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GROWTH, INSTABILITY AND DIRECTION OF INDIA'S CASHEW EXPORTS: A MARKOV CHAIN ANALYSIS

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ABSTRACT

Cashew is one of India's important export-oriented plantation crops, contributing significantly to foreign exchange earnings and rural livelihoods. The present study examined the growth, instability and direction of trade in India's cashew exports to major importing countries during the period 2015–16 to 2024–25. Secondary data on export quantities were collected from APEDA and analysed using the Compound Annual Growth Rate (CAGR), the Cuddy–Della Valle Instability Index (CDVI), and Markov Chain analysis. The results revealed that Vietnam emerged as the fastest-growing market with a significant CAGR of 16.30 per cent, while Spain recorded a marginal positive growth of 1.54 per cent, which was statistically non-significant. In contrast, exports to the USA (-20.31%), Belgium (-15.16%), the Republic of Korea (-10.71%), Saudi Arabia (-8.87%), Germany (-8.73%), Japan (-4.24%), the Netherlands (-4.08%) and the UAE (-3.95%) exhibited declining growth trends. Instability analysis indicated that the Republic of Korea (48.30%), Belgium (33.04%) and the USA (31.12%) experienced relatively higher export instability, whereas Saudi Arabia (9.90%), the UAE (14.10%) and Japan (15.55%) showed comparatively lower instability. Markov Chain analysis revealed that Vietnam was the most stable export destination, retaining 90 per cent of its previous import share, followed by the UAE (59%) and the USA (56%). The findings suggest that while Vietnam has emerged as a reliable and expanding market for Indian cashew exports, several traditional destinations have experienced declining demand and market retention. Therefore, strengthening trade relations with stable markets, diversifying export destinations, promoting value-added cashew products and improving export competitiveness are essential for sustaining India's position in the global cashew trade.

Keywords : Cashew export, Growth, Instability, Markov chain analysis, trade direction.

Introduction

Cashew (*Anacardium occidentale* L.) is an important tropical plantation crop belonging to the family Anacardiaceae and is widely recognised for its economic and commercial significance. Native to eastern Brazil, the crop was introduced to several tropical regions of the world by Portuguese explorers. In India, cashew was first introduced in Goa during the sixteenth century and subsequently spread to other parts of the country. Initially cultivated for soil conservation and erosion control, the crop gradually evolved into a high-value commercial commodity because of its adaptability, profitability, and increasing

demand in domestic and international markets (Bhagya *et al.*, 2025).

The cashew industry generates several commercially valuable products, including raw cashew nuts, cashew kernels, cashew nutshell liquid (CNSL) and cashew apples. Among these, cashew kernels constitute the most important export product and are obtained through processing operations such as roasting, shelling, peeling, grading and packaging. Cashew is cultivated in more than 30 countries across Asia, Africa, Latin America and Australia and has emerged as an important commodity in international agricultural trade (Juneja *et al.*, 2026). India occupies a prominent position in the global cashew trade

(Guledgudda *et al.*, 2024) and exports cashew kernels to more than 60 countries worldwide. Major export destinations include the United States, the Netherlands, Japan, Spain, Germany, the United Kingdom, Saudi Arabia, and the United Arab Emirates, reflecting the growing global demand for Indian cashew products (Nikitha, 2022).

India is one of the leading producers, processors and exporters of cashew in the world. The increasing global demand for cashew products has significantly contributed to the expansion of the country's export sector. The Cashew Export Promotion Council of India (CEPCI) has played a crucial role in promoting exports and supporting industry development through market promotion and policy advocacy initiatives. As of 2020, cashew was cultivated on approximately 1.02 million hectares in India, with an average productivity of 706 kg ha⁻¹. Maharashtra, Andhra Pradesh, Odisha, Kerala and Karnataka are the major cashew-producing states in the country. India accounts for more than 15 per cent of global cashew exports (Torane *et al.*, 2023) and continues to maintain a strong presence in international markets. During 2021–22, the value of India's cashew exports increased from US\$ 420 million to US\$ 452 million, indicating the growing importance of the sector in generating foreign exchange earnings (Bhagya *et al.*, 2025).

The global cashew market is expected to witness steady growth owing to increasing consumer preference for healthy and nutritious food products. However, the COVID-19 pandemic posed significant challenges to the global cashew value chain. Restrictions on transportation, disruptions in supply chains, labour shortages, and delays in processing and shipment adversely affected the movement of raw and processed cashew products. West African countries, which are major suppliers of raw cashew nuts to processing hubs such as India and Vietnam, experienced severe logistical constraints during the pandemic. Consequently, kernel availability and export performance were affected in several countries. Nevertheless, the long-term outlook for the global cashew industry remains promising, with demand expected to increase substantially in the coming decades (Nikitha, 2022).

