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RESEARCH ARTICLE

Export performance of Indian onion: Markov chain approach

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Abstract

The study revealed that the growth in export value was found to be the highest (14.14%) followed by the growth in production (6.23%) and area (5.02%) and was found significant at 1% level. More instability was also observed in the export value (17.72%) followed by area (7.91%) and production (6.42%). Markov chain analysis and transition probability matrix indicated that Nepal was found to be the most liable country to import Indian onions, with 68.69% of its previous year's trade. Similarly, the countries pooled under others, Malaysia and Bangladesh, were also found to be liable countries since they retained almost more or less equal to 50% of their previous year's trade. Therefore, Export policies of India need to be oriented towards these countries since these countries can be trusted and India can rely on these countries to export the onion. India can also think of identifying those minor countries pooled under the category 'others' that are retaining a considerably good percentage of trade from the previous year.

Keywords: Export, Growth, Instability, Markov chain analysis, Onion.

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Introduction

India has been bestowed with a 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 fiber required to maintain good health. Fruits and vegetables account for nearly 90% of the total horticulture production in the country (shankariasparliament.com). India produces 11.88% of the world's primary vegetable production and ranks 2nd, whereas it ranks first in the production of onion (dry) with a 24.95% contribution (agriwelfare.gov.in). India's geographical condition varies from region to region for vegetable production which has immense potential for vegetable production. India produced 204.96 million metric tonnes of vegetables during 2023-24, and the area under cultivation of vegetables stood at 11.11 million hectares (Agricultural and Processed Food Products Export Development Authority, APEDA). India is the largest producer of Onions, ginger and okra among vegetables and ranks second in the production of potatoes, cauliflowers, brinjal, cabbages, etc (APEDA). The vast production of the vegetable base offers India tremendous opportunities for

export. During 2023-24, India exported vegetables worth Rs. 6861.05 crores (APEDA). Onions, mixed vegetables, potatoes, tomatoes and green chilies contribute largely to the vegetable export market. Onion is the most widely produced and consumed vegetables worldwide. It is the most regularly used ingredient in cooking. The production of onion has been increasing in India over the years. In other words, India is producing more onions than the domestic requirements. The major onion-producing states are Maharashtra, Karnataka, Madhya Pradesh, Gujarat, Bihar, Andhra Pradesh, Rajasthan, Haryana and Telangana. Maharashtra ranks 1st in onion production (35%) followed by Madhya Pradesh (17%) in 2023-24 (APEDA). The country has exported around 1,717,439.35 MT of fresh onions to the world for the worth of Rs. 3,922.78 crores (473.72 USD million) during the year 2023-24 indicating that there is a lot of demand for the Indian onion in the world (APEDA). Against this backdrop, the present study was undertaken to analyze the growth and stability in the area, production, productivity and export of onion from India and to examine the direction of trade in the export of onion from India.

Materials and Methods

The study is based on secondary data on the area, production, productivity and export of Indian onion over the period of 15 years (2006-07 to 2020-21) and is collected from different e-resources, such as Indiastat and APEDA.

Growth rate analysis

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

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

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 transformed into log linear form and written as;

$$\log Y = \log a + t \log b + U_t \quad \ldots\ldots (2)$$

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

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

$$g = (b - 1)*100 \quad \ldots\ldots (3)$$

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.

Instability analysis

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

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

A linear trend was fitted to the original data of area, production, productivity, and export of onion from India for a period of 15 years. The trend coefficients were tested for their significance. Whenever the trend of the series was found to be significant, the variation around the trend rather than the variation around the mean was used as an index of instability. The formula suggested by Cuddy and Valle (1978) 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.

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

Markov chain model

Annual export data of Indian onion was used for analysing the direction of trade and changing pattern of export. The trade directions of Indian onion were analyzed 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 the changing pattern of export of Indian onion to different countries. The average exports to a particular country were considered to be a random variable that depends only on the past exports to that country, which can be denoted algebraically as

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

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_{ij} = 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.

$$\sum_{i=1}^{n} P_{Ij} = 1 \text{ and } 0 \leq_{Ij} \leq 1$$

Thus, the expected export share of each country during the 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, the transitional probability matrix (T) was estimated using a 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_{Ij}

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.

