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Dynamics of turmeric market in Indian empirical analysis of price integration, instability and trade patterns

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Abstract

Turmeric (*Curcuma longa*), a vital spice crop with substantial economic and cultural significance, positions India as the global leader in production and export. This study examines turmeric's marketing dynamics, price behavior, and export trade patterns in Maharashtra, Telangana, and Tamil Nadu, which collectively account for over 50 percent of Indian turmeric production. Utilizing time-series data from 2009 to 2024, the analysis employs econometric tools such as the Augmented Dickey-Fuller (ADF) test, Johansen's co-integration test, Vector Error Correction Model (VECM), Granger causality, Cuddy-Della Valle Index (CDVI), and Markov Chain analysis. Results from the ADF test confirmed that turmeric price series in all three states are integrated of order one, I(1). Johansen's test identified a single co-integrating vector, indicating a long-run equilibrium among markets. VECM analysis revealed significant long-run price adjustments in Maharashtra, with weaker corrections in Telangana and Tamil Nadu. Granger causality showed unidirectional price influences from Tamil Nadu to Maharashtra and Telangana to Tamil Nadu. Price instability analysis indicated moderate volatility in Maharashtra and Tamil Nadu, but lower volatility in Telangana. Markov Chain analysis identified Morocco, Iran, UAE, and Bangladesh as stable importers of Indian turmeric, while the USA and Malaysia exhibited high volatility and low retention. The "other countries" category emerged as a reliable yet underexploited market. The study recommends policies to enhance market integration, stabilize prices, promote value addition, and diversify exports. Key suggestions include improving infrastructure, supporting processing units, empowering farmers, and establishing a Turmeric Export Development Board to reinforce India's dominance in the global turmeric trade.

Keywords: Turmeric, market integration, price instability, Markov chain analysis.

Introduction

Turmeric (*Curcuma longa*), that cherished "golden spice of life," is of tremendous significance in Indian agronomic, cultural and economic scenario. A member of the family zingiberaceae, its rhizomes contain Curcumin, the bioactive molecule responsible for the radiant yellow color of turmeric and the basis for its multifarious uses in food, medicine, textiles, cosmetics and pharmacy. India controls the world turmeric market with an almost 80 percent contribution to the total production and being the largest consumer and exporter. The states with the highest production in India are Maharashtra, Telangana and Tamil Nadu with popular varieties like Allepey, Madras, Lakadong, Erode and Salem each having distinctive Curcumin content, aroma and market demand. In 2023- 24, India sent over 162,000 tonnes of turmeric overseas, and its top importers were Bangladesh, the UAE, the USA, and Malaysia, representing the economic and trade importance of the crop. Although with such a strong international position, the turmeric industry is plagued by a number of long term problems, such as low productivity, shortage of high yielding and disease resistant varieties, price volatility, inefficient marketing systems and shortages of quality inputs. Meanwhile, increasing health consciousness, fast urbanization and increased foreign demand are pushing consumption upwards, providing opportunities as well as pressures. In order to support domestic requirements and enhance export competitiveness, there is a compelling imperative to raise productivity, improve quality and forge more effective value chains. Coherent strategies bridging research, farm practice and market linkages will be critical to reinforcing Indian leadership in the world turmeric economy.

Efficient market operations are crucial for a robust marketing system, ensuring fair returns for farmers while delivering affordable goods to consumers. A key measure of market efficiency is the presence of strong market integration, which reflects the interconnectedness of price movements for a commodity across multiple markets. Market integration influences the behavior of market participants and, consequently, the overall effectiveness of the marketing system. Highly integrated markets exhibit distinct dynamics compared to those with low integration or fragmentation. Markets in different regions vary in their level of integration, leading to differences in their efficiency. An integrated market allows price signals from other markets to influence commodity pricing. The concept of market integration captures the price relationships between spatially separated markets. When markets are well-integrated, they function cohesively, operating as a unified market system.

Materials and Methods

The analysis was performed in the major turmeric producing states of Maharashtra, Tamil Nadu, and Telangana, which together account for 52.96% of India's total production, with Sangli, Erode, and Nizamabad markets purposively selected on the basis of maximum arrivals. The analysis relied on secondary data compiled from authentic sources such as Indiastat, Agmarknet, APEDA, and peer-reviewed research articles. Information on area, production, productivity, prices, market arrivals, exports, and imports was collected for a continuous period of fifteen years (2009-2024) to reflect short-run variations and long-term movements, while monthly wholesale price data from 2021 to 2023 were used specifically for market integration and price instability analysis. Market integration was examined using the Granger Causality Test and Johansen Co-integration Test, price volatility was examined through the Cuddy-Della Valle Index, and trade patterns were analyzed using Markov Chain Analysis.