Despite the economic importance of cashew exports, fluctuations in export growth and changing trade patterns across importing countries continue to influence India's competitiveness in the global market. Therefore, an understanding of export growth, instability and market retention behaviour is essential for developing effective export strategies. Although several studies have examined the growth performance

and export competitiveness of Indian cashew, limited attention has been given to long-term export direction and market retention behaviour using Markov Chain analysis (Guledgudda *et al.*, 2024; Torane *et al.*, 2023). In this context, the present study was undertaken to analyse the growth performance, instability and direction of India's cashew exports using Compound Annual Growth Rate (CAGR), Coefficient of Variation (CV), Cuddy-Della Valle Instability Index (CDVI) and Markov Chain analysis.

Materials and Methods

Data Source: The study was based on secondary data about India's cashew exports collected from the Agricultural and Processed Food Products Export Development Authority (APEDA). The cashew products exported from India are Cashew Kernel, Cashew Nuts Fresh/Dried In Shell, Cashew Nuts Roasted/Value Added and Cashew Shell Liquid (Cnsl). Thus, the export of all these products was considered in the study.

Annual export data for the period 2015–2025 were compiled for the major importing countries of Indian cashew products. The top ten importing countries were selected based on their average share in India's cashew exports during the past 25 years (2000–2025). The selected countries included Vietnam, United Arab Emirates, United States of America, Japan, Netherlands, Saudi Arabia, Republic of Korea, Spain, Germany and Belgium. These export destinations were selected by sorting all the export destinations from the highest to the lowest for a period of 25 years.

Analytical Tools: To examine the growth performance, instability and direction of India's cashew exports, Compound Annual Growth Rate (CAGR), Coefficient of Variation (CV), Cuddy–Della Valle Instability Index (CDVI), and Markov Chain Analysis were employed.

Compound Annual Growth Rate (CAGR): To understand the trend in India's cashew exports, CAGR (Audichy *et al.*, 2017; Nidhishree & Deka, 2024) was estimated, keeping the base year as 2000 and the recent year as 2026. The growth rate was calculated from the exponential function given below;

$$Y = ab^t_e$$

$$\text{Log } y = \text{Log } a + t \text{ Log } b$$

$$\text{CAGR (\%)} = (\text{Antilog } b - 1) * 100$$

Where, CAGR = Compound Annual Growth Rate; t = Time period in years; y = Export quantity in Metric Tons; a & b = Regression parameters.

Cuddy Della Valle Index: The Cuddy Della Valle Index is used in this study to measure instability. Cuddy and Valle (1978) constructed CDVI to measure instability in time series data with a trend. The estimated form of the equation is as follows:

$$CDVI = CV * \sqrt{1 - \bar{R}^2}$$

Here, $\bar{R}^2$ stands for the coefficient of Determination from time trend regression adjusted by the number of d_f (Degrees of Freedom) and CV stands for the coefficient of Variation in Per cent

$$CV = \left(\frac{\text{Standard deviation}}{\text{Mean}} \right) * 100$$

The Cuddy-Della Valle index indicates minimal instability (0-15%), medium instability (15-30 %), and high instability (>30%) (Ramoliya *et al.*, 2022; Bashir *et al.*, 2023; Dhungana *et al.*, 2024).

Markov Chain Analysis: Based on the previous 26 years' data, the Transitional Probability Matrix (TPM) was constructed using LPSolve IDE software version 5.5.2.11. The Markov chain was developed based on the matrix value using Python software (Khorajiya *et al.*, 2018). The basic property of a Markov chain is that only the most recent point in the trajectory affects what happens next.

It means that X_{t+1} depends upon X_t , but it does not depend upon $X_{t-1} \dots X_1, X_0$. We formulate the Markov Property in mathematical notation as follows:

$$P(X_{t+1}=s | X_t=s_t, X_{t-1}=s_{t-1} \dots X_0=s_0) = P(X_{t+1}=s | X_t=s_t),$$

For all $t = 1, 2, 3 \dots$ and for all states $s_0, s_1 \dots s_t, s$.

The off-diagonal component A_{ij} ($i \neq j$), shows the probability of the i^{th} state moving to the j^{th} state. While the diagonal element A_{ij} ($i=j$) shows the probability of holding in the current state (Powrel & Mishra, 2024).

