



RESEARCH ARTICLE

From farms to foreign markets: Assessing India's banana export performance and trade direction (2014-2024)

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Abstract

The banana (*Musa* sp.) is one of the most traded commodities on the international market and a significant commercial fruit crop, ranking above mango in trade volume. Globally, banana ranks first in production but third in cultivated area. In India Andhra Pradesh leads in banana area, production and productivity followed by Maharashtra and Tamil Nadu. The study aims to evaluate the export performance and instability index of bananas for the past ten years (2014-2024). It also forecasts the export trends in the upcoming years. The study is based on secondary data collected from the official websites for the period 2014-2024. Statistical tools such as Markov Chain analysis, Instability Index (II), Revealed Comparative Advantage (RCA), Revealed Symmetric Comparative Advantage (RSCA), Trade Specialization Index (TSI) and Nominal Protection Coefficient (NPC) were used to analyze the data. The result revealed that from the transition probability matrix, the UAE was the most stable importer and retained 100 % of its market share. Iraq retained 42.63 % of its imports, while 57.37 % shifted to the UAE, indicating trade diversification where, Iran had lost its market share entirely, with 41.92 % redirected to "Others," suggesting an unstable trade environment. The II categorized Iran (70.18 %), Iraq (31.97 %) and Saudi Arabia (39.09 %) as high-risk markets, while Oman (14.21 %) and the UAE (28.32 %) demonstrated relatively stable trade patterns. However, a strong recovery was observed in 2024, with an RCA of 1.31 and a positive RSCA value, reflecting enhanced global positioning. The TSI remained consistently close to positive throughout the decade, indicating India's specialization and status as a net exporter with minimal banana imports. The NPC showed a declining gap between domestic and international prices from 50.93 % in 2014 to 33.64 % in 2024, suggesting increased competitiveness and better returns for Indian farmers in global markets.

Keywords: banana; comparative advantage; export; forecast price; instability; Markov Chain; trends

Introduction

India often referred to as the "Fruit and vegetable basket of the world," ranks second globally in fruit and vegetable production, after China (1). India is the world's top producer of mango (45 %), banana (29 %), papaya (37 %), pomegranates, sapota and acid lime. In addition to having the highest grape productivity in the world (21.6 t/ha) (2).

Horticulture is one of the most dynamic sectors of Indian agriculture, providing opportunities for enhanced income, employment generation, reduced dependency on cereals and improved food and nutritional security (3). Among horticultural crops, banana (*Musa paradisiaca* L.), is a globally significant tropical fruit belonging the Musaceae family, it is often called the "Apple of paradise" with its name derived from the Arabic word "*banan*, meaning "finger" (4). Banana ranks as the fourth most important food crop globally after rice, wheat and maize, owing to its economic importance. It is also a rich source of essential nutrients, including calcium, potassium and phosphorus (5). It is

the most significant crops in terms of area, production, productivity and in export potential.

The major banana producing states in India include Andhra Pradesh, Maharashtra, Tamil Nadu, Gujarat, Karnataka, Madhya Pradesh, Uttar Pradesh and Bihar (6). In 2024, the primary export destinations for Indian bananas included the United Arab Emirates, Iran, Saudi Arabia, Qatar, Kuwait, Oman, Bahrain and Nepal. As bananas are available year-round, farmers have the flexibility to export during periods of low domestic demand, ensuring consistent income (7).

The present study aims to analyze the growth performance of banana cultivation and trade in India, with a focus on evaluating its export potential and global competitiveness. Specifically, the objectives are: first, to assess the export competitiveness and examine the direction of trade of bananas from India; second, to analyze the instability in banana trade and forecast future trade trends for the next four years; and finally, to evaluate India's trade position by employing key trade indices such as the RCA, RSCA, TSI and

NPC. These analytical tools will provide a comprehensive understanding of India's standing in the global banana market and offer insights into policy formulation for enhancing export performance.

