An Application of Markov Chain Analysis to Study theIndian Cocoa Products Export Performance

Original Research Article

Abstract

The paper attempts to quantify the changing structure of Indian cocoa product exports. Data for analysis was considered for a period of 10 years from 2013-14 to 2022-23. The growth rates of exports of Indian cocoa products to Nigeria, Indonesia, USA, UAE, The Netherlands and other countries have shown a positive trend. The Markov chain analysis was attempted through the linear programming method to assess the transition probabilities for the major cocoa markets. The results revealed that Nigeria, Nepal, UAE and other countries were stable markets for Indian cocoa export products. Whereas, Indonesia and The Netherlands were the least stable markets based on the magnitude of transition probabilities.The export share predictions for 2025-26 behaved stagnant while also increasing slightly for major destinations.

Keywords: Cocoa, destination, growth rate,predictions,stable markets

Introduction

Cocoa is known as the "food of the gods" and it is an important plantation crop grown as a mixed crop. “The crop isa key commodity in the agricultural sector of many producing and consuming countries,and its social and economic relevance can hardly be undervalued” (Ahoa*et al.,* 2021). “In India, cocoa is largely cultivated inSouthern states viz, Kerala, Karnataka, Andhra Pradesh and Tamil Nadu. Cocoa products are high in demand due to their use in various food processing industries and other industries like confectioneries, beverages etc. Cocoa products, such as cocoa beans, cocoa powder, cocoa butter etc., are significant commodities in global trade. India has exported 34,249.85 MT of cocoa products to the world for a value of Rs. 1242.13 crores during the year 2022–23” (APEDA, 2023). “India is gaining foreign exchange by way of the export of cocoa beans and their products. As cocoa exports have been increasing in the international market, the country has a wider scope to improve the sector” (Sundariya*et al.,* 2022). Hence, the present study attempts to assess the trend and instability in exports of Indian cocoa products and also examines the trade directions and stability of exports to various

destinations with a suitable econometric model, which may help us to quantify the shifts in the shares to different markets as well as between the markets over a period of time.

Methodology

The study is mainly based on secondary data from various published issues of APEDA and agriexchange.apeda.gov.in. The data pertaining to exports of Indian cocoa products was obtained from the above mentioned sources for the time period of 2013-14 to 2022-23. The annual compound growth rates and coefficient of variation (CV) for the exports of Indian cocoa products were computed for the study period.

Direction of Trade

Annual export data for period 2013-14 to 2022-23 were used to analyze the direction of trade and changing pattern of exports in Indian cocoa productsusing Markov chain analysis.Similarly Satishkumar *et al.* 2016 used Markov chain analysis to study the export performance and competitiveness of basmati and non-basmati rice of India. The major importing destinations considered were USA, Indonesia, Nepal, Niger,UAE and The Netherlandsfor exports of Indian cocoa products. Markov chain analysis helps to analyze the structural changes of any system. The average export to a particular country was considered to be a random variable following a first order Markov process.

$$\mathbf{E_{jt}} = \sum_{\mathbf{i=1}}^{\mathbf{r}} \mathbf{E_{it-1}}\, \mathbf{P_{ij}} + \mathbf{e_{jt}}$$

Where,

E_{jt} = Exports from India during the year t to j^{th} country

E_{it-1} = Exports to i^{th} country during the period t-1

P_{ij} = Probability that exports will shift from i^{th} country to j^{th} country

e_{jt} = The error term which is statistically independent of E_{it-1}, and

r = Number of importing countries

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

$0 \leq P_{ij} \leq 1$

$$\sum_{i=1}^{n} P_{ij} = 1, \text{for all i}$$

Thus, the expected export share of a country during the period 't' was obtained by multiplying the actual exports in the previous period (t-1) by the transitional probability matrix. The transitional probability matrix is estimated in the linear programming (LP) framework by a method referred to as minimization of mean absolute deviation (MAD).

The linear programming formulation is stated as,

Min OP* + Ie

Subjected to

XP* + V = Y

GP* = 1

P* > 0

Where,

0 is the vector of zeros

P* is the vector in which probability P_{ij} are arranged

I is an apparently dimensioned vector of areas

e is the vector of absolute errors (|U|)

Y is the vector of exports to each country.

X is the block diagonal matrix of lagged values of Y

V is the vector of errors

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

Using the estimated transitional probabilities, the export in cocoa products from India to various destinations was predicted by multiplying the same with the respective market shares of the base year (Pavithraet *al*. 2016).

