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INDIA'S PROCESSED FOOD EXPORT COMPETITIVENESS: A DISAGGREGATED RCA ANALYSIS ACROSS PROCESSING LEVELS

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ABSTRACT

This paper analyses India's processed food export competitiveness using Revealed Comparative Advantage (RCA) indices calculated at seven processing stages — Raw, Minimal Processing, Salt/Sugar Processing, Fermentation/Smoking, Composite, Ingredients, and Precursor — in a dataset of 1751 observations between 1995 and 2023. The tools of analysis are descriptive statistics, time series analysis, variance decomposition and panel regression with Fixed Effects (FE) specification based on the Hausman test. Processing levels Results show that there is considerable variation in competitiveness across levels of processing). India holds a recurring and robust comparative advantage in Ingredients (mean RCA = 2.57) and Minimal Processing (mean RCA = 2.21) particularly in nuts and vegetable fats and in all the vegetable-based sub-sectors. By contrast, Salt/Sugar Processing (mean RCA = 0.39) and Precursor (mean RCA = 0.22) remain rather feeble. Variance decomposition shows that 62.71 percent of total RCA variation can be attributed to the category-level fixed effects, thus lining up with the FE specification. The results reveal a structural dualism characterizing India's Agro-food trade that portrays Agro-food competitiveness being firmed at lower and intermediate processing levels with marginal entry into high-value composite and precursor products."

KEYWORDS*: Revealed Comparative Advantage, Processed Food Trade, Export Competitiveness, Fixed Effects, India, Value Chain Upgrading*

1. INTRODUCTION

India is the world's second largest food producer and a significant agricultural exporter, yet its performance in processed food exports is fraught with structural imbalances. Primary commodity exports (including rice, spices and oilseeds) have traditionally been the mainstay of India's agri-trade basket, but the shift to the more lucrative processed food categories has been gradual and selective. To be able to formulate appropriate trade and industrial policies it is important to know what types of food products are export competitive at what processing levels. The Revealed Comparative Advantage (RCA) index pioneered by Balassa (1965) is still the most popular empirical instrument to measure trade specialization. RCA, in contrast to models of comparative advantage that are fundamentally theoretical, is calculated based on actual trade data, making it a reliable gauge of observed export success on a global scale. When applied to a disaggregated set of processing categories, and over an extended panel of almost three decades, RCA analysis can reveal persistent patterns that are hidden in aggregate trade data. Global trade in processed foods has experienced significant structural change over the past three decades, as a result of rising consumer incomes, rapid urbanization and the growing cross-border integration of Agro-food value chains. For emerging economies such as India, the processed food industry holds a critical place - connecting the agricultural production base with export-led manufacturing and creating significant employment across the supply chain. India is the second largest food producer in the world after China and the food processing industry is estimated to contribute around 8.9 per cent of the gross value added in the manufacturing (Ministry of Food Processing Industries, Government of India, 2022). In spite of this scale of production, India's share in global sales of processed food is rather meagre indicating a structural bias towards primary and minimally processed categories rather than high-value transformed products. To know how and why the pattern of export competitiveness varies by level of food processing is not just an interesting academic exercise it has direct relevance for trade policy, the prioritisation of investment and industrial strategy. The Balassa index, or known also as the Balassa Revealed Comparative Advantage index (RCA), is based on the Ricardian comparative advantage model and was first introduced by Balassa (1965), it has been proved as a highly effective and popular tool for analyzing the actual trade specialization derived from the observed export flow. When compared with measures based on productivity or factor costs, RCA analysis summarizes the outcome, on international markets, of a country's competitiveness position, which is why it is very well suited also for cross-category and longitudinal studies. Following three key research questions the paper analyses: (i) How does India's export competitiveness in processed food vary by product category and level of processing? (ii) Can we observe any structural trends in RCA for the period 1995–2023? (iii) What do the variance decomposition and panel regression indicate regarding the relative significance of category-specific and time-specific effects?