Materials and Methods

This study analyzes India's banana exports over a 10-year period (2014-2024), focusing on their significant contribution to the overall value of agricultural export. Annual time series data of export quantity, export value, export destinations, as well as area and production statistics, were collected from various official sources, including IndiaStat, the Food and Agricultural organization (FAO), the National Horticultural Board (NHB), the Directorate General of Foreign Trade (DGFT), the Agricultural and Processed Food Products Export Development Authority (APEDA) and Ministry of Agriculture and Farmers Welfare.

The following analytical tools and techniques were employed to evaluate the export performance and competitiveness of bananas from India:

Markov Chain analysis

Instability Index (II)

Revealed Comparative Advantage (RCA) and Revealed Symmetric Comparative Advantages (RSCA)

Trade Specialisation Index (TSI)

Nominal Protection Coefficient (NPC)

Markov Chain analysis

The Markov Chain approach was employed to analyze the direction of banana trade from India by assessing structural changes in export shares to various importing countries. The main goal of estimating trade matrices was to identify the key connections between importing nations. Using Markov Chain analysis, the systemic change in any structure whose improvement over time can be assessed in terms of a single outcome variable was examined. In Markov Chain analysis, a transitional probability matrix 'P,' with components P, ij, representing the probability of exports moving from nation 'i' to country 'j' over time, is designed.

In the context of selected importing nations, changes in export shares were assumed to follow a process. It was considered that the average export volume to a particular country is a random variable influenced only by historical export patterns to that country. This assumption underpins the use of the Markov process in modeling trade transitions, which may be expressed in Eqn. 1 as:

$$E_{jt} = \sum_{i=1}^I E_{it-1} P_{ij} + e_{jt} \quad (\text{Eqn. 1})$$

Where

E = Exports of banana from India to j the country jt th during the year t

E = Exports of banana from India to i the country it-1 th during the period t-1

P = Probability that the exports will shift from i country ij th to j country th

e = The error term which is statistically independent of E jt it-1

t = number of years studied for the analysis

r = number of importing countries

However, estimates of each country's proportion of exports during the period (t-1) were produced by multiplying transitional probabilities by shipments to these nations in the prior year.

Instability analysis

To examine the extent of variability in the export of banana fruits in India, the Cuddy-Della Valle Index (CDVI) was used (8) and expressed in Eqn. 2 as:

$$\text{CDVI index (\%)} = \text{CV} \times \sqrt{(1-R)^2} \quad (\text{Eqn. 2})$$

Where;

CV = Coefficient of variation (in percent)

R squared = Coefficient of determination from a time-trend regression adjusted by the number of degrees of freedom. The range and interpretation for CDVI as (9);

CDVI= 0 to 15= Low instability

30<CDVI>15= Medium instability

CDVI>30= High instability

Revealed Comparative Advantage

A method to calculate the revealed RCA of the country trade patterns for any item was created (10). This index can be used to determine which commodities and country has a comparative advantage in and expressed in Eqn. 3 as:

$$\text{RCA} = (X_{ij}/X_{wj}) / (X_i/X_w) \quad (\text{Eqn. 3})$$

Where

Xij denotes the exports of commodity 'i' in country 'j'

Σi Xij denotes the total exports of country 'j'

Σ j Xij signifies the world exports of commodity 'i'

Σj Σi Xij denotes the total world exports

If the RCA index is less than 1, it means that India's exports make up a lesser percentage of the nation's total export business than its share of global trade. If the RCA index is greater than 1, it indicates that the country has a comparative advantage in that specific commodity since its import-export shares are higher than global shares.

Revealed Symmetric Comparative Advantages (RSCA)

To solve the issue of double counting refers to a situation where the same trade values (especially exports) are included multiple times across various calculations, leading to distorted or inflated results. An additional method of assessing a country's competitiveness and expressed in Eqn. 4 as (11):

$$\text{RSCA}_{ij} = [\text{RCA}_{ij} - 1] / [\text{RCA}_{ij} + 1] \quad (\text{Eqn. 4})$$

To avoid zero issues, the values of this index fall between -1 and +1. Both stability and a country's capacity to compete are indicated by positive index numbers. This measurement also shows how long-lasting the specific products.