Results and discussion

Country-wise share of exports of Indian cocoa products

The country-wise percentage share of exports of Indian cocoa products (TE-2022) to each destination is presented in Fig. 1. The results revealed that among the major importing destinations, the USA is a major share holder with a maximum share of 23.57 per cent followed

by The Netherlands (6.15 %), Nepal (5.84 %), Nigeria (5.50 %), Indonesia (4.74 %) and the UAE (4.15 %), respectively. Whereas all other destinations constitute the remaining 50.05 per cent of total Indian cocoa product exports.

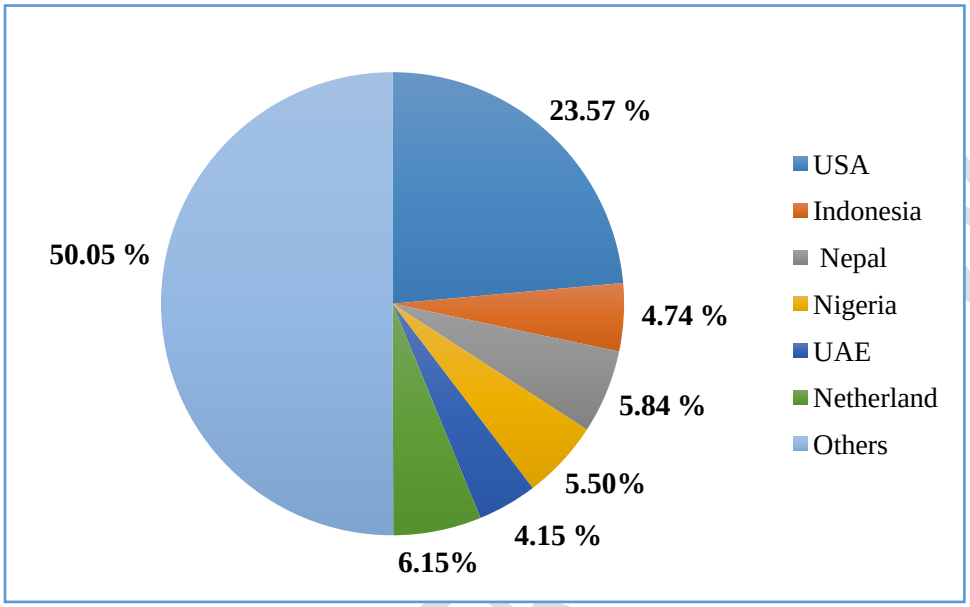

Fig 1: Country-wise share of exports of Indian cocoa products (TE - 2022)

Growth and Instability in exports of Indian cocoa products

The growth rate and instability in exports of Indian cocoa products are presented in Table 1. The results showed that the exports of Indian cocoa products to Nigeria are increasing with a growth rate of 75.17 per cent followed by Indonesia (12.10 %), USA (7.38 %), UAE (5.32 %), The Netherlands (3.32 %) and other countries (3.87 %). Whereas,exports to Nepal showed a declining trend with a growth rate of 5.22 per cent. The total exports of Indian cocoa products over the study period grew by 4.78 per cent per annum. Similar results were obtained byKarpagalakshmi and Muthusamy (2019) who reported in their study that the annual growth rates for total Indian cocoa products showed a significant and consistent growth performance.

The coefficient of variation was used to analyze the instability in the exports of Indian cocoa products. The highest CV value was found for Nigeria with 101.40 per cent followed by The Netherlands (52.34%), Indonesia (44.76%), USA (27.93%), other countries (24.35%) and Nepal (21.40%). The results indicated that the fluctuation in export to Nigeria was higher compared to other countries.

Table 1: Compound growth rates and CV of export of Indian cocoa products (2013-14 to 2022-23)

Country	CAGR (Per cent)	CV (Per cent)
USA	7.38	27.93
Indonesia	12.10	44.76
Nepal	-5.22	21.40
Nigeria	75.17	101.40
UAE	5.32	33.80
The Netherlands	3.32	52.34
Others	3.87	24.35
Total Export	4.78	19.88

Trade Directions of exports of Indian cocoa products

The trade directions of exports of Indian cocoa products were estimated by computing the transitional probability matrix.Similarly Deepika *et al.*, 2015 and Swarnalatha *et al.*, 2024 studied the trade directions of exportsusing the transitional probability matrix.The major importing countries, viz., the USA, Indonesia, Nepal, Niger, UAE and The Netherlands were considered for analysis. The remaining importing countries were pooled under the 'others' category. The row elements in the transitional probability matrix provide information on the extent of loss in trade to the competing countries depicted in the respective top columns. The column element indicates the probability of gains in volume of trade from other competing countries and the diagonal element indicates the probability of retention of the previous year's trade volume by the respective country.