Analytical Tools

Augumented Dickey Fuller (ADF) Unit Root Test

The Augmented Dickey-Fuller (ADF) test proposed by Dickey and Fuller (1979) was used to assess whether the time series were integrated of order one. The ADF test is a widely used statistical procedure for distinguishing between stationary and non-stationary series.

The data analysis was undertaken using both the level values and the first-differenced price series. Stationarity was assessed by estimating the standard ADF regression equation.

$$\Delta Y_t = \alpha + \beta_t + \delta Y_{t-1} + \sum_{i=1}^{n} \Delta Y_{t-1} + e_t$$

Where, $\Delta Y_t = (Y_t - Y_{t-1})$; $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$

Where, Y_t refers to the vector tested for co-integration, t stands for the time variable, e_t denotes a white-noise error term, α is a constant term, βt represents the time-trend coefficient.

Johansen Test for Multiple Co-integration

The co-integration approach was applied to establish long-run equilibrium relationships among the variables and to assess the rank of the co-integration space. Residuals were derived by estimating an ordinary least squares regression in level form, reflecting departures from long-run price equilibrium. The resulting residuals were subsequently tested for co-integration.

To analyze the price linkage across the two markets, the below standard model widely employed in market integration studies was specified:

$$P_{it} = \alpha_0 + \alpha_1 P_{jt} + \varepsilon_t$$

Let, P_{it} refer to the turmeric price series in the i_{th} market at time t, P_{jt} indicates the corresponding price series in the j_{th} at the same time period, the intercept term α_0 reflects domestic transfer costs, processing charges, and applicable sales taxes., The slope coefficient α_1 represents the extent to which variations in Pjt affect P_{it}, The disturbance term ε is assumed to be independently and identically distributed. The assessment of market integration becomes straightforward when both P_{it} and P_{jt} exhibit stationarity.

Vector Error Correction (VECM) Analysis

Once long run linkage between the two price series was confirmed, a Vector Error Correction Model (VECM) was employed to examine short-run deviations and the adjustment process, thereby estimating the speed at which prices return to long-run equilibrium.

To capture both the short-run dynamics and long-run relationships of prices, a generalized VECM framework was formulated, beginning with the autoregressive distributed lag (ADL) representation as follows:

$$Y_t = a_{01} X_1 + a_{11} X_{t-1} + a_{12} Y_{t-1} + \varepsilon_t$$

$$\Delta Y_t = a_{01} \Delta X_t + (1 - a_{12})[\frac{(a_{01} + a_{11})}{1 - a_{12}} X_{t-1} + Y_{t-1}] + \varepsilon_t$$

The equation's general form incorporates an intercept and k lags:

$$\Delta Y_t = a_{00} \sum_{i=0}^{k-1} a_{i1} \Delta X_{t-i} + \sum_{i=1}^{k-1} a_{i2} \Delta Y_{t-i} + m_0 (m_1 X_{t-k} - Y_{t-k}) + \varepsilon_t$$

Where, $m_0 = (1 - \sum_{i=1}^{k} a_{i2})$, and $m_1 = \frac{\sum_{i=0}^{k} a_{i1}}{m_0}$

ΔY_t denotes the price series differences across markets, while a_{i1} and a_{i2} are the short run co-efficient. The parameter m_0 measures the speed of adjustment toward long-run equilibrium, ranging from 0(no adjustment) to 1 (instantaneous adjustment), with intermediate values indicating gradual correction.

Granger Causality Analysis

Granger (1969) proposed a statistical method to examine whether past values of one time series help predict another. A variable X is said to Granger-cause Y if its lagged values improve the prediction of Y beyond the information contained in past values of Y. Similarly, Y Granger-causes X if its past values enhance the prediction of X. This relationship is tested using two ordinary least squares (OLS) regression equations.

$$Y_i = a_i Y_{t-i} + b_i X_{t-i} + e_i$$

$$X_i = c_i Y_{t-i} + D_i X_{t-i} + v_i$$

Where, X_i and Y_i are stationary time series with zero means, while e_i and v_i are correlated.

