the regressand) appears in the logarithmic form. For descriptive purposes a model in which the regressand is logarithmic will be called a log lin model (Gujarati, 2003).

The growth rate was estimated by taking the anti-log of X_t, i.e.

$X_t = \text{antilog}(\beta_0 + \beta_1 t).$

Forecast. Forecasts can be made by various methods like purely judgmental approaches, structural economic models, univariate time series models, multivariate time series models and econometric models. Economic models require detailed information to specify functional relations among different variables. The functional forms, which minimize the subjective aspects of model construction are becoming increasingly popular as a tool of data analysis among economists. Many economists have applied time series models for generating forecasts. Keeping in mind the nature of study, available data efficiency of the model to forecast, ARIMA model was selected from amongst the various available time series models for forecasting the Production of Kinnow.

A non-seasonal ARIMA model is denoted by ARIMA (p, d, q), according to Box and Jenkins (1976).

Where:

p is the order of the auto regressive process,

d is the order of homogeneity, i.e. the number of differences to make the series stationary,

q is the order of the moving average process.

The general form of ARIMA is:

$$\Delta^d Z_t = C + (\varnothing_1 \Delta^d Z_{t-1} + ... + \varnothing_p \Delta^d Z_{t-p}) - (\Phi_1 a_{t-1} + ... + \Phi_p a_{t-p}) + a_t$$

Where

'C' is a constant,

Δ is a difference operator such that

$\Delta Z_t = Z_t - Z_{t-1}$,

$\Delta^2 Z_{t-1} = \Delta Z_t - \Delta Z_{t-1}$

$Z_{t-1} \ldots Z_{t-p}$ are past series values (lags),

$\varnothing$ is the coefficient to be estimated by auto-regressive model.

The auto-regressive model of order 'p' denoted by AR (P) is:

$$Z_t = C + \varnothing_1 Z_{t-1} + \varnothing_2 Z_{t-2} + \ldots + \varnothing_p \Delta^d Z_{t-p} + a_t$$

Where:

a_t is a random variable with zero mean and constant variance. Φ is coefficient in the moving average (MA) model, whereas moving average model is of order 'q' or MA (q) can be written as:

$$Z_t = a_t - \Phi_1 a_{t-1} - \Phi_2 a_{t-2} - \ldots - \Phi_p a_{t-p}.$$

The model was employed for analyzing the quantitative relationship of data and to forecast future trend of Kinnow production up to the year 2023.

RESULTS AND DISCUSSIONS

Growth Trends of Production of Kinnow. As mentioned in methodology, the equation for estimating the growth rate is:

$$\text{Ln } X_t = \beta_o + \beta_1 t$$

Where:

X_t = Production

t = Time.

The equation was regressed by employing data where the estimated equation is given below:

$$\text{Ln } X_t = 7.041 + 0.02874t$$

S.E. (0.038) (0.003).

In this model β_1, the slope coefficient, measures the relative change in X for a given change in the value of the regressor (in this case the variable "t"), that is:

$$\beta_1 = \frac{\text{Relative change in regressand } (X_t)}{\text{Absolute change in regressor (t)}}$$

Multiplying the relative change in X_t by 100, we get % age change or growth rate in X for an absolute change in t, the regressor.

Relative change is:

β_1 = 0.02874

Growth rate = β_1. 100

Growth rate = 0.02874 x 100

Growth rate = 2.874%.

This illustrates that the production under Kinnow grew at the rate of 2.874% per year for the years 1982-2002.

This growth rate is an instantaneous (at a given point in time) rate of growth and not the compound (over period of time) rate of growth. Compound growth rate (r) was estimated from the instantaneous rate of growth:

Instantaneous growth rate = 0.02874

We know that Ln (1 + r) = β_1 thus:

Ln (I + r) = β_1

Ln (I + r) = 0.02874

(I + r) = Anti-Ln 0.02874

1 + r = 1.02916

r = 1.02916 – 1

r = 0.02916.

Where:

Compound rate of growth (r) = 0.02916 x 100

r = 2.916%.

Over the period, 1981 - 2002, the compound rate of growth of production under Kinnow worked out to be 2.916%. This growth rate is slightly greater than the instantaneous growth rate.

