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Indian Chilli Exports: A Gravity Model Analysis of Trade Determinants and Growth Opportunities

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ABSTRACT

India, a top chilli producer and exporter, dominates global trade with a 44.22 per cent market share, high competitiveness with RCA of 10.82, and strong trade intensity with TII of 3.67. Markov chain analysis showed China and Vietnam as stable markets, while others fluctuated. A gravity model revealed GDP, population, urbanization, trade openness, and Ease of Doing Business in importing nations boosted exports. Regional factors such as ASEAN membership and shared languages also enhanced trade. The study highlights economic strength, trade policies, and regional integration as key drivers for sustaining India's chilli export growth.

Keywords: Chilli exports, competitiveness indices, Markov chain analysis, Panel Gravity model

JEL codes: C23, F13, F14, O24, Q17,

I
INTRODUCTION

India plays a vital role in global trade, contributing significantly to both regional and international markets (GoI, 2024). As the world's fifth-largest economy, India's trade relationships extend globally, with its exports reaching Rs. 3.95 lakh crores in agricultural products for the fiscal year 2023-24, which makes it one of the largest players in international trade (IBEF, 2024). The major trading partners of India are the United States, China, and the European Union (European Commission, 2023). The country's diverse and competitive industrial base, combined with a large skilled workforce, contributes to its significant share in the global market.

India plays a crucial role with its robust agricultural sector contributing about 11 per cent share in India's total merchandise exports (GoI, 2023). India is the world's largest producer and exporter of spices, contributing nearly 70 per cent of the global spice production accounting for about Rs 0.37 lakh crores (IBEF, 2022; Spices Board of India, 2024). India is the world largest producer and exporter of chilli, producing about 26 lakh tonnes annually and exporting about 6 lakh tonnes. India's chilli exports constitute about 39 per cent of the total volume and 33.80 per cent by value (Spices Board of India, 2024).

India's major chilli varieties, such as Sannam S4, Teja, Byadgi and Guntur are globally recognized for their intense heat, vibrant colour, and distinctive flavour, making them highly sought after in international markets (Eximpedia, 2024). The natural pigments, particularly Capsanthin and Capsorubin, give these chillies their

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vibrant red hue, enhancing their visual appeal and making them desirable for spice powders and food products worldwide (Baenas *et al*., 2019). Indian chilli is sought after for use in culinary, pharmaceutical, and cosmetic industries, with key markets including China, Sri Lanka, Thailand, Bangladesh, and Indonesia (Crop outlook, 2024; Gade *et al*., 2020). Based on the data from FAOSTAT (2025), the distribution of India's chilli exports to major countries emphasizes the critical role these markets play in driving the country's chilli export industry (Figure 1). Notably, 87 percentage of India's chilli exports are directed toward these key markets, underlining their importance in the global chilli trade.