The results of causality analysis are highly sensitive to the choice of lag length. Therefore, the optimal number of lags was determined using the Akaike Information Criterion

(AIC) and the Schwarz Bayesian Criterion (SBC). In this study, the Granger causality test was employed to identify the direction of price relationships between the two markets.

Price Instability Analysis

Cuddy-Della Valle Instability Analysis

The Cuddy-Della Valle Index (Cuddy and Della Valle, 1978) is an adjusted form of the coefficient of variation that accounts for the presence of trends commonly observed in economic time series data. This adjustment makes it a more reliable indicator of instability than measures such as the standard deviation. The index is computed as follows:

$$\text{CDVI} = \text{CV}\sqrt{X}$$

Here, X = 1 - $\bar{R}^2$, CV is coefficient of variation, and $\bar{R}^2$ is adjusted R^2. The CDVI ranges are as follows (Rakesh Sihmar, 2014):

Instability is categorized as low (0-15), medium (15-30), and high (above 30).

Markov Chain Transition Analysis

A first-order Markov chain was used to analyse Indian turmeric exports. A key component of this method is the transition probability matrix (P), where each entry Pij shows the likelihood of export shares moving from country 'I' to country 'j. The diagonal terms of the Pij matrix capture the probability that an importing country maintains its existing market share, thereby reflecting the degree of market retention or loyalty to a specific exporter.

Annual exports (2013-14 to 2022-23) were analysed, treating each country's average export as a random variable based on past levels.

$$\sum_{i=1}^{n}(Eit-1)\,Pij+ejt$$

Where,

E_{jt} = India's exports to the j^{th} country in year t

E_i t - 1 = Exports of the i^{th} country in the previous year (t-1).

P_{ij} = Probability of export shifting from the i^{th} to the j^{th} country.

e_{jt} = Error term, independent of E_i (t-1)

n = Total number of importing countries

The transitional probabilities $P_{ij,}$ which can be arranged in a (c x n) matrix, have the following properties:

$\sum_{i=1}^{n} Pij = 1$ And $0 \leq P_{ij} \leq 1$

Accordingly, the projected share of exports for each country in period *t* is obtained by applying the transition probability index to that country's exports in the previous period (*t-1*).

The transition probability matrix (TTT) is derived using linear programming (LP) framework with Mean Absolute Deviation (MAD) minimization.

Min, OP* + I e.

Subject to,

X P* + V= Y

GP* = 1

P* ≥ 0

Where,

P* is a vector of the probabilities P_{ij} to be estimated is the vector of zeros

I is an appropriately dimensional vectors of areas

e is the vector of absolute errors

Y is the vector of export share proportions for each country.

X is a block diagonal matrix of lagged Y

V is the error vector.

G ensures that probabilities in P∗ sum to one.

The analysis used turmeric export quantities to eight major countries and a combined group labelled "other countries." These data were formulated as a linear programming problem using the Mean Absolute Deviation (MAD) minimization method, and the solution provided the transition probability matrix elements.

Market integration analysis

Augumented Dickey Fuller (ADF) Unit Root Test

The Augmented Dickey-Fuller (ADF) test was applied to examine the stationarity of the price series. The ADF test outcomes for turmeric prices in the selected states are shown below.

Telengana

At the level form, the ADF statistic (-1.5162) was higher than the 1% critical value (-3.639), and the probability value (0.5138) was not significant. This indicates the presence of a unit root, suggesting that the price series was non-stationary. However, after taking the first difference, the ADF statistic (-4.4051) became more negative than the 1% critical value, with the probability (0.0018) showing strong significance. This implies that the price series became stationary at first difference, confirming integration of order one, I (1).

Maharashtra

Similar to Telangana, the price series at level form was non-stationary, with the ADF statistic (-1.5431) being above the critical value (-3.639) and the probability (0.5004) insignificant. Upon first differencing, the ADF statistic (-5.2917) was much lower than the critical value, and the probability (0.0001) was highly significant. Hence, the price series became stationary at first difference, showing I(1) behaviour.

Tamil Nadu

The non-stationarity was more pronounced in Tamil Nadu, where the ADF statistic at level form (0.4426) was not only higher but positive, with an insignificant probability (0.8903). This clearly confirmed the presence of a unit root in the level series. After taking the first difference, the ADF statistic (-4.9023) was well below the 1% critical value, with a probability (0.0003) indicating significance at the 1% level. Thus, the series turned stationary at first difference, confirming I(1) integration.