Table 1: Growth rate and stability in area, production, productivity and export of Indian onion

Year	Area (000'ha)	Production (000' mt)	Productivity mt/ha	Export	
				Quantity (000'mt)	Value Crore Rs.
2006-07	767.90	10847.40	14.10	24.18	157.35
2007-08	821.00	13900.40	16.90	59.13	230.41
2008-09	834.20	13564.50	16.10	27.48	143.17
2009-10	756.20	12158.80	14.20	28.96	238.65
2010-11	1063.80	15117.70	16.10	38.34	287.49
2011-12	1087.20	17511.10	16.00	56.09	388.00
2012-13	1051.50	16813.00	16.10	51.52	458.00
2013-14	1203.60	19401.70	16.10	40.88	509.85
2014-15	1173.30	18927.40	15.90	52.98	679.07
2015-16	1320.00	20931.00	17.20	53.67	730.92
2016-17	1306.00	22427.00	18.10	66.60	745.21
2017-18	1285.00	23262.00	18.70	63.34	591.97
2018-19	1220.00	22819.00	18.20	72.26	719.51
2019-20	1431.00	26091.00	16.40	60.84	795.24
2020-21	1624.00	26641.00	16.30	74.81	1063.25
Mean	1129.65	18694.20	16.43	51.41	515.87
CAGR	5.02***	6.23***	1.09**	6.50***	14.14***
Instability Index	7.91	6.42	6.20	19.47	17.72

Source: Indiastat, APEDA; Note: ***Significant at 1% level, ** Significant at 5% level mt indicates metric ton

Using the estimated transitional probabilities, the exports of Indian onion to various destinations were predicted by multiplying the same with the respective shares of a base year. The export shares of Indian onion to different countries were expected for the years 2021-22 to 2025-26 by using 2-step, 3-step, 4-step, and 5-step transitional probabilities.

Results and Discussion

Growth and stability in area, production, productivity and export of Indian onion

Table 1 indicates that all the five parameters (area, production, productivity, export quantity and export value) considered for the study showed a positive growth rate. Among these parameters, the highest growth rate was observed in the case of export value (14.14%) followed by export quantity (6.50%), production (6.23%) and area (5.02%), whereas the growth rate in productivity of onion was found to be just above 1%. All the parameters were found to be significant at 1% except productivity which was found significant at 5%. The results are in line with the findings of Kulkarni *et al.* (2012).

It is also evident from the table that the instability was observed more in the case of export quantity (19.47%) followed by export value (17.72), area (7.91%), production (6.42%), and productivity (6.20%).

Onion export trend

The transition probability matrix of export of onion from India to different countries has been represented in table 2. It provides a broad indication of changes in the direction of trade of export of Indian onion to different countries over the study period considered. The major export destinations of Indian onion were Bangladesh, Malaysia, UAE, Sri Lanka, Nepal and all other countries grouped under the category 'others.' The transitional probability matrix was obtained for the study period considered. It can be observed from the table that Nepal was found more stable in importing onion from India, with a retention of 68.69% of its previous year's trade and was found loyal to India. It lost 31.31% of its trade to other countries. Similarly, other countries category was also found stable and loyal to India in importing Indian onion with retention of more than 50% (55.54%). It lost its previous trade to the extent of around 30% to Sri Lanka, 10.43% to UAE and 3.95% to Nepal, but at the same time, it gained trade from competing countries like 42.04% from Sri Lanka, 31.31% from Nepal, 28.91%, from Malaysia and just around 3% from Bangladesh. This is contrary to the findings of the Kusuma and Shreeshail (2016), where Bangladesh was the most stable and loyal country to India in importing onions from India and Nepal was a minor country and pooled under the category 'others'. That means Nepal is gaining the major trade share year on year and has been found to be a stable and loyal country to India in case of onion import

Table 2: Transition probability matrix of Indian onion to different destinations

	Bangladesh Pr	*Malasia*	*UAE*	*Sri Lanka Dsr*	*Nepal*	*Others*
Bangladesh Pr	0.4700	0.3157	0.0973	0.0855	0.0000	0.0315
Malasia	0.0000	0.4920	0.1636	0.0552	0.0000	0.2891
UAE	0.7670	0.0000	0.2308	0.0022	0.0000	0.0000
Sri LankaDsr	0.5781	0.0000	0.0000	0.0000	0.0014	0.4204
Nepal	0.0000	0.0000	0.0000	0.0000	0.6869	0.3131
Others	0.0000	0.0000	0.1043	0.3008	0.0395	0.5554

