Dynamics of Production and Export of Tomato from India: Markov Chain Approach

Abstract:

India is the second largest producer of tomatoesin the world after China contributing around 10 per cent of the world's total tomato production and it has got a lot of demand in the international market. The study was conducted to know the growth and stability in the area, production, productivity, and export of Indian tomatoes. The study also aimed to analyse the changing direction and magnitude of India's tomato export to different countries. The study is based on secondary data collected from different sources over a period of 15 years (2006-07 to 2020-21). Compound annual growth rate analysis and instability index analysis were used to work out the growth and instability in the area, production, productivity, and export of Indian tomatoes. To analyse the direction of trade to different export destinations and to workout export projections, the Markov chain analysis/transition probability matrix through linear programmingwasused.The findings of the study revealed that there was positive growth in the area, production, productivity, and even export of tomatoes from India but growth rates as well as instability were found to be more in export compared to area, production, and productivity. The results of the Markov chain analysis/transition probability matrix showed that other minor countries pooled under the category 'others', Bangladesh and UAE were more stable importers of Indian tomatoes whereas Nepal and Oman were found not at all stable countries with no retention of trade.

Keywords: Compound growth rate, Export, Markov chain analysis, Tomato

1. Introduction:

India has been bestowed with wide range of climate and physic-geographical conditions as such is most suitable for growing various kinds of horticultural crops such as fruits, vegetables, flowers, nuts, spices and plantation crops. Fruits and vegetables are important supplements to the human diet as they provide the essential minerals; vitamins and fibre required for maintain good health. Fruits and vegetables account for nearly 90 per cent of the total horticulture production in the country. India produces 11.78 per cent of world's vegetable production. Thousands of farmers, businessmen and industries (seeds, fertilisers, pesticides, vegetables with pesticides, etc.) are dependent on vegetables. India's geographical condition varies from region to market for vegetable production which has immense potential for vegetable production. India produced 191 million metric tonnes of vegetables during 2019-20 (NHB, 2020). The area under cultivation of vegetables was stood at 10.35 million hectares. According to FAO (2019), India is the largest producer of ginger and okra amongst the vegetables and ranks second in the production of tomatoes, potatoes, onions, cauliflowers, brinjal, cabbages, etc. The vast production base offers India tremendous opportunities for export. During 2020-21, India exported vegetables worth Rs. 4,971.22 crores. Onions, mixed vegetables, potatoes, tomatoes and green chillies contribute largely to the vegetable export market.

Tomato is very important vegetable crop next to potato. The major tomato growing countries are China, India, USA, Italy, Turkey and Egypt. India ranks second in area as well as production of tomato in the world. India contributes around 10 per cent of the tomato production in the world. The surplus production of tomatoes causes glut in the market and thereby lead to distress sale and low profit to the farmers. One of the probable solutions to this market glut is to export the surplus tomatoes to the other countries and to realise more profit. Although India started exporting tomatoes during 1970s, its export is very negligible when compared to production. Hence, this study was undertaken to know the growth in area, production, productivity and export performance of Indian tomatoes, their trade directions, export projections in the near future., etc. The findings of this study will help to analyse the growth in area, production, productivity as well as export performance of Indian tomatoes. The study will also aim to identify the loyal countries to India in importing of Indian tomato, to predict export projections in near future and to frame the policies related to export of tomatoes accordingly.

2. Materials and methods:

2.1 Data: Study is based on secondary data on area, production, productivity and export of Indian tomato over the period of 15 years (2006-07 to 2020-21).

2.2 Analytical techniques:

2.2.1 Growth rate analysis

For computing compound annual growth rate of area, production, productivity and export of tomato, the exponential function of the following form was used.

$$Y = a\, b^{t} e^{Ut} \quad \text{.....(1)}$$

Where,

Y = Area /production /productivity/export

a = Intercept

b = Regression coefficient

'a' and 'b' are the parameters to be estimated

t = time period

U_t= Disturbance term in year 't'

The equation (1) was be transformed into log linear form and written as;

$$\log Y = \log a + t \log b + U_t \quad \text{.....} \quad (2)$$

Equation (2) was estimated by using Ordinary Least Squares (OLS) technique.