In summary, the ADF test results revealed that the turmeric price series in Telangana, Maharashtra, and Tamil Nadu were non-stationary at level but became stationary after first differencing. Therefore, all three series were integrated of order one, I(1), which provided the necessary precondition to apply Johansen's co-integration technique to examine the long-run equilibrium relationship among the selected turmeric markets. The appropriate lag length for this analysis, determined through the Schwarz Information Criterion (SIC), was found to be one, with the preferred model including an intercept but no deterministic trend.

Stationarity Analysis of Monthly Turmeric Prices Using ADF Test

Particulars	Lag		ADF Statistic	Prob*	Critical Value (1%)
Telengana	Level 0	0	-1.5162	0.5138	-3.639
	Difference 1	0	-4.4051	0.0018*	
Maharashtra	Level 0	0	-1.5431	0.5004	
	Difference 1	0	-5.2917	0.0001*	
Tamil Nadu	Level 0	1	0.4426	0.8903	
	Difference 1	0	-4.9023	0.0003*	

*denotes significance at 1% level
Data Source: www.indiastat.com

Johansen Test for Multiple Co-integration

To examine the long-run relationship among the turmeric markets, Johansen's Multiple Co-integration Test was employed. The results of the trace test and maximum eigenvalue statistics are presented.

The trace statistic for the null hypothesis of no co-integration (None*) was found to be 35.19, which is greater than its corresponding 5% critical value of 29.79, with a probability value of 0.0108. This indicates the null hypothesis of no cointegration is rejected at the 5 per cent significance level, suggesting the presence of at least one co-integrating relationship.

However, for the hypotheses of Atmost 1 and Atmost 2 co-integrating vectors, the trace statistics (9.06 and 0.29, respectively) were lower than their corresponding critical values (15.49 and 3.84) and were not statistically significant.

Thus, the results confirm the existence of one co-integrating equation among the selected turmeric markets. This implies the existence of a long-run equilibrium linkage among the markets, meaning that even though short-run deviations may occur, the turmeric prices in these markets converge and move together over the long term.

Johansen Cointegration Test Results for Monthly Turmeric Prices Across Selected Markets

Hypothesized number of CE(s)	Eigen value	Trace statistic	0.05 Critical value	Prob**
None*	0.546875	35.19100	29.79707	0.0108
Atmost 1	0.233381	9.068649	15.49471	0.3591
Atmost 2	0.009001	0.298391	3.841465	0.5849

Source: *www.indiastat.com*
Trace test indicates 1 cointegrating eqn(s) at the 0. 05 level
* denotes rejection of the hypothesis at the 0. 05 level
**MacKinnon-Haug-Michelis (1999) p-value.

Vector Error Correction Mechanism (VECM)

The Johansen cointegration results confirm the existence of a long-run equilibrium relationship among the prices of Telangana, Maharashtra, and Tamil Nadu turmeric markets. In the cointegrating equation, Maharashtra shows a positive and significant impact, whereas Tamil Nadu exerts a negative and significant influence.

The VECM results reveal that the error correction term for Maharashtra (-0.780318, t = -4.25) is negative and statistically significant at 10% level, indicating that nearly 78% of any previous disequilibrium is corrected within one period, thereby confirming a strong long-run adjustment mechanism. However, the error correction terms for Telangana (-0.055831, t = -1.38) and Tamil Nadu (-0.063886, t = - 0.62) are not significant, implying weak or no long-run adjustment for these markets.

In short run, in case of Maharashtra, the coefficient of (0.307959) of its own one month lagged changes was positively significant at 10% level, while other short-run coefficients are not statistically significant. Maharashtra exhibits both short-run and long-run dynamics, whereas Telangana and Tamil Nadu do not significantly adjust to deviations from long-run equilibrium.

The lagged prices of the integrated markets were observed to be both positive and negative. This reveals that the prices are transmitted in the short run among these markets. This confirms that the selected markets for the study are well integrated in the short run.