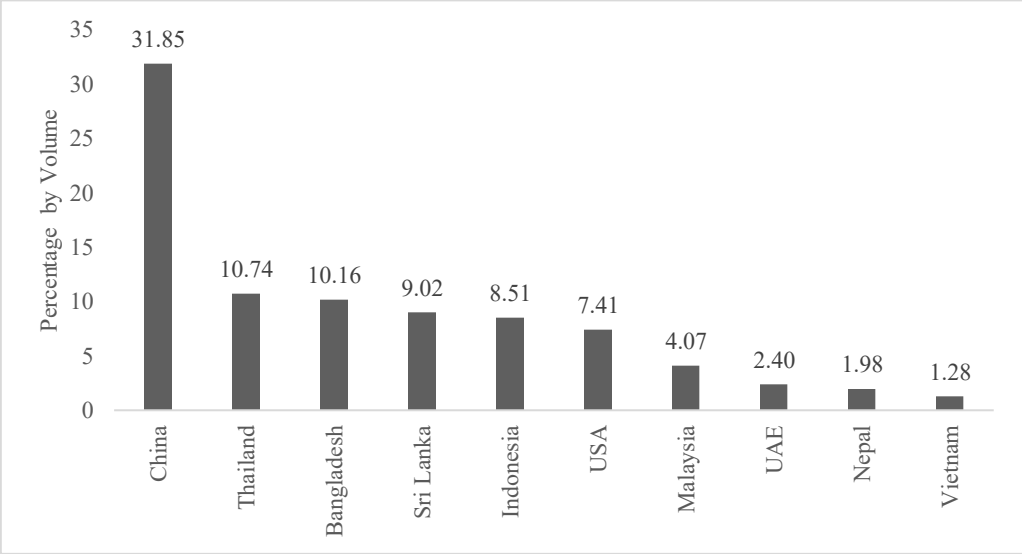

FIGURE 1. MAJOR EXPORT DESTINATIONS OF INDIAN CHILLI DURING 2002-2023

The dynamics of Indian chilli exports have been rapidly shifting due to changes in political and economic conditions, necessitating a reassessment of the sector's potential. Though many studies have analysed the dynamics and determinants of exports, including those by Kea *et al*., (2019), Nguyen, (2022), Sun *et al*., (2022) and Kumar *et al*., (2024), they are not specific to chilli market and do not specifically address its concerns. There is a need to analyze the dynamics of chilli exports from India to different countries and assessing the competitiveness of chilli exports from India which guides in developing long-term strategies to usher exports. By exploring evolving export patterns and identifying the factors driving trade success, the research seeks to uncover strategies to enhance India's position as a leading chilli exporter.

This paper aims to study India's performance in chilli exports and the prospects with the following specific objectives to evaluate the trade directions of

Indian chilli exports, and to analyse the key determinants influencing Indian chilli trade performance. The findings will contribute to sustainable growth in the sector, enabling India to strengthen its competitive advantage in the global chilli market.

II

METHODOLOGY

The study aimed to analyse the trade determinants of chilli exports from India using competitiveness indices, Markov chain analysis, and a Panel Gravity model as the analytical framework. Data for the competitiveness indices was collected for the triennium years 2021 to 2023, while time-series data for the Markov chain and Panel Gravity models spanned the periods 2012-2023 and 2002-2023, respectively. The analysis focused on the top 10 major chilli-importing countries (FAOSTAT, 2025), which were purposively selected based on their contribution to India's average total exports (TE) of chilli during 2021–2023. Accordingly, the countries, viz., China, Thailand, Bangladesh, Sri Lanka, Indonesia, the USA, Malaysia, the UAE, Nepal, and Vietnam were selected.

The data collection emphasized trade-related economic variables affecting chilli exports. Variables such as GDP, trade agreements, exchange rates, population, distance and other relevant economic indicators were considered for both India and the importing countries.

2.1 Statistical Analysis

2.1.1 Compound Annual Growth Rate

Compound annual growth rate (CAGR) was used to estimate the growth patterns of chilli production and export value at the global level. The growth rate was calculated using an exponential trend model, following the approach of Gade *et al*., (2020).

The equation as follows as

$$Y = ab^t$$

$$\text{CAGR \%} = 100 * \left(e^b - 1\right)$$

Where

Y = Quantity of chilli production / Value of chilli exports

a = Intercept and

b = Regression coefficient

2.1.2 Trade Competitiveness

To evaluate the competitiveness of India's chilli trade, export data pertaining to the triennium ending (TE) 2023 was sourced from FAOSTAT (2025). The assessment was conducted using the following indices:

2.1.2.1 Revealed Comparative Advantage

To measure the comparative advantage of a country in products, Balassa's Index of Revealed Comparative Advantage (RCA) is the most widely accepted approach (Balassa, 1965). The RCA index is defined as:

$$RCA_{ij} = \left(\frac{X_{ij} / X_{it}}{X_{wj} / X_{wt}} \right)$$

Where,

X_{ij} = Quantity of chilli exports (j) from India (i)

X_{it} = Quantity of total exports (t) from India (i)

X_{wj} = Quantity of chilli exports (j) from World (w)

X_{wt} = Quantity of total exports (t) from World (w)

If the value of RCA > 1, the country has revealed comparative advantage in that product. For RCA<1, there is a comparative disadvantage in the relevant sector (Jain and Singh, 2009).

2.1.2.2 Trade Intensity Index

The Trade Intensity Index (TII) is a measure used to evaluate the strength or intensity of trade between two countries, relative to the world average. It helps to assess whether a country is trading more or less with a specific partner than would be expected based on its share of world trade. Mathematically derived, this index quantifies a nation's significance in the world trade arena by the following formula (Brown, 1949 & Kunimoto, 1977; Kumar *et al*., 2024):

$$TII = \left(\frac{X_{ij} / X_{iw}}{M_j / M_w} \right)$$

Where,

X_{ij} = Chilli exports from India (i) to partner country (j).

X_{iw} = Total chilli exports from India(i) to the world(w).