Trade Specialisation Co-efficient (TSC)/Lafay index

The TSC index, also known as Lafay index was used to determine how competitive Indian exports were during the study periods (12). The following is a representation of the TSC index expressed in Eqn. 5 as:

$$\text{TSC} = [X_{ij} - M_{ij}] / [X_{ij} + M_{ij}] \quad (\text{Eqn. 5})$$

Where,

X_{ij} represents the total exports of the commodity

M_{ij} represents the total imports of the commodity

This index shows the proportion of a country's trade balance (changes between imports and exports) to the total trade value (cumulative value of imports and exports) for that specific item. The index ranges between -1 and +1. The value of this index equals 'zero' when a commodity's exports are equal to its imports.

When the index is positive, it means that the nation exports more of a given commodity than it imports. Therefore, this metric shows how well a certain commodity's imports and exports are balanced and it's a good way to compare trends over a longer time frame.

Nominal Protection Coefficient (NPC)

However, previous works argued that comparative advantage should be further developed into competitive advantage in the philosophy of international commerce (13). At best, price-cost comparisons serve as early predictors of competitiveness. NPC indexes control the commodity's level of import and export competition and quantify the difference between domestic and foreign prices. It is expressed in Eqn. 6 as:

$$NPC = P_d / P_b \quad (\text{Eqn. 6})$$

Where,

P_d = Domestic price index of commodity i

P_b = World reference price index of commodity i

A product that has an NPC less than one is not protected, whereas one that is more than one shows that producers are receiving operational incentives related to free trade. In the same way, a commodity with an NPC <1 is exportable and export competitive. A commodity that is importable and not export competitive is indicated by an NPC greater than 1.

Results and Discussion

India is one of the leading producers and exporters of banana in the world. To understand the dynamics of banana export and to assess the structural shifts in the direction of trade over time, Markov Chain analysis was employed. This technique is particularly effective in estimating the probability of banana exports being retained in or diverted from one importing country to another over the study period.

Direction of trade of banana from India

Markov Chain analysis was used to examine structural changes in trade patterns over time, based on a single outcome variable the export shares. The transitional probability matrix derived from this analysis helped to predict potential changes in future trade flows. The matrix explained the switching behaviour of banana among the major importing countries over a period of time indicating the change in direction. The trend in sustaining the existing market and the gains and loss period banana from India by major importing countries were obtained from the transition probability matrix (14).

The major importing countries considered for the

analysis were Iraq, Iran, the United Arab Emirates (UAE), Oman and Saudi Arabia. The export to remaining countries were pooled under group name of other countries.

Transition probability matrix for India (export of banana)

The transition matrix for banana exports reveals significant shifts in market retention and trade redirection among major importers (15). The analysis indicates Iraq, Iran, UAE, Oman, Saudi Arabia and "Others" as key players in the banana trade from the exporting country. Table 1 summarizes the direction of trade during the study period (2014-2024) by using Eqn. 1.

Iraq had retained 42.63 % of its export share, while the remaining 57.37 % was diverted to the UAE. This indicated a major trade shift, as more than half of Iraq's banana imports were redirected. Iran experienced a complete market loss to the UAE, Oman and "Others", retaining none of its previous import share. While 9.68 % of Iran's earlier share had shifted to Iraq, a significant 23.34 % moved to the UAE, 25.05 % to Oman and 41.92 % to "Others", suggesting a highly unstable market for Iran in banana imports. The UAE emerged as the most stable market, having retained 100 % of its previous banana import share and gained an additional 23.34 % from Iran. This reflected the UAE's strong and consistent demand for banana imports. Oman retained only 10.74 % of its market share, having lost a significant 89.26 % to Others. However, it gained 25.05 % of Iran's lost market share, showing a moderate shift in import trends. Saudi Arabia retained 93.99 % of its banana import market, indicating stability, but it lost 6.01 % to Oman, suggesting a minor trade redirection. The "Others" category absorbed major market share shifts, gaining 41.92 % from Iran and 89.26 % from Oman; however, it failed to retain any of its previous import share, indicating instability in banana imports for this segment.