2. LITERATURE REVIEW AND RESEARCH GAP

Comparative advantage, as described by Ricardo (1817) and then subsequently developed in the Heckscher-Ohlin model, provides the foundation for the theory of trade specialization. Balassa (1965) developed the RCA index as a heuristic device and the index quantifies a country's export share of a product relative to its share in world exports. An RCA greater than one means revealed comparative advantage. Vollrath (1991) developed alternative formulations to deal with asymmetry problems, whereas Leromain and Orefice (2014) suggest a normalized RCA with better distributional characteristics. Fertő and Hubbard (2003) conducted an analysis of RCA for central European Agro-food industries, finding that the degree of competitiveness differed widely across product groups and over time. Jambor and Babu (2016) established that competitiveness in processed food was diminishing in a number of developing countries and associated this with weak value-chain integration. For India, more specifically, Kumar and Prabhakar (2017) revealed a strong RCA in unprocessed agri-commodities, however, a relatively weaker showing in processed segments which they ascribed to that country's infrastructural weaknesses and costs associated with sanitary and phytosanitary compliance. The Fixed Effects (FE) estimator is the most natural choice when unobserved unit-specific effects are correlated with the regressors — as in product-category panels. The FE versus Random Effects (RE) specification is commonly tested using the Hausman (1978) test. Complementary evidence on the relative dominance of between-category variation and within-category variation can also be found in variance decomposition via the Intraclass Correlation Coefficient (ICC). Abstract Current analyses are based on aggregate trade data and do not consider the heterogeneity at the processing stage in the revealed comparative advantage of India within finer food sub-categories.

3. NEED AND SIGNIFICANCE OF THE STUDY

Although India's processed food industry has a large share in value-added agriculture and in India's agricultural exports, the policy debate is largely based on aggregate trade statistics which hide important heterogeneity within the sector. So far, the literature has not systematically analysed how India's competiveness in exports varies among the different stages of processing - from raw commodities to sophisticated precursor products. These categories, however, still do not provide the detail dived depth of granularity required to ascertain the exact products that should be promoted and those that exporters should ignore. The period 1995–2023 includes several policy regimes and global demand cycles, which necessitates a disaggregated longitudinal study for formulation of suitable evidence-based industrial and trade policies for India's Agro-food sector. This study offers a novel contribution by introducing disaggregation by processing levels to the analysis of India's RCA – a method not applied in the current Agro-food trade literature. Demonstrating that category-level fixed effects explain 62.71% of RCA variation, this study argues that competitiveness is structurally rather than temporally-determined, which not only shifts policy focus away from across the business cycle macroeconomic stabilization towards sector-specific structural intervention.

4. OBJECTIVE

1. To analyse India's RCA at seven levels of processing of food using disaggregated trade data from the UNCTAD s for the years 1995–2023.
2. To analyse structural trends and category-specific determinants of the competitiveness of Indian exports of processed food with the help of Fixed Effects panel regression and variance decomposition.

5. DATA AND METHODOLOGY

5.1Data

This paper analyses the export competitiveness of India in the processed food industry employing Revealed Comparative Advantage (RCA) indices at seven processing stages of a hierarchical nature – Raw (A), Minimal Processing (B), Salt/Sugar Processing (C), Fermentation/Smoking (D), Composite (E), Ingredients (F) and Precursor (G). The source of data is the United Nations Conference on Trade and Development (UNCTAD) Statistics database (https://unctad.org/statist ics) for the period under review 1995–2023.

5.2 Revealed Comparative Advantage

The Balassa (1965) RCA index is defined as:

$$\mathbf{RCA_{ij} = (x_{ij} / X_i) / (xw_j / Xw)}$$

where x_{ij} represents India's exports of category j, X_i is the total exports of India, xw_j is the world exports of category j, and Xw represents the total world exports. RCA > 1 implies a revealed comparative advantage.

5.3 Econometric Specification

The panel regression model is:

$$\mathbf{RCA_{it} = \alpha + \beta_1 \cdot Trend_t + \mu_i + \lambda_t + \varepsilon_{it}}$$

where μ_i includes category-level fixed effects and λ_t includes time effects. Model choice between FE and RE is based on ICC and the Hausman (1978) test. Non-normality of RCA is confirmed by the Shapiro-Wilk test ($W = 0.5623$, $p < 0.001$), justifying the use of non-parametric robustness checks.

Time-trend analyses are based on linear regressions of RCA on a standardized time over six subperiods (1995–99, 2000–04, 2005–09, 2010–14, 2015–19, 2020–23). Panel regression with Fixed Effects (FE) specification is employed in line with variance decomposition, where the Intraclass Correlation Coefficient (ICC = 0.6271) suggests that most of the variance resides within the categories does not change across sub-samples. The Hausman (1978) test also statistically confirms the FE model over RE. According to the Shapiro-Wilk test the distribution of RCA is non-normal ($W = 0.5623$, $p < 0.001$) and results of both parametric and non-parametric robustness checks are reported as well.

6.RESULTS AND DISCUSSION

6.1Descriptive Statistics by Processing Level: On the whole, just 25.36% of India's group-year observations have RCA > 1, suggesting that comparative advantage is a rarity in the processed food industry in India. A complete breakdown is given in table 1.