M_j = Total chilli imports by partner country (j) from the world (w)

M_w = Total world chilli imports (w)

TII_{ij} >1: Trade between India and country j is more intense than expected based on their global trade shares. This indicates a strong trade relationship.

TII_{ii}1: Trade between the two countries is proportional to their global trade involvement.

TII_{ij} <1: Trade between country i and country j is less intense than expected.

2.1.2.3 Export Market Share

The Export Market Share (EMS) refers to the percentage of global exports that a specific country holds for a particular product. It is a vital metric for understanding how competitive a country is in the global market for that product. EMS is calculated as:

$$EMS = \left(\frac{X_{it}}{X_{wt}}\right) * 100$$

Where,

X_{it} = Total India(i) chilli exports in year t

X_{wt} = Total World(w) chilli exports in year t

EMS is measured in percentage terms. It represents the share of a country's exports to the global export of the same product.

2.1.3 Markov Chain Analysis

Markov chain analysis was used in the study to analyse the transitions in trade directions and patterns, enabling the identification and quantification of shifts in India's chilli export markets over time. This approach provides valuable insights into evolving market dynamics. It involves creating a transitional probability matrix P, where each element P_{ij} represents the probability of India's chilli exports shifting from country i to country j (Dent, 1967; Lee *et al*., 1970; Gillet, 1976). The diagonal elements P_{ii} indicate the probability of retaining import share, reflecting the loyalty of importing countries to India's chilli exports.

In the context of India's chilli exports, structural changes were treated as a random process. It is assumed that the average export of chilli to importing countries in any period depends only on the exports in the previous period, with this relationship consistent across all periods. This is expressed algebraically as:

$$E_{ijt} = \sum_{i=1}^{n} (E_{ijt-1}) p_{ij} + e_{jt}$$

Where

E_{ijt} = Exports of chilli from India(i) to the partner countries (j) in the year t

E_{ijt-1}= Chilli exports from India (i) to the partner countries (j)in the year t-1

p_{ij} = Probability chilli exports shift from India(i) to the partner countries (j)

e_{jt} = Error term which is statistically independent of e_{it-1},

n = Major 10 importing countries(n)

The transitional probabilities $p_{ij,}$ which can be arranged in a cxn matrix, have the following properties.

$$\sum_{i=1}^{n} p_{ij} = 1 \quad \text{and } 0 \leq p_{ij} \leq 1$$

The expected export share of each country in period t is obtained by multiplying the exports to those countries in the previous period $(t-1)$ by the transitional matrix. The transitional probability matrix T was estimated using a linear programming (LP) framework with the minimization of the Mean Absolute Deviation (MAD) method.

$$\text{Minimize} \quad OP^{*}Ie$$

$$\text{Subject to: } XP^{*} + V = Y, GP^{*} = I, P^{*} \geq 0$$

Where, X is a blocking diagonal matrix of the lagged valued of Y, P^{*} is a vector of the probabilities p_{ij}, V is the vector of errors, Y is the proportion of chilli exports to each country, G is a grouping matrix to add the row elements of P arranged in P^{*} to unity, $I$is an appropriately dimensional vector of exports, 0 is the vector of zeroes.

After calculating the transitional probability matrix, the expected share of chilli exports to each country at time t is calculated using:

$$Y_{jt} = \sum_{j-1}^{n} Y_{it-1} * P_{ij} (j = 1,2,3 \ldots n)$$

Where,

Y_{jt} is the predicted share of chilli exports to country j at time t, Y_{it-1} observed share of chilli exports to country i at time $(t-1)$, and $P_{ij}$is the estimated transitional probability matrix. This method multiplies the exports from the previous period by the transitional matrix to predict future export shares. For this analysis, secondary data was collected on the total quantity of chilli exports from India to the major importing countries for the period 2012 to 2023.

2.1.4 Panel Gravity model

The origin of the gravity model can be traced back to the works of Sir Isaac Newton (Newton, 1883), who introduced the law of gravitational force. The gravity model of international trade was introduced and explained by Tinbergen in his piece of work titled '*Shaping the World Economy*' (Tinbergen, 1962). The following equation represents the basic gravity model of trade:

$$Trade_{ijt} = G\frac{m_{it}m_{jt}}{r_{ij}^2}$$

Here, $Trade_{ijt}$ represents the trade flow between country i and country j at time t, m_{it} and m_{jt} represent the economic size of country i and country j at time t depicted in terms of GDP, respectively. r is the distance between countries i and j, and G is the gravitational term used here as trade constant. The basic gravity equation can be expressed in a natural logarithmic form as follows:

$$lntrade_{ijt} = lnG + lnm_{it} + lnm_{jt} + lnr_{ij}^2 + \sigma_{ij}$$

The augmented gravity model extends the traditional gravity model of trade by incorporating additional factors like gross domestic product, population, exchange rate, *etc.* These additional variables help to explain the factors that influence trade flows beyond economic size and distance. These explanatory variables can be further categorized into two types: economic variables, such as Gross domestic product, population, exchange rate, *etc*., which directly impact trade flows, and trade enhancing variables like common regional language, membership in the Association of Southeast Asian Nations (ASEAN), non-Regional Comprehensive Economic Partnership (non-RCEP), etc. which also play a significant role in influencing trade. Consequently, the augmented gravity equation has seen notable progress and application in various studies related to trade, treaties, and international agreements. The study employed an augmented form of the gravity model to examine trade patterns. For this analysis, secondary panel data covering the period from 2002 to 2023 was collected for the variables detailed below, specifically focusing on the top 10 major chilli-importing countries.

$$\begin{aligned} lnX_{ijt} = \propto\ & +\beta_1 \ln(GDP_{it}) + \beta_2 \ln(GDP_{jt}) + \beta_3 \ln(POP_{jt}) + \beta_4 \ln(SD_{ij}) \\ & + \beta_5 \ln(EXCRT_{jt}) + \beta_6(EXTURB_{jt}) + \beta_7(TPG_{jt}) + \beta_8(EDB_{jt}) \\ & + \beta_9(ASEAN_{jt}) + \beta_{10}(NONRCEP_{jt}) + \beta_{11}(COMLANG_j) + \mu_{ijt} \end{aligned}$$

Where

ln = Natural logarithm

X_{ijt} = Quantity of chilli export from India (i) to trading partners ('j') in period 't' (tonne)

GDP_{it} = Gross Domestic Product (GDP) of country 'i' at time 't' (Lakh US$)

GDP_{jt} = Gross Domestic Product (GDP) of country 'j' at time 't' (Lakh US$)

POP_{jt} = Population in trading partners 'j' in period 't' (million)

SD_{ij} = Shipping distance between the country 'i' to the country 'j' (km)

$EXCRT_{jt}$ = Bilateral exchange rate of 'Rupee' of India to trading partners 'j' in period t'(US$)

$EXTURB_{jt}$ = Extent of urbanization of trading partners 'j' in period 't' (%)

TPG_{jt} = Trade as a percentage share of GDP of trading partners 'j' in period 't' (%)

EDB_{jt} = Score of Ease of Doing Business of trading partners 'j' in period 't'

$ASEAN_{jt}$ = ASEAN dummy; 1: country 'j' is a member of ASEAN, 0: otherwise in period 't'

$NONRCEP_{jt}$ = Non-Regional Comprehensive Economic Partnership (Non-RCEP) dummy; 1 country j is a non-RCEP in period 't' 0: otherwise in period 't'.

$COMLANG_j$ = Common Regional Language dummy; 1 Common Language between country 'i' and 'j' , 0: otherwise

III

RESULTS AND DISCUSSION

India, Bangladesh, and Thailand emerged as the leading chilli producers of the world, contributing on an average 22.9 lakh tonnes, 5.9 lakh tonnes, and 3.3 lakh tonnes respectively for the TE 2023. This clearly highlights India's dominance in the global chilli supply, followed by Bangladesh and Thailand, indicating a strong regional presence in chilli cultivation (Figure 2).

