An Econometric Assessment of Rice Production and Export Performance in India (2000–01 To 2024–25)

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ABSTRACT:
This study analyses the trends, growth, and instability in rice production and export performance in India from 2000–01 to 2024–25, utilizing secondary data and standard econometric tools. Linear and semi-logarithmic trend models were utilized to assess the direction and compound growth rates of area, production, yield, export value, and export quantity of rice. Additionally, instability was measured by using the Coefficient of Variation and the Cuddy–Della Valle Instability Index. The findings revealed that rice production in India underwent consistent rise, predominantly propelled by enhancements in productivity rather than an increase in cultivated area. Production and yield exhibited notable positive trends, with compound growth rates of 2.3 percent and 1.8 percent, respectively, while area of cultivation had a slight annual expansion of 0.4 percent. Rice exports experienced significant growth, with export value and quantity increasing by 16.2 percent and 10.0 percent, respectively, while also capturing a larger share in total agricultural exports. Instability analysis indicated low variability in area, production, and yield, yet high instability in export value and quantity, signifying heightened sensitivity of exports to global market fluctuations and policy alterations. The study indicated that India has a robust and steady production foundation that can facilitate export growth, however, export performance is susceptible to external shocks. Consequently, suitable policy support is crucial for maintaining productivity growth and stabilizing export revenues.

Keywords: Rice production, rice exports, trend analysis, compound growth rate, Cuddy–Della Valle index

1. Introduction

Rice holds a crucial role in the Indian agricultural economy, functioning as a staple food for a significant portion of the population and a primary source of foreign exchange revenue. India is among the foremost producers and exporters of rice globally, with its export activities considerably impacting international rice markets. In the last twenty-five years, rice production and exports in India have experienced significant transformations due to technological innovations, regulatory measures, enhanced irrigation infrastructure, and variations in global demand and pricing. The timeframe from 2000–01 to 2024–25 experienced significant changes in rice cultivation area, production levels, and export revenues. Productivity advances enhanced output, whereas rice exports were affected by domestic supply conditions, minimum support price rules, export limits, and global trade dynamics. These factors introduced unpredictability in export performance, necessitating the evaluation of both growth trends and the extent of instability in production and exports.

An empirical examination of trends, growth rates, and instability in rice cultivation, production, and export value is essential for comprehending the long-term performance and sustainability of India's rice sector. This analysis offers significant insights for policymakers, researchers, and stakeholders engaged in agriculture planning and

export enhancement. This study analyses the trends, growth patterns, and instability in area, production, productivity, and export value of rice in India from 2000–01 to 2024–25 utilizing suitable econometric tools

2. Review of Literature

Numerous scholars have analyzed the domestic production performance and dynamics of rice in India, emphasizing critical elements of growth, sources of variation, and instability. Balaji and Ramesh (2025) utilized a Markov chain analysis to investigate the stability and competitiveness of India's rice export markets. Their findings indicated discrepancies in export stability among various importing nations and underscored the influence of major producing states on export trends. The research highlighted the significance of enduring stability in international trade ties for maintaining India's export efficacy.

Agrawal (2021) examined the trends in India's rice exports utilizing annual export data and discovered that both basmati and non-basmati rice exports exhibited substantial rise from 2008–09 to 2017–18. The study underscored India's increasing participation in the global rice trade and emphasized the need of export diversification in enhancing market presence. Agrawal employed trend coefficients to measure growth trajectories and identified significant export destinations such as Saudi Arabia, the UAE, and the U.K.

Dalal et al. (2024) examined trends, compound growth rates, and instability in the production and export of Basmati rice from 2001 to 2021. The study utilized techniques such as CAGR, Coefficient of Variation (CV), Cuddy–Della Valle Instability Index, and regression analysis to discern patterns of performance acceleration and deceleration. This study elucidated the framework of export dynamics for a significant rice category within India's comprehensive trade landscape.

Mondal et al. (2024) conducted an empirical analysis of growth and instability in rice production at the district level in Maharashtra, focusing on area, production, and yield. While concentrated at the state level, their methodology employing compound annual growth rates and the Cuddy–Della Valle Instability Index offers valuable econometric tools applicable to national level analysis as well.