Results and Discussion

Growth and Instability in India's Cashew Exports:

The growth and instability analysis of India's cashew exports to major importing countries during 2015–16 to 2024–25 revealed substantial differences in export performance across destinations. Figure 1 represents the trend of cashew imports in the top importing countries for the past ten years.

Figure 1 presents the mean export quantity of Indian cashew exports to major importing countries during the study period (2015–16 to 2024–25). The results indicate considerable variation in the average quantity exported across destination markets. Among the selected markets, Vietnam emerged as the largest importer of Indian cashew with a mean export quantity of 16,113.04 MT, followed by the UAE (15,466.79

MT) and the USA (8,626.81 MT). The increasing prominence of Vietnam reflects its position as the world's leading cashew processing and re-export hub, which has strengthened its demand for imported cashew kernels and raw materials. Recent global trade reports indicate that Vietnam continues to dominate international cashew processing and exports, accounting for a major share of world cashew trade (Asemconnect Vietnam, 2025).

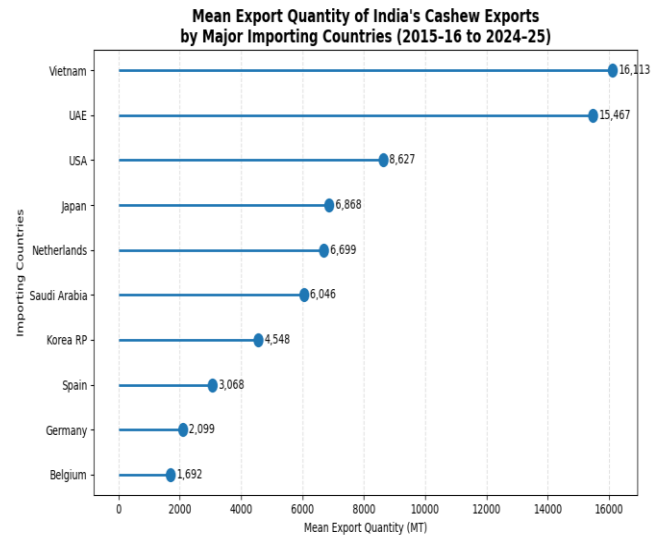


Fig. 1: Mean Export Quantity of India's Cashew Exports
Source: Lollipop Chart generated by the author

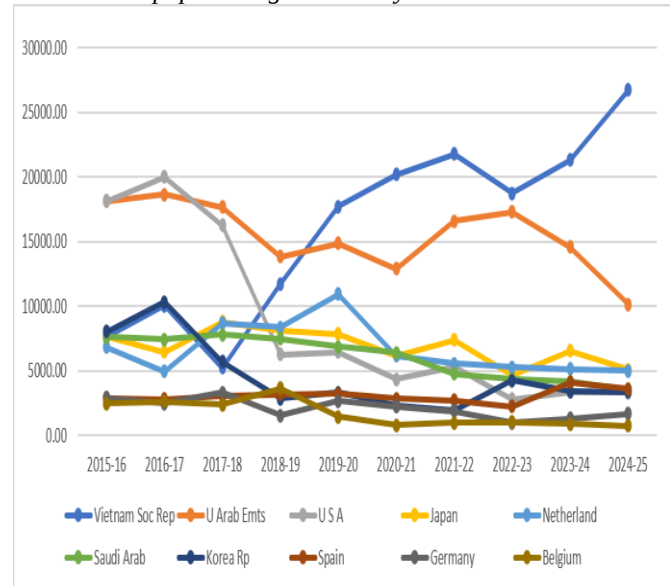


Fig. 2 : Trend in the import of Cashew in top 10 importing countries (Qty in MT)

Source: Line Graph generated by the author

The compound annual growth rate (CAGR) analysis showed that Vietnam recorded the highest and statistically significant growth rate (16.30%, $p < 0.01$), indicating a sustained increase in India's export quantity to this market. The positive growth may be attributed to the expansion of Vietnam's processing industry and increasing integration within global

cashew value chains. Spain also recorded a marginal positive growth rate (1.54%), although the trend was statistically non-significant ($p=0.43$), suggesting stagnation rather than expansion (Table 1).