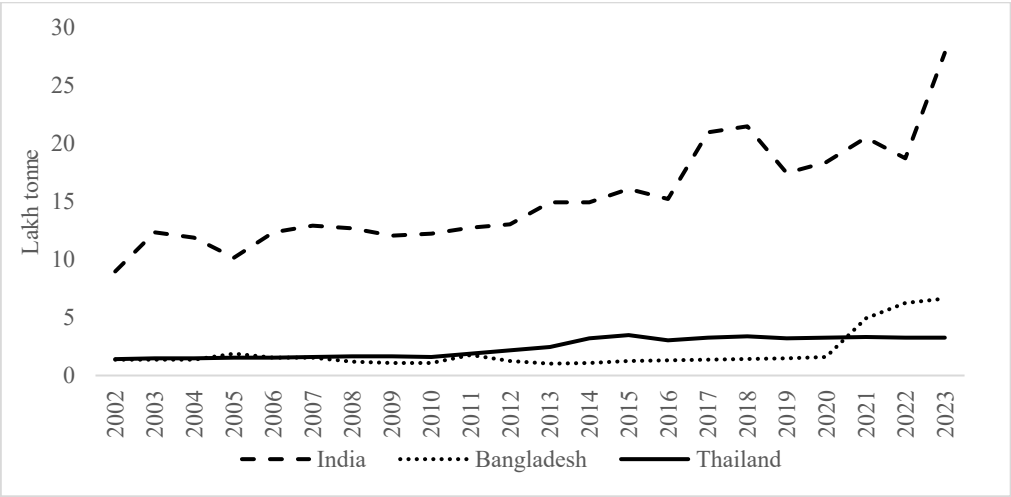

FIGURE 2. LEADING CHILLI PRODUCING COUNTRIES BY VOLUME (2002- 2023)

Over the period 2002–2023, India's chilli production growth rate was 3.92%, while Bangladesh (4.69%) and Thailand (5.33%), reflecting sustained expansion in domestic production. Even though Thailand showed the highest growth rate but India reinforced its dominant and steadily strengthening position in global chilli production, solidifying its role as the world's largest and most influential producer.

Likewise, India, China, and Spain are the leading countries in the world chilli export market, with export values of 1207 crore US $, 741 crore US $, and 272.77 crore US $, respectively (TE 2023). This underscores India's dominant position in the global chilli supply chain, with China and Spain following behind, reflecting a strong international presence in chilli production and trade (Figure 3). India not only holds the highest export value but also records the fastest growth rate at 15.06 per cent, surpassing China (10.41%) and Spain (8.80%). This strong performance highlights India's growing competitiveness and expanding dominance in the global chilli export market.

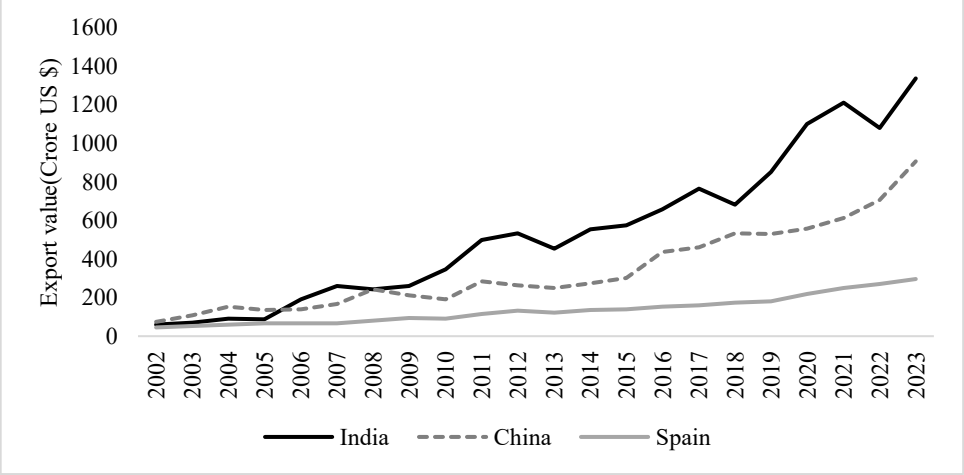

FIGURE 3. LEADING CHILLI EXPORTING COUNTRIES BY VALUE (2002-2023)

3.1 Competitiveness Analysis

The results from Table 1 revealed the comparative advantage through three indices. The Revealed Comparative Advantage (RCA) value of 10.82 shows India's strong comparative advantage in chilli exports, with its share about 10 times the global average. This reflects India's competitive edge due to factors like favourable conditions and high demand. India should focus on policies and strategies to sustain and expand this advantage.

A Trade Intensity Index (TII) of 3.67 for chilli exports from India to the partner countries indicates that India's chilli trade is about three times stronger than

expected based on global trade patterns. This suggests a significant reliance on India for chilli, likely due to factors such as geographic proximity, competitive pricing, or cultural preferences. Strengthening trade ties and addressing barriers could further enhance India's market position.

TABLE 1. COMPETITIVENESS INDICES OF INDIA'S TRADE (2021-2023)

S.no	Indicators	Value
1	Revealed Comparative Advantage (RCA)	10.82
2	Trade Intensity Index (TII)	3.67
3	Export Market Share (EMS)	44.22%

The export market share of chilli from India stands at 44.22 per cent, indicating a dominant position, supplying the majority of the chilli imports. This highlights India's strong competitive advantage, likely driven by cost, quality, or established trade relations. However, diversifying trade partners and monitoring competitors is crucial to sustain and grow this market share.