Monthly Turmeric Price Dynamics in Selected Markets Using VECM

Error correction	D(Telangana)	D(Maharashtra)	D(Tamil Nadu)
Coint Eq.1	-0.055831	-0.780318	-0.063886
	(0.04037)	(0.18352)	(0.10261)
	[-1.38308]	[-4.25197]*	[0.62262]
D(Telengana(-1)	0.017809	0.102991	-0.446686
	(0.19651)	(0.89340)	(0.49952)
	[0.09062]	[0.11528]	[-0.89423]
D(Maharashtra(-1)	0.047305	0.307959	0.041487
	(0.03525)	(0.16027)	(0.08961)
	[1.34187]	[1.92149]*	[0.46297]
D(Tamil Nadu(-1))	0.039317	-0.077021	0.164714
	(0.08580)	(0.39007)	(0.21809)
	[0.45824]	[-0.19746]	[0.75524]
C	-1.436196	69.06748	107.9142
	(53.8257)	(244.707)	(136.821)
	[-0.02668]	[0.28225]	[0.78873]
R-Squared	0.194532	0.505811	0.108059
Adj. R-Squared	0.083433	0.437647	-0.014968

Source: *www.indiastat.com*

Note: () indicates Standard Error, [ ] indicates the t-statistic, * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Granger Causality Analysis

Granger causality analysis was conducted to examine the short-run dynamic relationships among the turmeric markets of Telangana, Maharashtra, and Tamil Nadu. The results are summarized as follows:

Tamil Nadu → Maharashtra

The null hypothesis that Tamil Nadu is not a Granger cause of Maharashtra was rejected at the 1% level of significance (F = 10.8436, p = 0.0003). This indicates that past price movements in Tamil Nadu significantly influence the price formation in Maharashtra. However, the reverse hypothesis (Maharashtra → Tamil Nadu) was not significant (p = 0.7503), suggesting a unidirectional causality from Tamil Nadu to Maharashtra.

Telangana ↔ Maharashtra

The test statistics showed no significant causality in either direction (p = 0.6904 and p = 0.0528). This implies that prices in Telangana and Maharashtra move independently in the short run, and neither market has predictive power over the other.

Telangana → Tamil Nadu

The null hypothesis of no Granger causality from Telangana to Tamil Nadu was rejected at the 5% level of significance (F = 3.6693, p = 0.0380). This suggests that past prices in Telangana have a predictive influence on Tamil Nadu prices. In contrast, the reverse relationship (Tamil Nadu → Telangana) was not significant (p = 0.4630). Hence, there exists unidirectional causality from Telangana to Tamil Nadu.

Pairwise Granger Causality Analysis of Monthly Turmeric Prices among Identified Markets

Null Hypothesis	Obs	F-statistic	Probability	Causality Direction between Variables
Tamil Nadu does not exhibit Granger causality with Maharashtra.	34	10.8436	0.0003	Unidirectional
Maharashtra does not exhibit Granger causality with Tamil Nadu.		0.29019	0.7503	
Telangana does not exhibit Granger causality with Maharashtra.	34	0.37526	0.6904	No Influence
Maharashtra does not exhibit Granger causality with Telangana.		3.26175	0.0528	No Influence
Telangana does not exhibit Granger causality with Tamil Nadu.		0.79075	0.4630	Unidirectional
Tamil Nadu does not exhibit Granger causality with Telangana.	34	3.66933	0.0380	

Source: *www.indiastat.com*

Cuddy Della Valle Index (CDVI)

In time series analysis, data instability is commonly assessed using the Cuddy-Della Valle Instability Index, as this measure accounts for the presence of trends in the data, unlike the widely used coefficient of variation (CV). While the CV captures variability around the mean, the Cuddy-Della Valle Index measures fluctuations around the underlying trend. Given that time series data often exhibit trends, de-trending is necessary to accurately assess instability across markets. Therefore, price instability was calculated across the three markets, and the findings are summarized below. The findings show that the Maharashtra and Tamil Nadu markets experienced a moderate level of instability, whereas the Telangana market showed relatively low instability, suggesting greater persistence of price volatility in the Maharashtra and Tamil Nadu markets.