Reliability of the results. Following estimated values, describe the reliability of results.

Ln X_t	=	7.041 +	0.02874 t
S.E.	=	(0.038)	(0.003)
t	=	(186.604)	(10.002)
R^2	=	0.833.	

As Standard Error (SE) explains the variability in the data set, i.e. higher the S.E. higher will be the variability in the data set and vice versa, therefore, a low value of S.E. is necessary for the reliability of results. The S.E. of slope coefficient is 0.003, which is very low and confirms reliability of results.

The significance of the coefficients is a vital part of research findings. Estimated coefficients were found significant at one percent (1%) level of significance. As such they were highly significant.

R^2 exhibits the value of regressand, which is explained by the regressor. Calculated value of R^2 was 0.833, which shows that 83.3% regressand (X_t) is explained by the regressor (t). This means that the dependent variable is highly dependent on the independent variable. This confirms reliability of the estimated model.

Table I. Area and Production of Citrus

Year	Area (000' hectares)	% Age change	Production (000' tons)	% Age change
1990-91	173.3	-	1609	-
1991-92	176.2	1.673	1630	1.305
1992-93	176.2	-	1665	2.147
1993-94	185.0	4.994	1849	11.0151
1994-95	190.7	3.081	1933	4.543
1995-96	193.6	1.1521	1960	1.394
1996-97	194.4	0.413	2003	2.194
1997-98	196.1	0.874	2037	1.697
1998-99	197.0	0.458	1862	-8.591
1999-00	197.7	0.355	1943	4.35
2000-01	198.7	0.506	1865	-2.316
2001-02	194.2	-	1830	0.052

Source: Federal Bureau of Statistics (2001-02)

Forecasting Production of Kinnow. One of the objectives of research was to forecast production of Kinnow up to the year, 2023. Time series data was analysed by employing ARIMA model in four steps, as proposed by Box and Jenkins (1970) for the purpose of forecasting. Various steps followed are given as below:

a) Model Identification: It was the specification of p, d, q.

b) Model estimation: It consisted of estimating the parameters of the model.

c) Diagnostic checking: It consisted of the application of a variety of tests to see whether the estimated model fits the data adequately.

d) Forecasts: Forecasts obtained at 95% confidence interval with lower and upper limits.

(a) Model identification. Because most of the economic time series vary in a systematic way, the first step in identification was to choose and to check that the data were stationary or not. The time series data about Kinnow production was analysed and auto-correlation function and partial auto-correlation functions were estimated.

Originally, the time series was non-stationary. Auto correlation function did not fall as quickly as the lag K increased. To know the order of homogeneity of the time series data i.e. how many times the time series be differenced to have a stationary series, differenced time series and the auto correlation function of the differenced series were taken.

Correlogram of first differenced series of the auto-correlation function showed the properties of the stationary series. To check the further stationarity, second differenced time series was observed. Correlogram of the first differenced series showed appropriate stationary behaviour than the second differenced series. Auto correlation function fell as quickly as the lag K increased. Thus the selected value of "d" was 1.

The selected value of parameters "p" and "q" were 3 and 2, respectively. After the determination of parameters p, d, q, appropriate model estimated was ARIMA (3, 1, 2).

(b) Model estimation. The model ARIMA (3, 1, 2), was estimated using the E-view and Stat Graphic computer programs. The estimated values are presented in Table II.

(c) Diagnostic checking. Augmented Dickey - Fuller unit root test was applied. Following results were obtained.

ADF – Test statistic = -5.524261, 1% critical Value = -3.8572

5% critical Value = -3.0400, 10% critical Value = -2.6608.

As the absolute value of ADF test-statistic is grater than the critical values at 1%, 5% and 10% level of

Table II. Estimates of the Parameters

Parameter	Estimate	S. E.	t-ratio	P-value
AR (1)	0.477126	0.250846	1.90207	.076542
AR (2)	-0.606181	0.265412	-2.28392	0.076542
AR (3)	0161758	0.258265	0.626325	0.540517
MA (1)	0.517793	0.1581	-9.15	0.000000
MA (2)	-0.922593	0.10083	1.46389	0.163866
Mean	42.071	28.73931	1.46389	0.163866
Constant	40.6952			