Srikalaa et al. (2018) examined the trade direction and export competitiveness of Indian rice from 2000–01 to 2014–15 by Markov chain analysis and competitiveness metrics. Their findings revealed that Bangladesh and Benin were the most consistent markets for Indian rice exports, whilst nations like Sri Lanka and Nepal exhibited erratic import demand patterns. The study determined that Indian rice demonstrated a modest level of export competitiveness during the study period, emphasizing strategic avenues for enhancing market retention and diversification.

Kumar (2025) analyzed the export performance of India's principal agricultural commodities, particularly Basmati and non-Basmati rice, utilizing trend data and revealed comparative advantage (RCA) during the past decade. The study revealed that Basmati rice exhibited a robust comparative advantage and consistent export growth compared to other commodities, whereas non-Basmati rice demonstrated greater instability and required specific governmental interventions to improve global competitiveness.

3. Methodology

The research relies solely on secondary data spanning twenty-five years from 2000–01 to 2024–25. Data regarding the area under rice cultivation and rice production were sourced from official publications of the Ministry of Agriculture and Farmers' Welfare, Government of India. In contrast, data on the export value and quantity were acquired from entities such as the Directorate General of Commercial Intelligence and Statistics (DGCI&S), the Agricultural and Processed Food Products Export Development Authority (APEDA), and pertinent government reports.

The study utilized common econometric tools, including trend analysis, compound growth rate estimation, and instability analysis, to investigate

the long-term behaviour of rice production and export performance.

Linear trend models were employed to examine the direction and magnitude of changes in area, production, yield, export value, and export quantity of rice over the study period. The model is specified as: $\mathbf{Y_t = a + bt + e_t}$

Where,

Yt = Value of the variable in year t

a = Intercept

b = Annual rate of change (trend coefficient)

t = Time variable

e_t = Random error term

The significance of the trend coefficient was tested using the Student's *t*-test.

Compound Growth Rates (CGR) were calculated utilizing semi-logarithmic model to estimate the average annual growth rates of the chosen variables. The Compound Growth Rate (CGR) was computed as $\mathbf{CGR = (e^b - 1)\times 100}$; where b denotes the estimated regression coefficient of the semi-log model.

The instability in area, production, productivity, export value, and export quantity of rice was assessed using the Coefficient of Variation (CV) and the Cuddy–Della Valle Instability Index, which accounts for trend effects and offers a more dependable measure of variability over time. The Coefficient of Variation (CV) was calculated to measure the degree of variability in the selected variables.

$$CV = \frac{\sigma}{\bar{X}} \times 100$$; where

σ = Standard deviation

X = Mean of the variable

Although CV measures variability, it does not account for the effect of trend in the time series.

To obtain a more reliable measure of instability, the Cuddy–Della Valle Instability Index (CDVI) was employed. The index adjusts the coefficient of variation by removing the effect of the trend.

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

Where,

CV = Coefficient of Variation

R^2 = Coefficient of determination obtained from the linear trend regression.

Based on the CDVI values, instability was classified as follows:

CDVI (%)	Level of Instability
0–15	Low
15–30	Moderate
Above 30	High

The integration of these econometric approaches facilitated a thorough evaluation of growth performance and instability in India's rice sector during the study period.

4. Results and Discussion

Table 1 delineates the trends in the area of cultivation, production, and yield of rice in India from 2000–01 to 2024–25. The table offered a comprehensive summary of the principal production metrics of the rice sector, helping to understand the trends in cultivated area, production, and productivity over time. This preliminary research served as the foundation for the next econometric evaluation of growth performance.

Table 1 Area of Cultivation, Production and Yield of Rice in India During 1294-1302 to 1294-1302

Year	Area (In Lakhs Hectares)	Production (In Lakhs Tonnes)	Yield per Hectare (Kg/ha)
1294-1302	447	849.8	1901
1294-1302	449	933.4	2079
1294-1302	412	718.2	1744

1294-1302	426	885.3	2077
1294-1302	419	831.3	1984
1294-1302	437	917.9	2102
1294-1302	438	933.6	2131
1294-1302	439	966.9	2202
1294-1302	455	991.8	2178
1294-1302	419	890.9	2125
1294-1302	429	959.8	2239
1294-1302	440	1053.0	2393
1294-1302	428	1052.4	2461
1294-1302	440	1066.5	2424
1294-1302	439	1054.8	2390
1294-1302	435	1044.1	2400
1294-1302	440	1097.0	2494
1294-1302	438	1127.6	2576
1294-1302	442	1164.8	2638
1294-1302	437	1188.7	2722
1294-1302	458	1243.7	2717
1294-1302	463	1294.7	2798
1294-1302	478	1357.6	2838
1294-1302	478	1378.3	2882
1294-1302	514	1490.7	2899

Source: Ministry of Agriculture & Farmers Welfare, Government of India.