Table 2. Transitional probability matrix for Indian cocoa exports, 2013-14 to 2022-23

Country	USA	Indonesia	Nepal	Nigeria	UAE	The Netherlands	others
USA	**0.2465**	0.2104	0.0000	0.0000	0.0000	0.0151	0.5280
Indonesia	1.0000	**0.0000**	0.0000	0.0000	0.0000	0.0000	0.0000
Nepal	0.0000	0.0000	**0.4419**	0.0000	0.0580	0.5001	0.0000
Nigeria	0.2277	0.0000	0.0000	**0.7328**	0.0000	0.0396	0.0000
UAE	0.5682	0.0000	0.0000	0.0000	**0.4318**	0.0000	0.0000
The Netherlands	0.0000	0.0000	0.0000	0.0000	0.1084	**0.0592**	0.8324
others	0.2051	0.0000	0.0713	0.0285	0.0292	0.0116	**0.6543**

It is evident from Table 2 that Nigeria was the most stable market among the major importers of Indian cocoa products, as reflected by the probability of retention of 0.7328 followed by Nepal and UAE with retentions of 0.4419 and 0.4318 of total exports from India. The USA and The Netherlands were the least stable markets with retentions of 0.2465 and 0.0592. The Indonesia is the most unstable market with zero retention. The 'others' retained 0.6543 of cocoa exports from India. The results are in line with the findings of Swamy*et al.*, 2017.

Actual and Predicted share of exports in Indian cocoa products

The market share projections of Indian cocoa product exports to the major importing countries were computed up to the year 2025–26 using the transitional probability matrix. The actual and predicted values of Indian cocoa product exports to major importers from 2014–15 to 2022–23 and projections up to 2025-26 are presented in Table 3. The actual share of exports toNigeria had shown huge fluctuation over the study period. In actual terms, it increased from 0.17 per cent to 6.91 per cent. A slightly different picture was in the prediction of export share too, where the increase was from 1.52 per cent to 5.80 per cent. The estimation for 2025–26 is expected to rise from 5.80 percent to 5.90 per cent.

Regarding the USA, the actual and predicted export share showed an increment from 21.87 per cent to 25.21 percent and 20.07 per cent to 25.21 per cent respectively. But, the estimation for 2025-26 suggested an approximate stagnancy by falling only by 0.14 per cent during the period ranging from 2022-23 to 2025-26.The actual proportion of Indonesia's market share of imports from India showed an increment from 3.07 per cent to 3.92 per cent. The predicted export share behaved stagnant by increasing slightly from 4.04 per cent to 4.05 per cent during the study. The estimation for 2025-26 suggested an increase from 4.05 per cent in 2022-23 to 5.32 per cent.

With respect to Nepal, the actual proportion of exports showed a significant decreasing trend, i.e., decreased from 13.40 per cent to 5.57 per cent. The predicted proportion also showed a significant decline in share from 11.42 per cent to 6.30 percent. Exports to Nepal are expected to reach a market share of 6.21 per cent by 2025-26. Regarding the UAE, both the actual and predicted market share of Indian cocoa product exports showed a slight increase from 4.35 per

cent to 4.44 per cent. The UAE is expected to further lose its market share by 0.43 per cent by 2025-26. The Netherlands, the actual and predicted market share of Indian cocoa product exports showed a significant decrease from 9.93 per cent to 4.44 per cent. The Netherlands is expected to see a slight increment in its market share of 0.10 per cent by 2025-26. The actual and predicted proportion of export shares of India's cocoa exports to ‘others’ showed a slightly different but similarly increasing trend from 47.20 per cent to 49.50 per cent and 48.68 per cent to 49.77 per cent respectively. It is expected that a 0.82 per cent loss awaits this group by 2025-26. Similar, results were reported by Thulasiram*et al.,* 2018.

