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Trend Analysis of Onion (*Allium cepa*) Exports From India

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ABSTRACT

Trend of exports of onion from India are analyzed by empirically fitting different types of trend curves to annual export data of onion from the year 1950-2015. Six types of trend curves like Linear, Logarithmic, Quadratic, Cubic, S-curve and exponential curves are fitted to the data. Under the assumption that the fitted trend will continue for some more years the forecasting of exports were also done and forecast accuracy of different models were evaluated.

Key words *Cubic, exponential, extrapolation, trend, quadratic.*

Onion is one of the most important crops of India. Onion is an important ingredient of almost all the dishes prepared in Indian kitchens. It is also important for its nutritional and medicinal values. China and India are leading onion growing countries with a total production of 247.00 and 159.30 lakh tons, respectively during the year 2011, followed by USA, Iran, Egypt, Turkey, Russian Federation, Pakistan, Brazil, Netherlands, Brazil, Korea, Mexico and Spain as per FAO report. The productivity of onion is highest (66.16 tons/ha) in Republic of Korea, followed by USA (56.26 tons/ha), Spain (53.31 tons/ha) and Netherlands (51.64 tons/ha) while the productivity in India is quite low (14.35 tons/ha). Maharashtra, Madhya Pradesh, Gujarat and Karnataka are some of the major onion producing states of India. Currently in India the production of onion is 168.13 lakh tons from an area of 10.51 lakh hectares with the productivity of 16.0 tons/ha respectively. There is a considerable increase both in area (from 2, 50,900 to 10, 51,530 ha.) and production (from 25, 97,800 to 1 68, 13,010 tons) of onion from the year 1981-82 to 2012-13 respectively (source NHRDF). Among the different onion growing states, Maharashtra tops in area and production, followed by Karnataka, Madhya Pradesh and Andhra Pradesh. Maharashtra has highest share both in area (24.73%) and production (27.72%).Apart from this the onion export is a major foreign exchange earner for the country in the agriculture sector. Global trade of onion export is 6.77 million tons and Netherland tops, exporting 1.33 million tons, followed by the India, China, Egypt, Mexico, USA, Spain, Argentina, Turkey and Poland during the year 2011 as per FAO report. Bangladesh, Malaysia, Russian Federation, UK, Japan, USA, Saudi Arabia, Germany, Netherlands, UAE, Canada, Sri Lanka and Belgium are major onion importing countries in the world. Modeling the onion exports from India is of paramount importance because it will help to understand the nature and pattern of exports from India. It will help the government to plan and encourage farmers to increase onion production. By extrapolating the trend curves fitted to the data forecasting of exports can be done which will be beneficial for exporters as well as planners.

MATERIALS AND METHODS

Onion export data from the year 1950 to 2015 was downloaded from the website www.nhrdf.com. Different curves were fitted for analyzing the trend of the export. SAS 9.2 was used for analyzing the data. The data set was divided in to two halves. The data from 1950 to 2011 was used for calibration of different models and for the years 2012 to 2014 for validation purpose and for checking the forecasting accuracy of different curves under the assumption that the trend will continue for some more years. These curves along with their equations and parameters are given on next page :

1. Linear. Model

$$Y = b_0 + (b_1 * t). \quad (1)$$

2. Logarithmic. Model whose equation

$$Y = b_0 + b_1 * \ln(t). \quad (2)$$

3. Quadratic. Model whose equation is

$$Y = b_0 + (b_1 * t) + (b_2 * t^2) \quad (3)$$

The quadratic model can be used to model a series that "takes off" or a series that dampens.

4. Cubic. Model that is defined by the equation

$$Y = b_0 + (b_1 * t) + (b_2 * t^2) + (b_3 * t^3) \quad (4)$$

5. Compound. Model whose equation is

$$Y = b_0 * (b_1^t) \text{ or } \ln(Y) = \ln(b_0) + (\ln(b_1) * t \quad (5)$$

6. S-curve. Model whose equation is

$$Y = e^{(b0 + (b1/t))} \text{ or } \ln(Y) = b_0 + (b_1/t) \quad (6)$$

7. Exponential. Model whose equation is

$$Y = b_0 * (e^{**}(b_1 * t)) \text{ or } \ln(Y) = \ln(b_0) + (b_1 * t) \quad (7)$$

Criteria for Comparing the Prediction Accuracy

Different criteria are used to make comparisons between the forecasting ability of fitted trend curves The first criterion is the absolute mean error (AME). It is a measure of average error for each point forecast made by the different curves. AME is given by

$$AME = (1/T)\sum|P_t - A_t| \quad (8)$$

The second criterion is the mean absolute percent error (MAPE). It is similar to AME except that the error is measured in percentage terms, and therefore allows comparisons in units which are different.