In contrast, most traditional importing countries exhibited declining growth trends. The USA recorded the sharpest decline with a CAGR of - 20.31 per cent, followed by Belgium (- 15.16%), Korea RP (- 10.71%), Saudi Arabia (- 8.87%), Germany (- 8.73%), Japan (- 4.24%) and UAE (- 3.95%) (Table 1). The significant negative growth observed in these markets indicates declining competitiveness of Indian cashew exports and increasing competition from countries such as Vietnam and African producers. The growing efficiency and mechanisation of Vietnam's cashew industry have enabled it to strengthen its position in global markets, thereby affecting India's market share in several developed economies (The Times of India, 2025).

The Coefficient of Variation (CV) and Cuddy-Della Valle Instability Index (CDVI) were used to assess export instability. The USA exhibited the highest variability with a CV of 77.99 per cent and a CDVI of 31.12 per cent, indicating substantial fluctuations in export quantity over the study period. Belgium (CV: 59.38%; CDVI: 33.04%) and Korea RP (CV: 59.57%; CDVI: 48.30%) also displayed high instability (Table 1). Such fluctuations may be attributed to changes in consumer demand, international price volatility, competition from alternative suppliers, and trade policy adjustments. Similar observations regarding instability in cashew export markets have been reported in recent studies on India's cashew trade (Shanker *et al.* 2025).

On the other hand, relatively stable export performance was observed in the UAE (CV: 17.42%; CDVI: 14.10%), Spain (CV: 16.54%; CDVI: 16.82%) and Japan (CV: 19.19%; CDVI: 15.55%) (Table 1). Lower instability values indicate stronger and more consistent trade relationships with these markets. The UAE, in particular, remains an important and dependable destination for Indian agricultural exports due to its strategic position as a regional trading and redistribution centre.

Thus, the findings indicate a structural shift in India's cashew export destinations from traditional developed markets towards emerging Asian markets, particularly Vietnam. While Vietnam offers significant opportunities due to its expanding processing sector, excessive dependence on a single market may expose exporters to external shocks and trade uncertainties. Therefore, efforts should be directed towards

diversifying export destinations, strengthening value-added cashew products, improving quality standards, and enhancing competitiveness in traditional markets such as the USA, Germany and Japan. Market diversification and product differentiation are essential for ensuring stable and sustainable growth in India's cashew export sector (Rangasamy, 2025). Furthermore, investments in research, modern farming practices, and farmer training are critical for increasing yields and maintaining India's competitive advantage in the global cashew market (Bhagya *et al.*, 2025). Sustainable farming practices, combined with policy support for modernisation, will ensure the continued growth of the cashew industry, making it more profitable and resilient.

The transition probability matrix (TPM) was estimated using the Markov Chain approach to examine the stability and direction of India's cashew export markets during the study period. In a TPM, the diagonal elements represent the probability of retaining market share (market loyalty), whereas the off-diagonal elements indicate gains or losses in market share among competing importing countries. Higher diagonal values signify greater market stability and reliability (Nidhishree *et al.* 2025; Yousafzai *et al.* 2022) (Table 2).

The results presented in Table 2 reveal that Vietnam emerged as the most stable and loyal market for Indian cashew exports, retaining 90 per cent of its import share over the study period. This exceptionally high retention probability indicates a strong and consistent trade relationship between India and Vietnam. The finding is particularly significant as Vietnam has become a major global hub for cashew processing and re-export, thereby generating sustained demand for imported cashew kernels. Among the other importing countries, the United Arab Emirates (0.59) and the United States (0.56) also exhibited relatively high retention probabilities, indicating moderate market stability. In contrast, Japan, the Netherlands, Saudi Arabia, and Germany recorded zero retention probabilities, indicating the absence of market loyalty during the study period. This suggests that India's export shares in these markets were highly vulnerable to competitive shifts and changing import patterns. Likewise, Belgium retained only 4 per cent of its market share, reflecting a highly unstable import market. Such low retention probabilities indicate that these markets are susceptible to diversion of trade towards competing suppliers and alternative destinations. Similar observations of unstable market behaviour in cashew exports have been documented in previous Markov chain studies (Kandeeban & Mahendran, 2019).