Forecast for the next four years

Analyzing the export trends of bananas to key Middle Eastern countries-Iraq, Iran, UAE, Oman, Saudi Arabia and "Others". The instability in India's banana exports to various countries was assessed using the coefficient of variation and the instability based on the results from the Table 2. The comparative performance of India in this sector was evaluated by analyzing its share of banana exports within total agricultural exports relative to international trade patterns assuming no significant trade disruptions. Iraq and Saudi Arabia exhibited a declining trend, with steadily decreasing import volumes, possibly due to trade constraints or changing consumer preferences. Oman showed signs of steady growth, likely surpassing 30000 metric tons, while the UAE experienced a decline after peaking in 2024. Meanwhile, the "Others" category expanded, indicating new export opportunities

Table 1. Transition probability matrix for India export of banana

	Iraq	Iran	UAE	Oman	Saudi Arabia	Others
Iraq	0.4262	0.0000	0.5737	0.0000	0.0002	0.0003
Iran	0.096795	0.0000	0.2334	0.2505	0.0000	0.4192
UAE	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
Oman	0.0000	0.0000	0.0002	0.1073	0.0000	0.8926
Saudi Arabia	0.0000	0.0000	0.0000	0.0000	0.9398	0.0602
Others	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000

Source : (22)

Table 2. Forecasting for the next four years

YEAR	Iraq	Iran	UAE	Oman	Saudi Arabia	Others
2023	54179	70818	43354	16902	12326	43508
2024	29950	86863	47616	20299	11585	44776
2025	21175	92392	37461	24639	10888	54533
2026	17969	91995	33717	26448	10233	60725
2027	16564	94443	31785	26504	9618	62174

beyond traditional markets, possibly exceeding 70000 metric tons in the following years. These trends underscore the importance of strategic diversification, enhanced trade facilitation and maintaining product quality to ensure sustained growth in India's banana export sector.

Instability Index (II)

The instability in India's banana exports to various countries was assessed using the coefficient of variation and the II (16). As shown in Table 3 by using the Eqn. 2, banana exports to Iran (70.19 %), Iraq (31.98 %) and Saudi Arabia (39.10 %) had higher instability. This might have been due to geopolitical factors, economic sanctions, trade policies, or fluctuations in demand and supply. The UAE recorded a moderate II of 28.32 %, indicating relatively consistent trade with occasional fluctuations, possibly influenced by regional trade dynamics and policy changes.

The lowest II was recorded in Oman (14.21 %), indicating steady and reliable export patterns. Stable demand, robust trade agreements and advantageous economic conditions that fostered long-term trade relationships might have been responsible for this. Overall, while preserving and growing trade ties with comparatively stable markets like Oman and the UAE, exporters were advised to consider risk mitigation strategies when dealing with highly unstable markets like Saudi Arabia, Iran and Iraq.

Table 3. Instability Index

S. No	Country	Average export (tonnes)	Coefficient variation (percentage)	Instability Index (percentage)	Interpretation
1	Iran	13298.48	168.82	70.18	High
2	Iraq	19848.24	90.36	31.97	High
3	UAE	17326.08	62.65	28.32	Medium
4	Oman	8129.45	57.21	14.21	Low
5	Saudi Arabia	5902.81	47.55	39.09	High

Revealed Comparative Advantage (RCA) and Revealed Symmetric Comparative Advantage (RSCA)

India's banana exports fluctuated significantly in value and quantity throughout the years. The comparative performance of India in this sector was evaluated by analyzing its share of banana exports within total agricultural exports relative to international trade patterns (17). Tools such as the RCA and RSCA indices were used to understand this dynamic and were presented in the table by using Eqn. 3 & 4.