The third criterion is mean square error (MSE), which measures the overall performance of a model. The formula for MSE is

$$MSE=(1/T)\sum(P_t - A_t)^2 \quad (9)$$

where P_t is the predicted value for time t, A_t is the actual value at time t and T is the number of predictions and the fourth criterion is RMSE which is the square root of MSE.

RESULTS AND DISCUSSION

The trend equations were fitted to the data by using SAS 9.2. Ordinary least squares method was used to find the best estimates of the parameters of the equations. R square and adjusted R square were computed and used for comparing the fit of the different equations (Table 1). From the table it is evident that the cubic curve fits the data best followed by exponential, then quadratic, linear, logarithmic and the S curve with R square values 0.903, 0.868, 0.839, 0.610, 0.332 and 0.218 respectively. The adjusted R square values showed the same trend with the cubic curve fitting the data best followed by exponential, then quadratic, linear, logarithmic and the S curve with adjusted R square values 0.898, 0.865, 0.833, 0.604, 0.321 and 0.214 respectively. The F values for all the regression models was significant showing that the variation explained by the curves was significant, with the greatest F value of 380.09 of exponential curve and the minimum of 16.4 of S curve.

The parameters of the different models are given in table-2, and all the parameter estimates were significant at 1% or 5% level of significance.

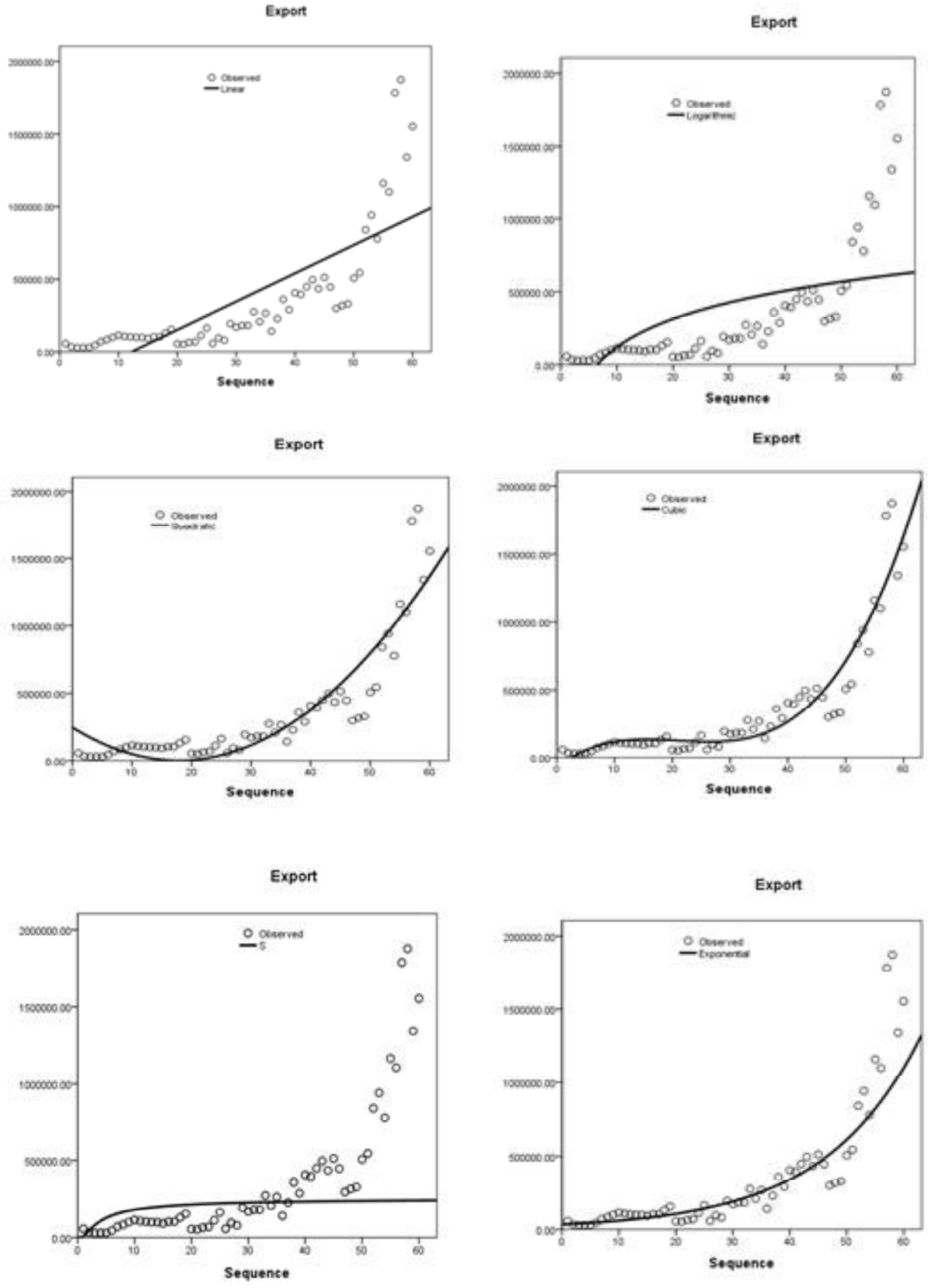

Fig. 1. Observed vs fitted graphs of different curves

Table 1. Fit statistics for Different curves

Model	R Square	Adjusted R Square	F values	P
Linear	0.610	0.604	90.882	.000
Logarithmic	0.332	0.321	28.844	.000
Quadratic	0.839	0.833	148.29	.000
Cubic	0.903	0.898	174	.000
S Curve	0.218	0.214	16.4	.000
Exponential	0.868	0.865	380.09	.000

Table 2. Estimated equations of different curves

Model	Estimated equations
Linear	19474.30636287858 * t + -238344.0440677966
Logarithmic	-519922.9052399894 + 278498.7595485397 * log(t)
Quadratic	246498.4471653999 + -27445.93472420495 * t + 769.1842801161234 * t^2