3.2 Dynamic Change in Export Pattern

India's chilli export quantity to major importing countries may have fluctuated over time. To analyse these trends, an importing countries trend (Figure 4) was drawn, illustrating changes in the quantity imported from India to major importing countries for the period 2012 to 2023. The analysis revealed significant variations in India's chilli exports to major trading partners, with notable growth in exports to China, Bangladesh, and Thailand in recent years. Further, the Markov chain analysis was conducted to examine trade patterns and shifts in export values among these countries.

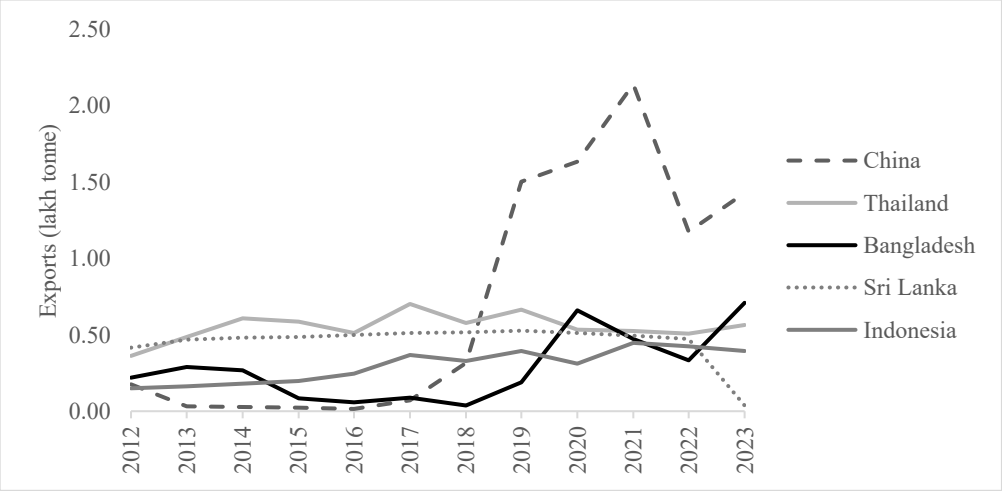

FIGURE 3. CHILLI EXPORTS FROM INDIA TO MAJOR IMPORTING COUNTRIES

The transition probability matrix (TPM) derived from the Markov chain analysis illustrated the dynamics and direction of chilli export flows from India for the period 2012 and 2023. Table 2 revealed that China had emerged as the most stable and consistent market for Indian chilli exports, with 89 per cent of its imports retained. China demonstrated a strong and sustained demand for Indian chilli. This strong retention rate indicated that China remains a key and reliable destination for India's chilli exports, showing limited fluctuation in demand. China's dominance suggests enduring trade relations and a steady consumption of Indian chilli, with minimal loss of market share to other countries like Bangladesh, Indonesia, and the USA. Thailand's market for Indian chilli imports exhibited less stability, with only 25 per cent retention of its chilli imports. The majority of Thailand's market share was shifted to Sri Lanka (45 per cent), which became a major importer. Bangladesh retained 36 per cent of its chilli imports from India, but it experienced notable market losses of 23 per cent to other countries. Sri Lanka and the UAE demonstrated zero retention rate for Indian chilli, showed a very high instability level. Indonesia showed a significant retention rate of 45 per cent of its import share from Indian, while it made substantial losses mainly to China (31 per cent). The USA is not a stable importer of chilli from India with 28 per cent retention rate. Nepal retained 32 per cent of its share of chilli imports from India but lost a substantial 68 per cent of its share to Bangladesh. Vietnam was a reliable market for Indian chilli with a 65 per cent retention share. These findings are consistent with that of Chaitra and Sonnad (2020), which concluded that Vietnam retained the most Indian chilli imports, while Sri Lanka showed zero retention.

The analysis showed that countries such as China and Vietnam are stable markets, while the UAE and Sri Lanka are unstable markets for Indian chilli exports. These patterns highlighted the interconnected and regionally dependent nature of global chilli trade.