Table 1. Descriptive Statistics of India's RCA by Processing Level, 1995–2023

Processing Level	N	Mean RCA	Median	Std. Dev.	Min	Max	% > 1
Raw (A)	358	0.9528	0.4079	1.4446	0.0000	11.1394	29.3%
Minimal Processing (B)	279	2.2056	0.4870	3.1407	0.0000	16.7006	36.6%
Salt/Sugar Processing (C)	352	0.3885	0.2028	0.5056	0.0070	3.8660	7.9%
Fermentation/Smoking (D)	157	0.7550	0.0561	1.6675	0.0000	14.9825	22.3%
Composite (E)	319	0.7759	0.1977	1.4032	0.0001	8.9943	24.1%
Ingredients (F)	145	2.5718	1.5660	2.2412	0.1546	9.8259	82.1%
Precursor (G)	141	0.2204	0.0428	0.4749	0.0003	3.5547	3.5%

Note: RCA > 1 denotes revealed comparative advantage. Source: Authors' computations.

The highest mean RCA (2.57) is observed for Ingredients category (F) with a share of RCA larger than one equal to 82.1%. Minimal Processing (B) has the second mean RCA highest for the second time. In striking contrast, Salt/Sugar Processing (C) and Precursor (G) have mean RCA scores of 0.39 and 0.22, respectively — indicative of a severe structural disadvantage in chemically transformed, and/or high-tech processing.

6.2 Top Competitive Categories

Table 2. Top 15 Processed Food Categories by Mean RCA — India, 1995–2023

Code	Category Label	Level	Mean RCA	Median	Std. Dev.	Yrs > 1
B13	Minimal Processing – Vegetable fats	Minimal Proc.	7.4096	7.9534	3.0682	28/29
F02	Ingredients – Fruit	Ingredients	6.2393	6.2572	1.1752	29/29
B10	Minimal Processing – Nuts	Minimal Proc.	5.9003	4.5640	2.5077	29/29
D16	Fermentation – Sugars, jams	Fermentation	5.2451	2.3131	6.5082	4/4
B01	Minimal Processing – Vegetable	Minimal Proc.	4.1865	4.2939	1.4578	29/29
A10	Raw – Nuts	Raw	4.0322	4.0078	2.2953	28/29
F01	Ingredients – Vegetable	Ingredients	3.4085	3.1384	1.0391	29/29
E13	Composite – Vegetable fats	Composite	3.0640	1.6592	2.6821	27/29
D07	Fermentation – Shellfish	Fermentation	3.0381	2.9462	0.7647	29/29
E01	Composite – Vegetable	Composite	2.8258	2.7112	1.0859	28/29
A07	Raw – Shellfish	Raw	1.9079	1.7572	0.8219	23/29
A11	Raw – Oilseeds	Raw	1.8635	1.0347	1.9921	18/29
B11	Minimal Processing – Oilseeds	Minimal Proc.	1.6282	0.5335	3.7407	8/25
A03	Raw – Cereals	Raw	1.5049	1.5279	0.2912	28/29
C09	Salt/Sugar – Egg	Salt/Sugar	1.4106	1.1700	0.8271	17/29

Note: 'Yrs > 1' = years out of total observations where RCA exceeded unity. Source: Authors' computations.

B13 Minimally Processed Vegetable Fats (B13) is at the top end with a mean RCA of 7.41 and RCA > 1 for as many as 28 out of the 29 years. Among the top fifteen categories four are from Minimal Processing (B) and three from Ingredients (F) – this further confirms that India’s competitive is based in relatively pre-processed state.

6.3 Temporal Trends in RCA by Processing Level

Table 3. Period-wise Mean RCA by Processing Level — India, 1995–2023

Processing Level	1995–99	2000–04	2005–09	2010–14	2015–19	2020–23	Trend
Raw (A)	0.9304	0.9971	1.1655	0.9504	0.8913	0.7612	↓ Declining
Minimal Processing (B)	1.9084	2.8313	3.0190	2.0356	1.7698	1.7787	↔ Peaked 2005–09
Salt/Sugar Processing (C)	0.3197	0.3925	0.4095	0.3702	0.4298	0.4154	↔ Stable
Fermentation/Smoking (D)	0.8231	0.6491	0.5947	1.0749	0.6884	0.6597	↔ Volatile
Composite (E)	1.0335	0.7659	0.8462	0.5025	0.7109	0.8018	↓ Weakened
Ingredients (F)	2.7347	2.7956	2.9208	2.4639	2.2698	2.1650	↓ Gradual decline
Precursor (G)	0.1469	0.2449	0.3909	0.1267	0.2089	0.1957	↔ Persistently weak

Note: Period averages computed from annual mean RCA values. Source: Authors' computations.