The RCA and RSCA trends indicated that India's comparative advantage in banana exports had been inconsistent over the years. As shown in Table 4 India recorded an RCA of 0.13 in 2014, indicating no comparative advantage in that year.

Table 4. India's banana export competitiveness using RCA & RSCA indices

India's banana export competitiveness using RCA & RSCA indices (2014-2024)

Year	India export quantity in '000 tonnes		World export quantity in '000 tonnes		RCA	RSCA
	Banana	Agri. products	Banana	Agri. products		
2014	54.65	20698.15	27074.47	1416660.82	0.13	-0.75
2015	80.90	8261.87	20756.64	1676925.88	0.79	-0.11
2016	113.93	1117.62	139801.71	1489125.79	1.08	0.04
2017	92.37	965.87	178197.43	1530327.45	0.82	-0.09
2018	116.74	487.97	74358.86	1732121.76	1.55	0.69
2019	174.66	27987.42	27435.66	780893.51	0.17	-0.69
2020	212.83	38746.12	27671.49	791035.69	0.15	-0.72
2021	341.54	51971.19	26102.81	802500.10	0.20	-0.66
2022	363.87	44265.84	24117.82	1665998.39	0.56	-0.27
2023	499.56	50481.16	24133.92	1781985.85	0.73	-0.15
2024	764.77	37840.77	19385.13	1640228.17	1.31	0.13

This explained that India's share of banana exports was significantly lower than its global share of agricultural exports, possibly due to limited infrastructure, lack of access to global markets and quality concerns.

From 2015 to 2018, RCA values improved (reaching 1.55 in 2018), indicating that India gained comparative advantage during those years. This improvement may be attributed to expanded export markets, enhanced pre- and post-harvest practices and supportive government interventions (13, 14). However, a drastic decline occurred in 2019 and 2020, with RCA dropping to 0.17 and 0.15 respectively. This was largely due to the COVID-19 pandemic, during which trade and logistical disruptions significantly affected perishable goods exports (18). Additionally, a global oversupply of bananas, particularly from Latin American exporters, intensified the competitive pressure on Indian exports.

From 2021 to 2023, RCA values began recovering steadily, reaching 0.73 in 2023. This moderate recovery reflected resilience in the export sector and improvements in logistics and quality control. Programs such as the development of cold chain logistics, GI tagging of banana varieties and cluster development schemes played a role in revitalizing exports.

In 2024, the RCA increased to 1.31, marking a return to comparative advantage. This was likely due to diversification into high-demand international markets (e.g., UAE, Iran and Europe), with exporters adopting traceability systems and sustainable packaging to meet international standards (19).

Trade Specialization Index (TSI) /Lafey Index

The following table presents data on banana exports and imports from the year 2014 to 2024, expressed in '000 tonnes. The data is used to calculate TSI also referred to as the Lafey Index, which measures a country's level of specialization in the trade of a particular commodity. The TSI values range from -1 to +1 (20) and the results are tabulated in Table 5 by using Eqn. 5.

The TSI values were extremely high, ranging from 0.9998 to 1.0000, indicating that India was highly specialized in banana exports and played a dominant role as an exporter with very limited or no dependency on imports, reflecting a high level of trade competitiveness and self-sufficiency in this

Table 5. TSI /Lafey Index

Year	Banana export In 000'tonnes	Banana import In 000'tonnes	TSI
2014	54.657	0.004	0.9999
2015	80.905	0	1.0000
2016	113.936	0	1.0000
2017	92.375	0	1.0000
2018	116.741	0	1.0000
2019	174.668	0	1.0000
2020	212.831	0.02	0.9998
2021	341.543	0	1.0000
2022	363.879	0	1.0000
2023	499.561	0	1.0000
2024	764.774	0	1.0000

sector. Export quantities showed a steady and significant increase from 54.657 thousand tonnes in 2014 to 764.774 thousand tonnes in 2024, while imports remained negligible, with minimal values recorded only in 2014 (0.004 thousand tonnes) and 2020 (0.02 thousand tonnes). The near-perfect TSI values close to +1 each year confirmed that India had been a net exporter of banana.