3.3 Factors Affecting the Exports of Chilli from India

Descriptive statistics of the factors affecting chilli exports from India were presented in Table 3, providing an overview of data patterns and variability. The chilli export volume showed a mean of 0.26 lakh tonnes, but the high standard deviation of 0.29 lakh tonnes indicated substantial disparities among trading partners, with some countries importing very small quantities while others reached 2.13 lakh tonnes. This variation reflected the fact that larger economies typically engage in higher levels of trade, whereas smaller economies tend to have more limited trade capacity.

TABLE 2. TRANSITIONAL PROBABILITY MATRIX OF MAJOR DESTINATIONS EXPORTS OF INDIAN CHILLI FOR THE PERIOD OF 2012 TO 2023

Importing Countries	China	Thailand	Bangladesh	Sri Lanka	Indonesia	USA	Malaysia	UAE	Nepal	Vietnam
China	0.89		0.04		0.03	0.03				
Thailand		0.25		0.45		0.05		0.10		
Bangladesh			0.36	0.09	0.06	0.19	0.03	0.04		
Sri Lanka		0.19				0.05				0.44
Indonesia	0.31				0.45	0.07		0.06	0.11	
USA			0.20			0.28	0.33	0.09	0.09	
Malaysia		0.05	0.10				0.35			
UAE					0.83	0.17				
Nepal			0.68						0.32	
Vietnam		0.14		0.08	0.07	0.06				0.65
Others		0.45		0.29		0.06	0.18			

Note: Blancs indicate zero or a value closer to zero

TABLE 3. DESCRIPTIVE STATISTICS OF SELECTED VARIABLES

Variables	Mean	Std. Dev.	Minimum	Maximum
X_{it}	0.26	0.29	0.00	2.13
GDP_{it}	1.91	0.70	0.89	3.20
GDP_{jt}	2.95	5.84	0.01	21.57
POP_{jt}	23.3	39.1	0.36	142.6
SD_{ijt}	3717	2823	802	11338
$EXCRT_{ij}$	-	-	1.00	23787
$EXTURB_{jt}$	48.74	23.59	14.24	87.83
TPG_{jt}	82.36	53.31	22.29	210.37
EDB_{jt}	63.73	15.13	19.17	88.59
$ASEAN_{jt}$	00.40	00.49	00.00	01.00
$NONRCEP_{jt}$	00.40	00.49	00.00	01.00
$COMLANG_{jt}$	00.39	00.49	00.00	01.00

Note: Std Dev.-standard Deviation; n=220

The economic size of trading partners showed substantial variation, with India averaging US$ 1.91 lakh crore and importing countries averaging US$ 2.95 lakh crore. The high range of values reflects the presence of both developing and developed nations in India's chilli export market. Population also plays a crucial role, as country *j*'s average population of 23.3 crore has a high standard deviation indicating significant variation in market sizes. Larger populations drive higher domestic demand and imports. Shipping distance ranged from 802 km to 11,338 km, highlighting that India's chilli exports reached both nearby regional markets and distant global destinations. Trade as a share of GDP in partner countries averaged 82.36 per cent, indicating that countries with higher trade openness tended to foster stronger trade relations with India. The Ease of Doing Business index (EDB_{jt}) demonstrated considerable variation suggesting that some countries are more conducive to trade due to fewer business barriers.

Finally, the binary variables like $ASEAN_{jt}$, non-$RCEP_{jt}$, and $COMLANG_{jt}$ had mean values of about 0.40, indicating that around 40 per cent of India's chilli export destinations had regional or linguistic linkages with India.

3.4 Panel Gravity model

The estimation of the Panel Gravity model, the results on India's chilli exports incorporated the natural logarithm (ln) transformations of quantitative variables to account for nonlinear relationships and percentage-based interpretations (Table 4). Although the coefficient of GDP ($lnGDP_{it}$) of the exporting country (India) is positive, but it is not significant, implying an uncertain influence on export flows. In contrast, the GDP of importing countries ($lnGDP_{jt}$) significantly impacted the exports of chillies from India to the tune of 0.65 per cent for every one percent change in their GDP. This finding was consistent with Natale *et al*., (2015), who

reported that sea exports of the world can increase with high GDP of importing countries, and with Masood *et al*., (2023), who similarly found that stronger importing economies increased overall trade flows.

Moreover, factors such as population size and exchange rate demonstrated a significant influence on trade flows. The population of importing countries ($lnPOP_{jt}$) has a positive influence on India's chilli exports. As the population increased, the demand for chillies for culinary purposes also rises, leading major importing countries to import larger quantities. This highlighted the demographic-driven nature of demand for chill. Similarly, Irandu *et al*., (2019) reported comparable findings for Kenya's horticultural exports, noting that larger populations in importing countries led to an increase in demand.