Processing is (B) is shown to exhibit a U-shape pattern with the minimum around 3.02 at 2005–09 and then a decline down to 1.78 at 2020–23. While Ingredients (F) holds a mean RCA over unity all through above 2.92 (2005–09) to 2.17 (2020–23) and seems to erode gent by gent.

6.4 Panel Regression and Variance Decomposition

Table 4. Linear Trend Regression Results by Processing Level — India, 1995–2023

Processing Level	Slope (β_1)	Intercept	R^2	p-value	Significance
Raw (A)	−0.0075	0.9526	0.0019	0.4082	n.s.
Minimal Processing (B)	−0.0287	2.2158	0.0060	0.1961	n.s.
Salt/Sugar Processing (C)	+0.0031	0.3895	0.0026	0.3369	n.s.
Fermentation/Smoking (D)	−0.0013	0.7560	0.0000	0.9354	n.s.
Composite (E)	−0.0103	0.7725	0.0038	0.2730	n.s.
Ingredients (F)	−0.0271	2.5629	0.0103	0.2240	n.s.
Precursor (G)	−0.0008	0.2207	0.0002	0.8676	n.s.

Note: n.s. = not statistically significant at 10% level. Source: Authors' computations.

Table 5. Variance Decomposition and Hausman Specification Test — India Panel

Statistic	Value	Interpretation
Within-category variance	1.6088	Variation in RCA over time within a category
Between-category variance	2.7053	Variation in RCA across categories
Total variance	3.6525	Overall RCA variability
ICC	0.6271	62.71% of variance from category-level effects
Hausman recommendation	Fixed Effects (FE)	High ICC favors FE model
Shapiro–Wilk	W = 0.5623, $p < 0.001$	Non-normal; supports non-parametric checks

The ICC of 0.6271 suggests that 62.71 percent of the variance of total RCA could be explained by the differences between categories, which provides a strong empirical basis for the Fixed Effects specification. None of the level-specific trend slopes are statistically significant, suggesting that fluctuations from one period to the next are due to structural breaks and volatility rather than monotonic trends.

7.SUMMARY

There exists a substantial structural duality within the processed food export competitiveness of India in the seven processing stages over the period 1995–2023. Based on 1,751 category-year observations in UNCTAD trade data, this research shows that observations exhibiting RCA > 1 are only 25.36% due to extreme heterogeneity across levels. The Ingredients group (F) has the highest average RCA of 2.57 with 82.1% of the observations are above unity, followed by Minimal Processing (B) with an average RCA of 2.21. Conversely, Precursor (G) and Salt/Sugar Processing (C) are continually uncompetitive with an average RCA of 0.22 and 0.39 accordingly. Minimal Processing competitiveness reached its highest point in 2005-09 (mean RCA=3.02) and then started to decline to 1.78 in 2020–23, while Ingredients experienced steady diminishing from 2.92 to 2.17 over the same period.-Term among top 15 competitive categories with mean RCA of 7.41 across 28 of 29 years.

8.POLICY IMPLICATIONS

The preeminence of Minimal Processing (B) and Ingredients (F) in india's competitive offering indicates that the current prominence of the export portfolio is based more upon basic factor endowments than upon value-chain upgrading. To move towards higher value-added exports, policies should focus on providing investment incentives in Salt/Sugar Processing and Composite sectors, in which India has average RCA scores of 0.39 and 0.78 respectively. The declining path in Ingredients (F) competitiveness from 2.92 (2005–09) to 2.17 (2020–23) is alarming. GI tagging, quality certifications, and preferential trade agreements for high-end markets could be the answers to stemming the tide. Continued weakness in Precursor (G) categories into the next decade reflects India's limited participation in global food ingredient value chains—investment in R&D to develop upstream capacity could yield new competitive niches.

9.CONCLUSION

This paper is the first to conduct a thorough disintegrated RCA analysis of the competitiveness of Indian processed food exports at seven processing levels over the period 1995 to 2023. The results reveal that a stark structural dualism can be found in the extent of comparative advantage: severe and persistent uncomparative advantage in Salt/Sugar Processing and Precursors and comparative advantage in Ingredients and Minimal Processing. Variance decomposition also supports that the category-level fixed effects contribute to 62.71% of total RCA variance, which can further justify the FE panel specification. These results indicate that India's Agro-food trade competitiveness is still based on rather early processing levels of an albeit rapidly evolving agro-based food processing industry.

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