Compound annual growth rate (g) was then computed by using the formula;

$$g = (b - 1)*100 \quad \text{.....} \quad (3)$$

Where,

g: Compound growth rate in per cent per annum

b: Antilog of log b

The standard error of the growth rate was estimated and tested for its significance with student's t test.

2.2.2 Instability analysis:

- The coefficient of variation was used as measure of the variability in area under cultivation, production, productivity and export of Indian tomato. The coefficient of variation or index of instability was computed by using the following formula;

$$CV = \frac{\text{Standard Deviation } (\sigma)}{\text{Mean } (\bar{X})} \times 100 \quad \cdots\cdots\cdots\cdots\cdots\cdots (4)$$

- Linear trend was fitted to the original data of area, production, productivity and export of tomato from India for a period of 15 years. The trend coefficients were tested for their significance. Whenever the trend of series found to be significant; the variation around the trend rather than the variation around mean was used as an index of instability. The formula suggested by Cuddy and Della was used to compute the degree of variation around the trend. The Coefficient of variation was multiplied by the square root of the difference between the unity and coefficient of multiple determinations (R^2) to obtain the Instability Index.

$$\text{Instability index } (I_x) = CV * \sqrt{(1 - R^2)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

2.2.3 Markov chain model

Annual export data of Indian tomato was used for analysing the direction of trade and changing pattern of export. The trade directions of Indian tomato were analysed using the first order Markov chain approach. The lingo software was adopted to study the transition probability matrix. Central to Markov chain analysis is the estimation of the transitional probability matrix 'P' whose elements, P_{ij} indicate the probability of exports switching from country 'i' to country 'j' over time. The diagonal element P_{ij} where i=j, measures the probability of a country retaining its market share or in other words, the loyalty of an importing country to a particular country's exports.

Annual export data for the period 2006-07 to 2020-21 for the period of 15 years was used to analyze the direction of trade and changing pattern of export of Indian tomato to different countries. The average exports to a particular country was considered to be a random variable which depends only on the past exports to that country, which can be denoted algebraically as

$$E_{jt} = \sum_{i=1}^{n} [Ei_{t-1}] P_{ij} + e_{jt}$$

Where,

E_{jt}= exports from India to the j^{th} country in the year t

Ei_{t-1} = exports of i^{th}country during the year t-1

$P_{i\,j}$ = the probability that exports will shift from i^{th} country to j^{th}country

e_{jt} = the error term which is statistically independent of Ei_{t-1}

n = the number of importing countries

The transitional probabilities P_{ij}, which can be arranged in a (c x n) matrix, have the following properties.

$$\sum_{i=1}^{n} P_{Ij} = 1 \text{ And } 0 \leq P_{I\,j} \leq 1$$

Thus, the expected export share of each country during period 't' was obtained by multiplying the exports to these countries in the previous period (t-1) with the transitional probability matrix. The probability matrix was estimated for the period 2006-07 to 2020-21. Thus, transitional probability matrix (T) was estimated using linear programming (LP) framework by a method referred to as minimization of Mean Absolute Deviation (MAD).

Min. OP* + I e

Subject to

X P* + V = Y

GP* = 1

P* ≥ 0

Where

P* is a vector of the probabilities $P_{I\,j}$

O is the vector of zeros

I is an appropriately dimensioned vector of export.

e is the vector of absolute errors

Y is the proportion of exports to each country.

X is a block diagonal matrix of lagged values of Y

V is the vector of errors

G is a grouping matrix to add the row elements of P arranged in P* to unity.

Using the estimated transitional probabilities, the exports of Indian tomato to various destinations was predicted by multiplying the same with the respective shares of base year.