TABLE 4. ESTIMATION OF PANEL GRAVITY MODEL

Variables	Coefficients	SE
$\boldsymbol{Intercept}$	-15.01**	3.30
$\boldsymbol{lnGDP_{it}}$	0.25^{NS}	0.28
$\boldsymbol{lnGDP_{jt}}$	0.65**	0.18
$\boldsymbol{lnPOP_{jt}}$	1.48**	0.24
$\boldsymbol{lnSD_{ijt}}$	-0.93**	0.12
$\boldsymbol{lnEXCRT_{ij}}$	0.09*	0.04
$\boldsymbol{EXTURB_{jt}}$	0.04**	0.01
$\boldsymbol{TPG_{jt}}$	0.01**	0.00
$\boldsymbol{EDB_{jt}}$	0.07**	0.01
$\boldsymbol{ASEAN_{jt}}$	4.89**	0.62
$\boldsymbol{NONRCEP_{jt}}$	5.46**	0.77
$\boldsymbol{COMLANG_{jt}}$	2.31**	0.32

*Note: ** & * 1% & 5% Level of Significance, NS- Non-significant, and SE-Standard error*

The log of shipping distance ($lnSD_{ijt}$) between India and chilli-importing countries showed a negative sign, indicating that greater distances reduce the flow of chilli trade, due to increased transportation costs. Similar finding was reported by Narayan and Nguyen, (2016) for Vietnam, where a greater distance to major importing countries reduced rice and coffee trade flows. Likewise, Sundari *et al*., (2023) found that increasing the distance between Indonesia and its trading partners negatively affected chilli exports. Likewise, the exchange rate ($lnEXCRT_{ij}$) between India and its importing countries showed that favourable exchange rate movements increased chilli trade flows, thereby enhancing India's chilli export performance. However, a contrasting result was reported by Yaseen *et al.,* (2025), who found that exchange rate movements reduced India's mineral trade with partner countries.

Similarly, the extent of urbanization in importing countries ($EXTURB_{jt}$) was positively related to India's chilli exports. As urbanization increased, modern food habits and a stronger preference for health-oriented diets led to higher demand for chillies, thereby boosting import levels. This indicates that rising urbanization in partner economies promoted greater trade growth for Indian chilli exports. The ease of doing business (EBD_{jt}) of importing countries positively influenced India's chilli exports due to more simplified procedures and greater regulatory transparency, strengthened trade relations with India.

India's chilli exports were also enhanced by trade relations with countries belonging to the ASEAN and non-RCEP blocs. These relationships substantially increased chilli export flows, suggesting that being part of regional trading frameworks, or maintaining strong partnerships with such blocs, strengthened India's export performance. A consistent result was observed by Kumar *et al.,* (2024), who showed that ASEAN membership of major importing countries positively influenced India's rice trade, leading to increased export flows. The common language (EBD_{jt}) variable showed a positive relationship with India's chilli trade, indicating that sharing a common language with importing countries increased India's chilli exports by lowering communication barriers and facilitating smoother economic exchange. This result aligned with the findings of Balogh *et al*., (2022), who reported that sharing a common language increased agricultural exports from the Latin American and Caribbean region.

The Panel Gravity model revealed that importing country GDP, population size, exchange rates, and regional affiliations significantly influenced India's chilli exports. Strengthening economic ties, trade openness, and regional agreements can enhance India's chilli export performance.

IV

CONCLUSION

India's strong presence in the global chilli trade is driven by its competitive advantage, stable demand in key markets, and favourable economic factors. The study highlights that India holds a strong comparative advantage in global chilli exports. This advantage can be enhanced by incentivizing farmers to boost quality production, promoting value addition, and strengthening export promotion through Brand India and One District One Product (ODOP) initiatives. While China and Vietnam showed high retention of Indian chilli imports, the UAE and Sri Lanka recorded zero retention. Effective strategies in terms of providing market-specific incentives, developing and promoting better chilli varieties, producing quality exportable crops through training on package of practices and ensuring a efficient value chain through developing infrastructure such as logistics, storage, market and processing can help in stabilizing exports.

As the GDP and population of importing countries are set to rise which significantly affect Indian chilli exports, India should deepen trade partnerships with high-GDP and ASEAN nations, negotiate favourable trade agreements, improve logistics, and strengthen digital platforms to sustain and expand chilli exports from India.

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