Table 1 illustrates that rice cultivation in India saw moderate area expansion alongside significant increases in production and productivity. In the initial year of the study period (2000–01), the area under rice farming was 447 lakh hectares, which varied over the years and increased to 514 lakh hectares by 2024–25. The area did not expand consistently; instead, it exhibited cyclical fluctuations attributable to variables such as monsoon variability, crop diversification, and policy changes. Nonetheless, the overall trend indicated a modest increase in the cultivated area. Conversely, rice production exhibited a significant increase trajectory. Production escalated from 849.8 lakh tonnes in 2000–01 to 1490.7 lakh tonnes in 2024–25, indicating substantial growth. Notwithstanding intermittent decreases (particularly in 2002–03 and 2009–10, presumably linked to unfavourable meteorological conditions), the long-term trend persisted robustly upward. Yield per hectare had the most continuous enhancement, increasing from 1901 kg/ha in 2000–01 to 2899 kg/ha in 2024–25. This signified that enhancements in productivity, rather than the expansion of cultivated area, were the principal factors contributing to the rise in rice production. The consistent increase in production could be ascribed to the use of high-yielding varieties, enhanced irrigation, efficient input utilization, and technical innovations in rice cultivation. The data indicated that India's rice sector throughout the research period was characterised by productivity-driven growth, with technological advancements being more significant than land expansion in enhancing output.

Table 2 presents the results of trend and growth performance analysis of area, production, and yield of rice in India from 2000–01 to 2024–25. This investigation aimed to ascertain the direction, magnitude, and statistical significance of changes in the main production indicators of rice.

Table 2 Trend Analysis and Growth Performance of Area, Production and Yield of Rice in India (2000–01 to 2024–25)

Variables	Linear Model			
	a	**b**	**t**	**R^2**
Area	419.450 (7.048)	1.888 (0.474)	3.983**	40.8
Production	748.385 (27.260)	23.948 (1.834)	13.060**	88.1
Yield	1818.000 (32.153)	42.905 (2.163)	19.837**	94.5
	Semi-log Model			**CGR**
	a	**b**	**t**	**R^2**
Area	6.041 (0.015)	0.004 (0.001)	4.007**	41.1	0.4
Production	6.661 (0.025)	0.022 (0.002)	13.372**	88.6	2.3
Yield	7.527 (0.015)	0.018 (0.001)	17.868**	93.3	1.8

Source: Computed by the Researcher

Figures in brackets indicate standard error

** Significant at one per cent level,

* Significant at five per cent level

Table 2 demonstrated a statistically significant increase in all three variables. The linear model revealed that the area under rice cultivation expanded annually by around 1.888 lakh hectares (t = 3.983), however the explanatory power was moderate (R^2 = 40.8 percent), indicating constrained growth of cultivated land. Conversely, rice production had a substantial and statistically significant annual growth of 23.948 lakh tonnes (t = 13.060), accompanied by a high R^2 of 88.1 percent, whilst yield enhanced by 42.905 kg per hectare annually (t = 19.837) with an exceptional fit (R^2 = 94.5 percent). The semi-logarithmic model further validated the growth pattern, indicating compound growth rates of 0.4 percent for area, 2.3 percent for production, and 1.8 percent for yield, all significant at the one percent level. The relatively modest increase in area, coupled with a significant rise in production and yield, unequivocally demonstrates that the augmentation of rice production in India during the study period was primarily driven by productivity enhancements rather than area expansion, highlighting the beneficial effects of technological advancements and improved crop management practices.

Table 3 illustrates the performance of India's rice exports from 2000–01 to 2024–25, encompassing export value, export quantity, the proportion of rice in total agricultural exports, and overall agricultural exports.