The export shares of Indian tomato to different countries was predicted for the years 2021-22 to 2025-26 by using 2 step, 3 step, 4 step and 5 step transitional probabilities.

3. Results

3.1 Growth and stability in area, production, productivity and export of Indian tomato

Table 1 depicts the growth in area, production, productivity and export of tomato for the period of 15 years from 2006-07 to 2020-21. It can be observed from the table that area under tomato was 596.00 thousand hectares during 2006-07 and it has been increased to 845.00 thousand hectares during 2020-21 with the annual growth rate of 2.21 per cent. Table also indicates that there was increase in the productivity of the tomato from 16.90 metric tonnes per hectare to 25.10 metric tonnes per hectare during the study period with the growth rate of 3.07 per cent per annum. It is also evident from the table that since there was increase in both area and productivity; there was tremendous increase in the production of tomato in the country from 10055.00 thousand metric tonnes in 2006-07 to 21181.00 thousand metric tonnes in 2020-21 with the annual growth rate of 5.35 per cent.

Apart from the area, production and productivity, the growth in export quantity as well as export value of tomato was also estimated and tested for its significance. The growth in export of tomato in terms of both its export quantity and export value was higher compared to that of production. The export quantity has showed a positive growth rate of 9.47 per cent per annum whereas the export value has showed the annual growth rate of 18.69 per cent. Tomato was exported to the different parts of the world to the extent of 0.66 thousand metric tonnes during 2006-07 and it has been increased to 4.28 thousand metric tonnes during 2020-21. The export value was also increased form Rs. 2.40 crores in 2006-07 to Rs. 59.02 crores during 2020-21. It is also important to notice from the table that growth in production, productivity and export of tomato were found to be significant at 1 per cent level whereas the growth in area was found to be significant at 5 per cent.

In order to assess the consistency of growth performance of these variables, instability analysis was carried out and the instability indices are presented in the table 1. Cursory look at the table 1 reveals that a significant instability was observed in growth of area, production, productivity and export of tomato. Highest instability was observed in case of growth of export quantity of tomato (49.09 %) over the study period followed by its export value (28.42 %), area (11.63 %) and production (11.23 %) whereas instability in the growth of production was under 5 per cent (3.89 %).

Table 1. Growth rate and stability in area, production, productivity and export of Indian Tomato

Year	Area (000'ha)	Production (000' MT)	Productivity MT/ha	Export

				Quantity (000'MT)	Value (CroreRs.)
2006-07	596.00	10055.00	16.90	0.66	2.40
2007-08	566.00	10303.00	18.20	1.15	6.54
2008-09	599.00	11149.00	18.60	1.32	8.04
2009-10	634.40	12433.20	19.60	1.37	8.61
2010-11	865.00	16826.00	19.50	8.93	28.08
2011-12	907.10	18653.30	20.60	2.48	16.83
2012-13	879.60	18226.60	20.70	2.75	18.03
2013-14	882.00	18735.90	21.20	2.90	26.87
2014-15	767.30	16385.00	21.40	2.73	33.21
2015-16	774.00	18732.00	24.20	2.94	33.46
2016-17	797.00	20708.00	26.00	3.57	41.67
2017-18	789.00	19759.00	25.00	3.24	34.46
2018-19	781.00	19007.00	24.30	3.31	31.83
2019-20	812.00	21187.00	26.10	3.47	34.38
2020-21	845.00	21181.00	25.10	4.28	59.02
Mean	766.29	16889.40	21.83	3.01	25.56
CAGR	2.21**	5.35***	3.07***	9.47***	18.69***
Instability Index	11.63	11.23	3.89	49.09	28.42