Table 3: Actual and projected exports values of Indian Onion (Rs. Crore)

Year	*Bangladesh Pr*		*Malasia*		*UAE*		*Sri LankaDsr*		*Nepal*		*Others*	
	A	*P*	*A*	*P*	*A*	*P*	*A*	*P*	*A*	*P*	*A*	*P*
2006-07	312.96 (26.90)	375.86 (32.31)	270.44 (23.25)	231.84 (19.93)	209.67 (18.02)	147.16 (12.65)	117.55 (10.11)	111.54 (9.59)	22.06 (1.90)	24.44 (2.10)	230.62 (19.82)	272.47 (23.42)
2007-08	410.86 (39.67)	365.66 (35.30)	206.42 (19.93)	231.25 (22.33)	144.17 (13.92)	122.01 (11.78)	107.22 (10.35)	90.00 (8.69)	23.65 (2.83)	22.07 (2.13)	143.45 (13.85)	204.79 (19.77)
2008-09	735.72 (40.26)	602.76 (32.98)	319.28 (17.47)	389.32 (21.30)	215.35 (11.78)	212.36 (11.62)	158.84 (8.69)	192.91 (10.56)	26.38 (1.44)	33.05 (1.81)	371.95 (20.35)	397.12 (21.73)
2009-10	1126.20 (48.56)	778.20 (33.55)	413.30 (17.82)	558.83 (24.09)	179.04 (7.72)	257.80 (11.11)	193.04 (8.32)	232.64 (10.03)	31.82 (1.37)	37.00 (1.60)	376.03 (16.21)	454.97 (19.62)
2010-11	572.33 (32.17)	499.25 (28.06)	491.87 (27.64)	422.66 (23.75)	165.74 (9.32)	210.50 (11.83)	178.42 (10.03)	180.44 (10.14)	25.30 (1.42)	31.30 (1.76)	345.62 (19.42)	435.14 (24.46)
2011-12	386.21 (22.41)	452.66 (26.27)	443.45 (25.74)	340.08 (19.74)	221.90 (12.88)	208.65 (12.11)	174.64 (10.14)	194.39 (11.28)	43.46 (2.52)	48.02 (2.79)	453.35 (26.31)	479.19 (27.81)
2012-13	437.56 (22.25)	506.82 (25.77)	491.06 (24.97)	379.72 (19.31)	238.21 (12.11)	235.84 (11.99)	204.92 (10.42)	232.11 (11.80)	39.60 (2.01)	49.44 (2.51)	555.28 (28.24)	562.70 (28.61)
2013-14	889.14 (28.05)	897.42 (28.31)	639.35 (20.17)	595.22 (18.78)	329.40 (10.39)	356.16 (11.24)	392.49 (12.38)	368.71 (11.63)	66.14 (2.09)	79.72 (2.52)	853.11 (26.92)	872.39 (27.52)
2014-15	779.65 (33.89)	705.79 (30.68)	416.22 (18.09)	450.87 (19.60)	247.73 (10.77)	249.06 (10.83)	258.39 (11.23)	228.33 (9.92)	139.40 (6.06)	114.28 (4.97)	459.16 (19.96)	552.20 (24.00)
2015-16	950.14 (30.68)	957.19 (30.90)	586.42 (18.93)	588.43 (19.00)	327.28 (10.57)	325.27 (10.50)	449.09 (14.50)	291.13 (9.40)	196.64 (6.35)	158.96 (5.13)	587.63 (18.97)	776.23 (25.06)
2016-17	975.91 (31.42)	917.64 (29.54)	493.09 (15.87)	550.64 (17.73)	399.29 (12.86)	352.36 (11.34)	264.21 (8.51)	355.37 (11.44)	163.11 (5.25)	144.46 (4.65)	810.47 (26.09)	785.58 (25.29)
2017-18	599.52 (19.41)	924.47 (29.93)	588.59 (19.06)	478.82 (15.50)	415.55 (13.45)	332.04 (10.75)	560.39 (18.14)	319.68 (10.35)	143.63 (4.65)	130.35 (4.22)	781.14 (25.29)	903.46 (29.25)
2018-19	1058.14 (30.50)	990.97 (28.57)	517.70 (14.92)	588.71 (16.97)	373.05 (10.75)	379.63 (10.94)	359.00 (10.35)	425.13 (12.26)	146.35 (4.22)	141.16 (4.07)	1014.64 (29.24)	943.28 (27.19)
2019-20	550.14 (23.71)	655.88 (28.26)	434.29 (18.71)	387.33 (16.69)	296.99 (12.80)	261.12 (11.25)	293.24 (12.64)	267.71 (11.54)	94.41 (4.07)	91.03 (3.92)	651.62 (28.08)	657.63 (28.34)
2020-21	755.48 (26.73)	789.63 (27.94)	461.47 (16.33)	465.51 (16.47)	330.50 (11.69)	308.88 (10.93)	313.22 (11.08)	331.81 (11.74)	164.77 (5.83)	145.30 (5.14)	801.09 (28.34)	785.41 (27.79)
2021-22	-	799.83 (28.30)	-	478.28 (16.92)	-	306.24 (10.83)	-	330.19 (11.68)	-	131.34 (4.65)	-	780.66 (27.62)
2022-23	-	801.67 (28.36)	-	487.78 (17.26)	-	308.21 (10.90)	-	330.33 (11.69)	-	121.56 (4.30)	-	776.99 (27.49)
2023-24	-	804.13 (28.45)	-	493.03 (17.44)	-	310.02 (10.97)	-	329.91 (11.67)	-	114.69 (4.06)	-	774.75 (27.41)
2024-25	-	806.43 (28.53)	-	496.40 (17.56)	-	311.30 (11.01)	-	329.74 (11.67)	-	109.88 (3.89)	-	772.78 (27.34)