Table 3 India's Rice Exports During 1294-1302 TO 1294-1302

Year	Rice Export Value (₹ In Crores)	Quantity (In Thousand Tonnes)	Share of rice Export in Total Agri Export	Total Agri Export (₹ In Crores)
1294-1302	2943	1534.4	10.30	28582
1294-1302	3174	2208.4	10.83	29312
1294-1302	5831	4967.8	17.31	33691
1294-1302	4708	3412.1	12.99	36247
1294-1302	6769	4778.1	17.10	39579
1294-1302	6221	4088.2	13.32	46703
1294-1302	7036	4747.9	11.93	58959
1294-1302	11751	6468.1	15.46	76006
1294-1302	11164	2488.2	13.66	81710
1294-1302	11255	2156.3	13.21	85211
1294-1302	11586	2471.4	10.40	111393
1294-1302	24109	7176.0	13.37	180279
1294-1302	33858	10147.0	15.17	223170
1294-1302	47087	10902.5	18.04	260953
1294-1302	48028	12001.0	19.96	240639
1294-1302	38202	10510.3	17.66	216369
1294-1302	38443	10756.0	16.95	226775
1294-1302	50308	12875.4	20.19	249182
1294-1302	53975	12062.6	19.89	271354
1294-1302	45427	9511.0	18.29	248385
1294-1302	65405	17779.0	21.18	308830
1294-1302	72116	21232.0	19.19	375742
1294-1302	89622	22353.1	20.85	429856
1294-1302	86194	16358.6	21.03	409844
1294-1302	105722	20195.7	23.68	446455

Source: Directorate General of Commercial Intelligence and Statistics (DGCI&S)

Table 3 delineates the performance of India's rice exports in terms of export value, export quantity, share in total agricultural exports, and total agricultural exports from 2000–01 to 2024–25. The data indicated a significant growth in India's rice export business throughout the study period. The export value of rice rose significantly from ₹2,943 crore in 2000–01 to ₹1,05,722 crore in 2024–25, reflecting the increasing significance of rice in India's export portfolio. Despite the observed oscillations (declines around 2008–10 and 2015–16), the long-term trajectory persisted in an upward direction. The quantity of rice exported increased significantly from 1,534.4 thousand tonnes in 2000–01 to 20,195.7 thousand tonnes in 2024–25. A significant structural shift was evident post-2011–12, indicating policy liberalization and enhanced global competitiveness of Indian rice, particularly non-basmati types. The proportion of rice exports among total agricultural exports has likewise increased over time. It rose from 10.30 percent in 2000–01 to 23.68 percent in 2024–25, indicating that rice has become an increasingly significant element of India's agricultural export revenue. Total agricultural exports increased consistently from ₹28,582 crore to ₹4,46,455 crore during the period, reflecting the general rise of the agricultural trade industry. Nonetheless, the increasing proportion of rice indicated that

rice exports expanded more rapidly than total agricultural exports. The table demonstrated that India's rice export performance from 2000–01 to 2024–25 exhibited significant growth in both value and quantity, enhanced global competitiveness, and an increasing share of overall agricultural exports.

Table 4 presents the results of trend and growth performance analysis of India's rice exports from 2000–01 to 2024–25.

Table 4 Trend Analysis and Growth Performance of India's Rice Exports: Value, Quantity, Share in Total Agricultural Exports and Total Agricultural Exports (2000–01 to 2024–25)

Variables	Linear Model			
	a	**b**	**t**	**R^2**
Rice Export	-15711.8 (4330.038)	3919.168 (291.270)	13.455**	88.7
Quantity	-799.059 (1178.699)	778.946 (79.288)	9.824**	80.8
Share of Rice Export	10.947 (0.913)	0.425 (0.061)	6.931**	67.6
Total Agri Exports	-43754.6 (15236.147)	17874.127 (1024.894)	17.440**	93.0
	Semi-log Model			**CGR**
	a	**b**	**t**	**R^2**
Rice Export	8.019 (0.109)	0.150 (0.007)	20.411**	94.8	16.2
Quantity	7.629 (0.163)	0.095 (0.011)	8.728**	76.8	10.0
Share of Rice Export	2.431 (0.061)	0.026 (0.004)	6.440**	64.3	2.7
Total Agri Exports	10.193 (2607.197)	0.123 (0.007)	18.807**	93.9	13.1