Note: *** Significant at 1 per cent level, ** Significant at 5 per cent level

3.2 Direction of trade in export tomato from India

The change in the direction of trade in in export of tomato from India to other parts of the world has been depicted in table 2. It can be observed from the table that other countries were found very stable in importing the tomato from India over the study period and found loyal to India since it retained about 89.23 per cent of the previous year's trade. At the same time the other two competitive countries Bangladesh and UAE were also found to be stable and loyal to India in importing tomato from India with the probability of retention of trade from the previous year of around 73.05 per cent and 61.02 per cent, respectively. Bangladesh lost a considerable share to Nepal (18.31%) but gained a very impressive trade share from the same country to the extent of 60.30 over the study period considered, 53.13 per cent from Qatar and 19.59 per cent from Nepal. The table also indicates that the Qatar was less stable with probability of retention of previous year's trade of just 33.21 per cent and remaining two countries (Nepal and Oman) retained nothing from the previous year's trade. Nepal lost its

entire trade to Bangladesh (60.30 %) and Oman (39.70 %) whereas Oman lost its whole trade to Qatar (50.20 %), Nepal (31.67 %) and UAE (18.13 %).

Table 2. Transition probability matrix of Indian Tomato to different destinations

	Bangladesh Pr	UAE	Nepal	Oman	Qatar	Others
Bangladesh Pr	**0.7305**	0.0864	0.1831	0.0000	0.0000	0.0000
UAE	0.1959	**0.6102**	0.0380	0.0000	0.0000	0.1559
Nepal	0.6030	0.0000	**0.0000**	0.3970	0.0000	0.0000
Oman	0.0000	0.1813	0.3167	**0.0000**	0.5020	0.0000
Qatar	0.5313	0.0000	0.1366	0.0000	**0.3321**	0.0000
Others	0.0000	0.1049	0.0000	0.0029	0.0000	**0.8923**

4. Discussions:

An increase in the area and productivity of tomato over the years resulted in an increase in the production of tomatoes in the country which intern lead to positive growth in export. The increase in export of Indian tomatoes to the other countries might be due to increasing demand for Indian tomatoes in the international market both in fresh and processed form. The positive growth rates were observed in all the parameters considered in the study like area, production, productivity and export of Indian tomatoes and these results are in conformity with the findings of the Kulkarni, Patil and Ramchandra (2012) and Siddayya and Atteri (2010).

As far as magnitude and direction of trade of Indian tomatoes to the export destinations is concerned, the other minor countries pooled under ‘others’, Bangladesh and UAE were most trusted countries and most loyal to India in importing the Indian tomato. Hence policies have to be drawn in such a way that they need to be oriented towards other countries, Bangladesh and UAE since they retained a very impressive shares of their trade with India with respect to import of tomato from India. Interestingly the countries like Nepal and Oman failed to retain the imports of Indian tomatoes as indicated by zero per cent retention. Hence these two countries are not trust worthy in export of tomato from India and India cannot rely upon these two countries in export tomatoes. Other countries retained around 89.23 per cent of the trade and hence Indian export policies need take advantage of this changed trade scenario and need to identify those countries among other minor importing countries to divert export of tomato from India in the future. The findings of the study are in same line with the findings of Kusuma and Rudrapur (2016), where the other minor countries were found loyal to the import of onion from India and the findings of Kusuma, Basavaraja and Rudrapur (2014) where the similar findings were observed in case of Indian Sapota.

Conclusions:

Positivegrowth in area, production and productivity of tomato in India was observed and which intern lead to positive growth in export of Indian tomato to different countries over the study period considered. The major export destinations of Indian tomato are Bangladesh, UAE, Nepal, Oman and Qatar. Among these major countries, Bangladesh and Nepal are trustworthy and liable to India after other minor importing countries pooled under the category, ‘others’ in importing Indian tomato in the near future and hence Indian export policies need to be oriented towards these countries to gain export earnings through tomato export whereas the countries like Nepal and Oman are not liable and India need not to trust these countries in export of tomato in the near future. The Indian export policies for tomato also need to identify those minor countries from the countries pooled under ‘others’ which

are gaining and retaining major trade share and frame the policies accordingly to export more quantities on tomato in the near future.

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