Cubic	-73999.1484552913 + 33114.29103202884 * t + -1692.394795311623 *t^2+ 26.90250355658741 * t^3
S Curve	exp(12.45640269817721 + -3.504283633106735 / t)
Exponential	32680.07578794559 * exp(0.05864115656482796 * t)

The Fit of the curves has been shown in fig:1 in which the observed and fitted curves are shown

Under the assumption that the curves can be extrapolated to predict the future values of the export, forecasted values of export were obtained for the years 2012-13,2013-14 and 2014-15(Table-3). Among the curves the minimum mean absolute percentage error (MAPE) was of exponential curve followed by quadratic, linear, cubic, logarithmic and the S curve with a MAPE of 21.87, 25.48, 28.51,42.89,53.66 and 82.14 respectively.

Different types of curves were fitted to the annual export from India to different countries. The data was divided into the calibration set and the validation set. During the calibration stage the cubic curve fits the data best followed by exponential, then quadratic, linear, logarithmic and the S curve with R square values 0.903, 0.868, 0.839, 0.610, 0.332 and 0.218 respectively. But during the validation set it was found that the exponential curve predicts the future exports reasonably well with a MAPE of 21.87 followed by quadratic, linear, cubic, logarithmic and the S curve. The cubic curves though, fit the data very well, in prediction it fails with a MAPE of 42.89. It can be concluded that the exponential curve which fits the data best with the greatest F value of 380.09. The prediction also indicates that exponential trend is expected to continue in the near future also.

Table 3. Observed and predicted values by extrapolating different curves

		PREDICTED					
YEAR	Observed	Linear	Quadratic	Log	cubic	S	Expo.
2012-2013	1822760	949588.6	1434431	624950.4	1754929	242548.1	1168967
2013-2014	1358193	969063	1501595	629478.9	1885141	242773	1239567
2014-2015	1086072	988537.3	1570297	633935	2021977	242990.9	1314430
	RMSE	960918	637053.7	1473160	1076194	2109980	702612.5
	MAPE	28.51162	25.48257	53.66591	42.89749	82.14843	21.87615

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