Note: Figures in the parenthesis indicate percentage to total

from India. Malaysia and Bangladesh were also found stable, with nearly 50% retention of the previous year's trade, and similar interpretations can be made for these countries. UAE was found to be less stable in retention of its previous year's trade with just 23.08%. It lost its major share to Bangladesh to the extent of 76.70% and gained just around 16.36% from Malaysia, 9.73% from Bangladesh, and 10.43% from other competing countries. It is also important to notice that the country Sri Lanka was found not a loyal country since it was unable to retain even 1% of the previous year's trade. The probability of retention of the previous year's trade by Sri Lanka was just 0%. It lost its trade to Bangladesh (57.81%) and to other minor countries (42.04%). The results are in line with the findings of the Siddayya and Atteri (2010).

It can be observed from the table that Sri Lanka failed to retain the import of onion from India, as indicated by 0% retention, as shown in the results. Hence, India cannot trust and cannot rely on Sri Lanka for the export of onions. On the other hand, Nepal is the most stable and loyal country to India in import of Indian onion since it retained a very impressive trade share, followed by other minor countries, Malaysia and Bangladesh. Hence, the export policies of India need to be oriented towards these countries and rely on and trust these countries in the export of Indian onion in the future. UAE is also less stable and it lost its major share to Bangladesh. India need not be dependent on the UAE in the export of Indian onions in the near future. Instead, it needs to identify those countries among other minor importing countries and policies need to be oriented towards diverting the export of Indian onion towards these countries.

Actual, estimated and projected export of Indian Onion

The actual, estimated and projected export of Indian onion to different countries has been depicted in Table 3. The estimated values were obtained by using a transition probability matrix and actual values. In contrast, the projected values of the export of Indian onion were worked out by using estimated values and a transition probability matrix. The projections of Indian onion exports to different countries were computed up to 2024-25 (Kusuma et al. 2014). It could be seen from the table that the percentage share of actual export of Indian onion to Bangladesh had shown a very marginal decreasing trend from 26.90% (2006-07) to 26.73% (2020-21), whereas the estimated export showed a comparatively more decreasing trend from 32.31% during 2006-07 to 27.94% during 2020-21. The projected market share is expected to be 28.53% during 2024-25. In the case of Malaysia, the actual as well as estimated market share of importing onion from India showed a decreasing trend from 23.25% during 2006-07 to 16.33% in 2020-21 (actual) and from 19.93% to 16.47% (estimated). The export projections of Indian onion to Malaysia were also found to be decreasing (17.56%) in 2024-25. The actual export of Indian onion to UAE also showed a decreasing trend by a big margin like 18.02% in 2006-07 to 11.69% in 2020-21, whereas the estimated values showed a decreasing trend by a small margin, i.e., from 12.65% in 2006-07 to 10.93% in 2020-21. The projected export is expected to be 11.01% by the year 2024-25.