Conclusion

When the complete picture of the past, current, and future scenarios of India's cocoa was observed, a contrasting picture of figures became known. Considerable upward growth in export quantity was evident there, showing a positive picture of the situation. Though this could be seen from different perspectives, the positive side would lead us to the vast opportunities that lie beyond India. By investing in productivity enhancing research and other necessary aspects, India can fairly increase its market share alongside other countries. Also, by focusing on countries such as Nigeria for higher quality products, exploring more trade options in Nepal, UAE and other countries that show a huge retention probability of their imports and growing market share, as predicted figures show, India can improve exponentially in this segment of its agricultural exports. As the agricultural balance of trade has always been a savior in terms of tackling the forex deficit, promoting cocoa product growth can further its reputation.

Table 3. Projection estimates of Indian cocoa exports to major destinations (Quantity in MT)

	USA		Indonesia		Nepal		Nigeria		UAE		The Netherlands		Others	
Year	**A**	**P**	**A**	**P**	**A**	**P**	**A**	**P**	**A**	**P**	**A**	**P**	**A**	**P**
2014-15	4566 (21.87)	3204 (20.07)	641 (3.07)	644 (4.04)	2798 (13.40)	1822 (11.42)	36 (0.17)	242 (1.52)	909 (4.35)	694 (4.35)	2074 (9.93)	1585 (9.93)	9854 (47.20)	7770 (48.68)
2015-16	6186 (18.94)	4312 (20.66)	1016 (3.11)	961 (4.60)	1872 (5.73)	1940 (9.29)	50 (0.15)	307 (1.47)	1736 (5.32)	1067 (5.11)	1786 (5.47)	1707 (8.17)	20007 (61.27)	10584 (50.69)
2016-17	5978 (23.31)	7643 (23.41)	796 (3.10)	1301 (3.99)	2121 (8.27)	2255 (6.90)	543 (2.12)	607 (1.86)	1122 (4.37)	1636 (5.01)	1074 (4.19)	1369 (4.19)	14015 (54.64)	17842 (54.64)
2017-18	6811 (23.02)	5906 (23.02)	2114 (7.15)	1258 (4.90)	2018 (6.82)	1937 (7.55)	780 (2.64)	797 (3.11)	1651 (5.58)	1133 (4.42)	246 (0.83)	1398 (5.45)	15964 (53.97)	13220 (51.54)
2018-19	8697 (31.51)	8183 (27.66)	2061 (7.47)	1433 (4.84)	1923 (6.96)	2031 (6.86)	435 (1.57)	1026 (3.47)	1233 (4.47)	1322 (4.47)	261 (0.95)	1342 (4.54)	12995 (47.08)	14245 (48.16)
2019-20	7773 (28.36)	7670 (27.79)	1818 (6.63)	1830 (6.63)	1705 (6.22)	1777 (6.44)	732 (2.67)	689 (2.50)	897 (3.27)	1051 (3.81)	1265 (4.62)	1276 (4.62)	13221 (48.23)	13311 (48.22)
2020-21	6695 (25.98)	7122 (25.98)	1159 (4.50)	1635 (5.97)	1594 (6.19)	1697 (6.19)	830 (3.22)	913 (3.33)	929 (3.61)	1009 (3.68)	2040 (7.92)	1227 (4.48)	12521 (48.59)	13807 (50.37)
2021-22	5255 (19.24)	6095 (23.65)	1637 (5.99)	1409 (5.47)	1595 (5.84)	1598 (6.20)	1608 (5.89)	965 (3.74)	1177 (4.31)	1080 (4.19)	1813 (6.64)	1197 (4.64)	14233 (52.10)	13425 (52.10)
2022-23	8636 (25.21)	6887 (25.21)	1342 (3.92)	1106 (4.05)	1908 (5.57)	1720 (6.30)	2368 (6.91)	1584 (5.80)	1521 (4.44)	1212 (4.44)	1520 (4.44)	1213 (4.44)	16955 (49.50)	13596 (49.77)
2023-24		8352 (24.39)		1817 (5.31)		2053 (5.99)		2218 (6.48)		1427 (4.17)		1464 (4.28)		16918 (49.40)
2024-25		8662 (25.29)		1757 (5.13)		2114 (6.17)		2108 (6.15)		1388 (4.05)		1523 (4.45)		16698 (48.75)
2025-26		8586 (25.07)		1823 (5.32)		2126 (6.21)		2020 (5.90)		1374 (4.01)		1555 (4.54)		16766 (48.95)

Note: A- Actual exports, P= Predicted exports, Figures in parentheses indicates percentage to total exports.

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