Price Instability of the Major Turmeric Markets in India

S. No.	Market	Adjusted R Square	CV	CDVI	Range
1	Telangana	0.626372057	5.9911	3.662103	Low instability
2	Maharashtra	0.054158688	24.0705	23.40967	Medium instability
3	Tamil Nadu	0.264973698	25.3926	21.77006	Medium instability

Source: *www.indiastat.com*

Export Destination Analysis of Indian Turmeric

An assessment of the trade direction for Indian turmeric exports to various importing countries was undertaken through a Markov chain framework to estimate the matrix of transition probabilities. The outcomes are presented as follows

Transition Probabilities of Turmeric Export Destinations from India (2014-15 to 2023-24)

	LOSSES							
GAIN	**Destination**	**Bangladesh**	**U.A.E**	**Morocco**	**U.S.A**	**Malaysia**	**Iran**	**Others**
	Bangladesh	0.265993	0.286368	0.003341	0.079456	0.080894	0.000000	0.283949
	U.A.E	0.631260	0.301334	0.012011	0.000000	0.000000	0.055395	0.000000
	Morocco	0.620081	0.000000	0.379919	0.000000	0.000000	0.000000	0.000000
	U.S.A	0.000000	0.367306	0.632694	0.000000	0.000000	0.000000	0.000000
	Malaysia	0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000
	Iran	0.043175	0.000000	0.000000	0.207216	0.189239	0.349530	0.210841
	Others	0.053659	0.000011	0.004763	0.044321	0.042935	0.000000	0.854311

Source: *www.indiastat.com*

The transitional probability matrix explains the direction and stability of Indian turmeric exports during 2014-15 to 2023-24. The analysis covers Bangladesh, the UAE, Morocco, the USA, Malaysia, and Iran, with remaining destinations grouped as “other countries.” In the matrix, row values show the probability of losing export share, column values indicate gains, and diagonal elements measure market retention.

Morocco and Iran emerged as relatively stable importers, retaining 37.9 per cent and 34.9 per cent of their respective shares. Morocco lost 62.0 per cent of its share to Bangladesh but gained 63.2 per cent from the USA, along with smaller gains from the UAE (0.12 per cent), Bangladesh (0.03 per cent), and other countries (0.04 per cent). Iran lost shares to other countries (21.0 per cent), the USA (20.7 per cent), Malaysia (18.9 per cent), and Bangladesh (0.04 per cent), but gained 100 per cent from Malaysia and 0.55 per cent from the UAE.

The UAE retained 30.1 per cent of its share, despite losing 63.1 per cent to Bangladesh, 0.55 per cent to Iran, and 0.12 per cent to Morocco, while gaining 36.7 per cent from the USA, 28.6 per cent from Bangladesh, and 0.011 per cent from other countries. Bangladesh retained 26.5 per cent but lost 28.6 per cent to the UAE and smaller shares to Malaysia, the USA, Morocco, and others. The USA and Malaysia retained zero per cent, with the USA losing 63.2 per cent to Morocco and 36.7 per cent to the UAE, and Malaysia losing 100 per cent to Iran.

The “other countries” group showed high stability by retaining 85.4 per cent of its share, with minor losses to Bangladesh (0.53 per cent), the USA (0.44 per cent), Malaysia (0.42 per cent), and Morocco (0.04 per cent), while gaining 28.3 per cent from Bangladesh and 21.0 per cent from Iran. Overall, Morocco, Iran, the UAE, Bangladesh, and other countries appear to be stable importers of Indian turmeric, whereas the USA and Malaysia remain unstable markets.

Conclusion and Policy Implications

The study reveals that turmeric prices in Telangana, Maharashtra, and Tamil Nadu are integrated in the long run, although their short-run adjustments differ, with Maharashtra exhibiting strong long-run correction while Telangana and Tamil Nadu show weaker responses. Price instability is low in Telangana and moderate in Maharashtra and Tamil Nadu, indicating the need for stronger market efficiency measures. Export analysis shows that Morocco, Iran, the UAE, Bangladesh, and the “Other countries” group remain stable and loyal importing partner of Indian turmeric, whereas markets such as the USA and Malaysia show inconsistent demand These findings highlight the importance of strengthening real-time price transmission, expanding e-NAM linkages, and improving storage and grading systems to reduce volatility and enhance domestic market integration. To improve farmer income, policies must encourage FPO development, contract farming, and tailored crop insurance for high-value spices. On the export front, India must consolidate its strong presence in stable markets while adopting targeted strategies, product diversification, value addition, and improved quality certification systems to tap into emerging markets. Strengthening supply chain resilience, promoting high-curcumin and organic turmeric varieties, and enhancing global branding will be crucial for sustaining India’s turmeric sector and improving long-term export competitiveness.

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