Source: Computed by the Researcher

Figures in bracket indicate standard error

** Significant at one per cent level,

* Significant at five per cent level

The results in Table 4 indicate a robust and statistically significant rising trend across all variables. The linear model indicated that the annual increase in rice export value was ₹3,919.168 crore (t = 13.455), demonstrating a strong explanatory power (R^2 = 88.7 percent), signifying substantial growth in export revenues. Likewise, the export quantity exhibited a substantial yearly rise of 778.946 thousand tonnes (t = 9.824) with a R^2 of 80.8 percent, indicating

consistent growth in export quantity. The proportion of rice exports within overall agricultural exports increased notably by 0.425 percentage points per year (t = 6.931), though with comparatively moderate explanatory power (R^2 = 67.6 percent). Total agricultural exports demonstrated a robust increase trend, rising by ₹17,874.127 crore annually (t = 17.440) with an exceptional fit (R^2 = 93.0 percent). The semi-logarithmic model further validated the development trend, revealing compound growth rates of 16.2 percent for rice export value, 10.0 percent for export quantity, 2.7 percent for export share, and 13.1 percent for overall agricultural exports, all statistically significant at the one percent level. The comparatively greater increase in export value relative to quantity signifies an enhancement in export prices and the global competitiveness of Indian rice, while the escalating share corroborates the growing significance of rice in India's agricultural export portfolio during the study period.

Cuddy–Della Valle Instability Index of Rice Sector in India

The fluctuations in the area, production, productivity, export value, and export quantity of rice in India from 2000–01 to 2024–25 were assessed using the Cuddy–Della Valle Index (CDVI), which modifies the coefficient of variation to account for the trend component.

Table 5 Cuddy–Della Valle Instability Index

Variable	CV	R^2	CDVI	Instability Level
Area	4.90	40.8	3.77	Low
Production	17.72	88.1	6.11	Low
Yield (Productivity)	13.67	94.5	3.21	Low
Export Value	86.90	88.7	29.21	High
Export Quantity	68.40	80.8	29.97	High

Source: Calculated by the Author

The Cuddy–Della Valle instability index indicated significant differences between the domestic rice sector and export performance in India during the study period. The area (3.77%), production (6.11%), and yield (3.21%) of rice demonstrated low instability, signifying that India's rice production system has maintained relatively stable and resilient over time. Conversely, the export value of rice (29.21%) and export quantity (29.97%) exhibited significantly higher instability, indicating the susceptibility of export performance to international market dynamics, trade regulations, and price variations. The findings indicated that domestic rice production remained stable and productivity-focused, whereas the export sector exhibited relative instability. This disparity indicated that India had a steady production foundation capable of producing an exportable surplus; nevertheless, the realization of export revenues was more affected by external market dynamics than by domestic supply conditions.

5. Conclusion

This study evaluated the growth performance and instability of rice production and exports in India from 2000–01 to 2024–25 employing econometric tools. The results unequivocally demonstrated that India's rice industry has experienced substantial structural enhancement throughout the study period. The increase in rice production was mostly driven by productivity, as indicated by the higher growth rates of output and yield relative to the comparatively slight expansion of cultivated area. The linear and semi-log trend analyses validated a robust and statistically significant increase in production and productivity, indicative of the beneficial effects of technical advancement, enhanced irrigation, and superior crop management techniques.

India's rice exports surged significantly in both value and quantity, with the proportion of rice in overall agricultural exports rising consistently, underscoring its increasing significance in the nation's export portfolio. Nevertheless, the instability analysis uncovered a divergent trend: although domestic production indicators were reasonably steady, both export value and export quantity displayed significantly higher instability. This indicates that while India has established a robust manufacturing base capable of producing an exportable surplus, the realization of export revenues remains subject to global market instability, policy interventions, and trade barriers. The study concluded that India maintains a robust structural position in rice production and an increasingly significant role in global rice trade. Maintaining productivity growth while reducing export instability is essential for enhancing the long-term stability and competitiveness of the rice sector.

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