Table III. Augmented Dickey-Fuller Unit Root Test on D (PRODUCTION, 2)

ADF Test Statistic	**-5.524261**	**1%**	**Critical Value***	**-3.8572**
		5%	**Critical Value**	**-3.04**
		10%	**Critical Value**	**-2.6608**

* MacKinnon critical values for rejection of hypothesis of a unit root

Augmented Dickey-Fuller Test Equation

Dependent Variable: D (PRODUCTION, 3)

Method: Least Squares

Variable	Coefficients	Std. Error	T-Statistic	Prob
D (PRODUCTION (-1) ,2)	-2.282855	0.411431	-5.524261	0.0001
D (PRODUCTION (-1) ,3)	0.389264	0.230185	1.691094	0.1115
C	-16.32202	21.476290	-0.760002	0.4590
R-squared	0.850634	Mean dependent var.		4.072222
Adjusted R-Square	0.830719	S.D dependent var.		218.3162
S.E. of Regression	89.82359	Akaike info criterion		11.98458
Sum Squared Residual.	121024.2	Schwarz criterion		12.13298
Log likelihood	-104.8613	F-statistic		42.71229
Durbin-Watson stat	2.180273	Prob. (F-statistic)		0.000001

Table IV. Forecasts for the Production of Kinnow

No.	Year	Forecasts (000, tons)	Lower 95% Limit	Upper 95% Limit
1.	2002-03	1867.79	1670.89	2064.68
2.	2003-04	1872.42	1599.89	2145.27
3.	2004-05	1886.76	1518.47	2255.05
4.	2005-06	1937.60	1454.93	2420.27
5.	2006-07	1994.61	1423.08	2566.13
6.	2007-08	2034.01	1400.4	2667.61
7.	2009-10	2067.16	1377.62	2756.71
8.	2010-11	2109.02	1360.94	2857.10
9.	2011-12	2155.96	1325.05	2959.87
10,	2012-13	2199.04	1346.04	3025.04
11.	2013-14	2238.61	1340.46	3136.76
12.	2014-15	2279.66	1337.23	3222.09
13.	2015-16	2322.93	1337.33	3308.53
14.	2016-17	2365.78	1339.33	3392.23
15.	2017-18	2407.34	1342.14	3472.53
16.	2018-19	2448.88	1346.14	3551.62
17.	2019-20	2491.14	1351.78	3630.50
18.	2020-21	2533.53	1358.73	3708.4
19.	2021-22	2575.56	1366.51	3784.62
20.	2022-23	2617.45	1375.11	3859.78

significance, therefore, time series was stationary for the ARIMA (3, 1, 2). Hence, ARIMA (3, 1, 2), was found best fit for forecasting. The detailed results of unit root test are given in the Table III.

(d) Forecasts for production of kinnow. Forecasts for Kinnow production with 95% confidence intervals were generated by using ARIMA (3, 1, 2), model for the year 2002 - 2023. Forecasts with their upper and Lower Limits at 95% confidence interval are presented in Table IV.

Data presented in Table IV show that production of Kinnow will increase in future and the estimated production of Kinnow will range between 1670.89 and 2064.68 thousand tons. This means that sufficient volume of production of Kinnow will be available in future both for domestic Consumption and Export.

CONCLUSIONS

There is a great potential for an increase in the production of fruits in Pakistan. In the category of fruits, citrus occupies an important position. A well-organized citrus culture in Pakistan means a well-organized fruit sector, which will be acting as a gateway towards prosperous agriculture. In this context, following measures are suggested for bringing an improvement.

1. The analysis of growth trends provides the pattern of future growth of Kinnow. The forecasts also depict picture about future production. Keeping in view the results it is suggested that Government should provide supportive infrastructure.
2. Incentive should be provided by the Government for the growth and promotion of input industry, required for Kinnow production. Allied industries like packaging, processing, transportation and storage should also be promoted. A well integrated allied network would guarantee a prosperous future for Kinnow.
3. There is a need to launch campaign for boosting exports. In this regard, new markets should be identified and a culture of value addition in Kinnow should be promoted.
4. Government should devise a strategy to cope with changing environment under the up-coming WTO regime. Existing production and harvesting systems, packaging and post harvest management practices should be promoted, for increasing exports from Pakistan

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