Table 1: Growth and Instability in India's Cashew Exports (Quantity in MT is given below for 10 years)

Year	Vietnam	UAE	U S A	Japan	Netherland	Saudi	Korea Rp	Spain	Germany	Belgium
2015-16	7634.33	18149.23	18129.74	7617.64	6841.04	7626.46	8029.23	2909.11	2898.95	2481.82
2016-17	10043.17	18640.05	20013.97	6445.25	4968.11	7426.22	10337.58	2792.93	2485.16	2597.85
2017-18	5225.49	17658.41	16245.51	8790.03	8713.97	7826.69	5720.88	3025.29	3312.73	2365.79
2018-19	11747.73	13832.28	6275.31	8081.88	8382.54	7483.41	2859.54	3185.92	1548.00	3628.86
2019-20	17722.83	14865.88	6469.95	7840.31	10929.37	6892.01	3328.72	3237.96	2661.14	1456.39
2020-21	20184.63	12893.33	4342.09	6178.86	6156.62	6378.10	2278.15	2868.81	2228.30	772.56
2021-22	21784.18	16610.75	5321.36	7393.51	5579.86	4769.83	1961.61	2702.49	1882.00	959.30
2022-23	18739.62	17274.96	2791.98	4665.93	5282.72	4344.39	4228.39	2258.25	975.19	1017.32
2023-24	21302.64	14590.92	3351.98	6550.33	5129.51	4176.85	3386.65	4098.41	1303.33	880.83
2024-25	26745.73	10152.12	3326.28	5113.29	5009.56	3533.99	3351.10	3599.47	1691.55	754.59
MEAN (Qty in MT)	16113.04	15466.79	8626.81	6867.70	6699.33	6045.79	4548.18	3067.86	2098.63	1691.53
SD	7028.06	2693.92	6728.45	1317.99	2018.71	1659.78	2709.58	507.58	745.92	1004.40
CV (%)	43.62	17.42	77.99	19.19	30.13	27.45	59.57	16.54	35.54	59.38
ADJ R ²	0.71	0.34	0.84	0.34	0.11	0.87	0.34	-0.03	0.46	0.69
CDVI (%)	23.51	14.10	31.12	15.55	28.44	9.90	48.30	16.82	26.16	33.04
CAGR (%)	16.30	-3.95	-20.31	-4.24	-4.08	-8.87	-10.71	1.54	-8.73	-15.16
P VALUE	0.00	0.04	0.00	0.04	0.18	0.00	0.04	0.43	0.02	0.00

Table 2: Transition Probability Matrix (TPM) of India's Cashew Exports

	Vietnam	UAE	U S A	Japan	Netherland	Saudi	Korea	Spain	Germany	Belgium
Vietnam	0.90	0.07	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
UAE	0.00	0.59	0.00	0.17	0.00	0.05	0.07	0.10	0.00	0.02
U S A	0.00	0.11	0.56	0.00	0.00	0.23	0.00	0.00	0.00	0.09
Japan	0.00	0.22	0.00	0.00	0.52	0.08	0.01	0.00	0.13	0.03
Netherland	0.47	0.00	0.00	0.00	0.00	0.40	0.00	0.01	0.12	0.00
Saudi	0.00	0.05	0.24	0.54	0.17	0.00	0.00	0.00	0.01	0.00
Korea	0.00	0.00	0.16	0.20	0.17	0.00	0.41	0.00	0.06	0.00
Spain	0.38	0.00	0.00	0.00	0.00	0.00	0.25	0.38	0.00	0.00
Germany	0.00	0.86	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00
Belgium	0.00	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.04

Note: Diagonal elements represent the retention capacity and off-diagonal elements represent the transition capacity

Figure 2 presents the major market retention and transition probabilities of India's cashew exports. Vietnam exhibited the highest market stability, followed by the UAE and the USA. Significant market transitions were observed from Germany to the UAE and from Belgium to the Netherlands, indicating

changing trade linkages among importing countries. The results highlight the coexistence of stable export destinations and dynamic market shifts, emphasising the need for market diversification and sustained trade relationships.

Market Retention and Transition Dynamics of India's Cashew Exports

Fig. 3: Market Retention and Transition Dynamics of India's Cashew Exports
Source: Chord diagram generated by the author

Conclusion

The study demonstrates that India's cashew export sector is undergoing a gradual restructuring in response to changing global trade dynamics and evolving market preferences. The observed variations in growth, instability and market retention indicate that the competitiveness of Indian cashew exports is increasingly influenced by the ability to sustain market relationships and adapt to emerging trade opportunities. The findings highlight that sustained growth in cashew exports cannot be achieved solely through expansion of export volumes. Greater emphasis must be placed on strengthening market competitiveness through quality enhancement, value addition, branding, and compliance with international food safety standards. The increasing concentration of trade among a few destinations also underscores the need for market diversification to minimise export risks and improve resilience against fluctuations in global demand. Further, strategic trade promotion initiatives and stronger linkages between producers, processors and exporters are essential for expanding market access and sustaining export competitiveness. This may secure the future growth and global relevance of India's cashew export sector.

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