On the other hand, the market share of export of Indian onion to Sri Lanka has shown an increased trend. The actual export value of Indian onion to Sri Lanka increased from 10.11% in 2006-07 to 11.08% in 2020-21, whereas its estimated value was 9.59% in 2006-07 and was increased to 11.74% in 2020-21. The export projections of Indian onion to Sri Lanka were found to be 11.67% during 2024-25. Similarly, Nepal also showed an increasing trend in importing onions from India. The actual and estimated market share of export value of Indian onion to Nepal was just 1.90 and 2.10%, respectively, during 2006-07 and were increased to 5.83 and 5.14%, respectively, during 2020-21, whereas the export projections were expected to be 3.89% during the year 2024-25. It can also be seen from the table that the market share of Indian exports to other minor countries also showed an increasing trend both in terms of actual values as well as estimated values. The market share of actual export share of Indian onion to other minor countries increased from 19.82% during 2006-07 to 28.34% during 2020-21, whereas the estimated market share increased from 23.42% in 2006-07 to 27.79% during 2020-21. The export of Indian onion to other minor countries was projected to be 27.34% during 2024-25. The export projections of Indian onion showed that the export of Indian onion to Nepal is expected to decrease by 1.25% by the year 2024-25 by reducing its share from 5.14% in the last year (2020-21) to 3.89% during 2024-25. On the other side, the export of Indian onion to Malaysia is expected to increase by 1.09% by the year 2024-25. It was 16.47% during 2020-21 and is expected to increase to 17.56% during 2024-25. The export of Indian onion to remaining countries is expected to be more or less the same by the year 2024-25.

Conclusion

Positive growth in area, production and productivity of onion in India was observed and, which, in turn, led to positive growth in the export of Indian onion to different countries over the study period considered. The major export destinations of Indian onion are Bangladesh, Malaysia, UAE, Sri Lanka and Nepal. Among these major countries, Nepal, Malaysia and Bangladesh are trustworthy and liable to India in importing Indian onion in the near future. Hence, Indian export policies need to be oriented towards these countries to gain export earnings through onion export. In contrast, countries like Sri Lanka and UAE are not liable and India need not trust these countries in the export of onion in the near future. The Indian export policies for onion also need to identify those minor countries from the countries

pooled under 'others' that are gaining and retaining major trade share and frame the policies accordingly to export more quantities of onion in the near future. Future studies may also be encouraged to identify those minor countries and the direction of trade of Indian onion towards those identified individual countries.

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सारांश

अध्ययन (भारतीय प्याज के निर्यात प्रदर्शन: मार्कोव चेन दृष्टिकोण) में पाया गया कि निर्यात मूल्य में वृद्धि दर सबसे अधिक (14.14%) थी, इसके बाद उत्पादन (6.23%) और क्षेत्रफल (5.02%) की वृद्धि दर थी, जो 1 प्रतिशत स्तर पर महत्वपूर्ण पाई गई। निर्यात मूल्य (17.72%) में अधिक अस्थिरता देखी गई, इसके बाद क्षेत्रफल (7.91%) और उत्पादन (6.42%) में अस्थिरता पाई गई। मार्कोव चेन विश्लेषण और संक्रमण प्रायिकता मैट्रिक्स ने संकेत दिया कि नेपाल भारतीय प्याज आयात करने वाला सबसे भरोसेमंद देश है, जो अपने पिछले वर्ष के व्यापार का 68.69 प्रतिशत बनाए रखता है। इसी प्रकार, 'अन्य' श्रेणी में शामिल देश, मलेशिया और बांग्लादेश को भी भरोसेमंद पाया गया, क्योंकि ये अपने पिछले वर्ष के व्यापार का लगभग 50 प्रतिशत बनाए रखते हैं। इसलिए, भारत की निर्यात नीतियों को इन देशों की ओर उन्मुख करना चाहिए, क्योंकि ये देश भरोसेमंद हैं और भारत प्याज निर्यात के लिए इन पर निर्भर हो सकता है। इसके अतिरिक्त, भारत को 'अन्य' श्रेणी के तहत आने वाले छोटे देशों की पहचान करने पर भी विचार करना चाहिए, जो पिछले वर्ष के व्यापार का एक महत्वपूर्ण प्रतिशत बनाए रखते हैं।