Nominal Protection Coefficient (NPC)

Table 6 presents international and domestic prices of banana in India from 2014 to 2024, along with the calculated NPC. The NPC provides insights into the level of price protection domestic producers receive in comparison to international markets. An NPC value below 1 indicates that domestic prices are lower than international prices, while an upward trend in NPC suggests improving price realization for farmers over time.

The results from Table 6 by using Eqn. 6 revealed that the NPC for bananas in India remained below 1 throughout the 2014-2024 period, indicating that domestic prices were consistently lower than international prices (21).

However, the NPC showed a gradual increase from 0.49 in 2014 to 0.66 in 2024, reflecting a narrowing gap between domestic and global prices. This improvement implied that Indian farmers had been receiving relatively better prices over time, possibly due to enhanced market linkages or supportive policies.

The percentage difference between international and domestic prices, represented by $(1 - \text{NPC}) \times 100$, declined steadily from 50.93 % to 33.64 %, further emphasizing the improving trend. While domestic prices showed a steady upward trend, international prices appeared to stabilize after 2020. Overall, the data suggested growing competitiveness of Indian banana in the global market and a positive shift toward improved price realization for domestic producers.

Table 6. Nominal Protection Coefficient: (All prices in ₹/tonne)

Year	International price	Domestic price	NPC	!-NPC*100
2014	638.6	313.3	0.49	50.93
2015	636.2	310.4	0.48	51.21
2016	539.7	283.4	0.52	47.48
2017	544.2	307.8	0.56	43.43
2018	477.5	285.5	0.59	40.20
2019	436.7	262.6	0.60	39.86
2020	475.3	296.1	0.62	37.70
2021	490.0	310.0	0.63	36.73
2022	505.0	325.0	0.64	35.64
2023	520.0	340.0	0.65	34.61
2024	535.0	355.0	0.66	33.64

Source:(1 & 18).

Conclusion

India is one of the largest producers of banana in the world, contributing significantly to the global banana supply. Over the past decade, the country has increasingly focused on tapping the export potential of bananas, aiming to generate higher income through international trade and value addition. This study analyzed India's banana export trends from 2014–2024 to assess trade patterns, market dynamics and prospects.

The use of Markov Chain analysis revealed shifts in export destinations, with the UAE emerging as the most stable and dominant importer, while countries like Iran and Iraq displayed high instability. Oman stood out with the lowest II, indicating strong market reliability. Forecasts suggest potential recovery in Iran's imports, while Iraq and Saudi Arabia may decline, prompting the need for market diversification. India's competitiveness, as measured by RCA and RSCA, improved significantly by 2024, reflecting stronger global integration and better policy support.

The TSI remained consistently near positive throughout the decade, reflecting India's specialization and status as a net exporter with minimal banana imports. Moreover, the NPC reflected a steady narrowing of the price gap between domestic and international markets from 50.93 % in 2014 to 33.64 % in 2024 suggesting increased trade competitiveness and improved price realization for Indian farmers.

To sustain growth, India must enhance supply chains, diversify export destinations and maintain quality standards. With supportive policies and strategic trade interventions, India has strong potential to strengthen its leadership in global banana exports while ensuring inclusive growth for its farming community.

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Authors' contributions

SKN contributed to collecting data, writing and original draft preparation. UK and MM helped in guiding for preparing the manuscript, reviewing and supervision the entire article. VA, AV and KM helped in summarizing and revising the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

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