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Competitiveness and Structural Transformation of India's Agricultural Exports: A Product Mapping and Product Space Analysis, 1991–2020

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ABSTRACT

Using product mapping and product space analysis at the HS-4 level from 1991–2020, this study classifies 200 commodities by Revealed Symmetric Comparative Advantage and Trade Balance Index. Results show Group C (export specialization without comparative advantage) dominated, while Group A (strong competitiveness) remained stable and Group B indicated untapped potential. Product space analysis reveals gradual diversification into higher-complexity goods alongside persistent reliance on staples like rice and spices. Policy should prioritize agro-processing and supply-chain infrastructure to enable export upgrading.

Keywords: Agricultural Exports, Comparative Advantage, Product Mapping, Product Space, RSCA, Trade Competitiveness

JEL Code: F14, Q17, O14, O24, F10

I
INTRODUCTION

The agriculture sector, a lifeline of the Indian economy, has a strong linkage with livelihood, economic growth, employment generation, and foreign exchange earnings. The agricultural sector exports have grown over the years, but have transformed significantly in the post-liberalisation period. However, the export potential of the agricultural sector is not fully exploited compared with its potential. The theoretical understanding of agricultural export competitiveness evolved from classical theories of comparative advantage and factor endowments to dynamic export competitiveness. Current studies on competitiveness emphasise technological progress, institutional quality, infrastructure development, and global value chain integration of exporting countries. Traditional empirical methods of competitiveness, such as the Revealed Comparative Advantage (RCA) index, had their limitations, which were replaced with more efficient methods such as the Revealed Symmetric Comparative Advantage (RSCA) and Trade Balance Index (TBI). Product space theory and network-based analytical frameworks are some of the recent methods of trade analysis to evaluate export diversification patterns and identify high-potential products, providing a better understanding of competitive positions by mapping relationships between products and their pathways to structural transformations and diversification. Significant analytical gaps exist in the literature, as there is a paucity of studies that used integrated approaches that combine product mapping methodologies with product

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space analysis to capture export competitiveness and diversification potential. Also, these structural shifts are not studied at a finer classification of the HS-4 digit level. The paper addresses these gaps by combining RSCA and TBI-based product mapping to classify exports into four distinct categories, namely products with strong competitiveness, products with underutilized potential, products exhibiting export specialization without comparative advantage, and products with low competitiveness, using HS-4 digit level product classification. In addition, the diversification of agricultural commodities exports towards higher-complexity processed goods is examined. The findings of the paper, based on the innovative methodology using 30-year historical data, can help the stakeholders to identify products with a strong comparative advantage that can be exported to untapped high-value destinations. The paper is divided into five sections. The introduction is followed by section 2, which reviews relevant theoretical and empirical literature on agricultural trade competitiveness. Section 3 details data sources and methodology, including the application of RSCA, TBI, and product space analysis. The research findings and discussion on export composition, competitiveness patterns, and diversification trajectories are presented in Section 4. Section 5 concludes with policy recommendations and identifies directions for future research.

II

LITERATURE REVIEW

The conceptual foundations of product mapping can be traced to Shinohara's (1976) pioneering work on the "boomerang effect," which was further advanced through Matsubara's (2004) extension of these concepts to high-technology sectors. The methodological evolution of product mapping as an analytical tool gained substantial momentum with Balassa's (1965) introduction of the Revealed Comparative Advantage (RCA) index. Vollrath's (1991) comprehensive refinements of comparative advantage measurement addressed many of these limitations by introducing alternative formulations that provided more balanced and interpretable results.

Hausmann and Klinger (2006) introduced the concept of product space, which systematically mapped the transition of economics from simple to complex production structures through relatedness between different products and identifying pathways for structural transformation. Based on these foundations, Hidalgo et al. (2007) developed a network-based trade analysis that helped researchers move beyond static assessments of competitiveness to dynamic analyses of export diversification potential. These approaches provided unprecedented insights into how countries can strategically navigate their development trajectories through targeted export diversification. Expanding this framework, Hausmann & Hidalgo (2011) developed the Economic Complexity Index (ECI), measuring a country's productive knowledge through export diversity and product ubiquity, showing that higher economic complexity correlates with future GDP growth.

The product space analysis attempted in the literature to analyse the patterns of structural transformation in agricultural exports. Hausmann and Klinger's (2007) study of Latin American trade patterns showed that economies with denser product networks achieve more sustainable export growth through enhanced diversification capabilities and reduced vulnerability to external shocks. Zhuang and Yeats' (2010) analysis showed how successful agricultural exporters systematically develop capabilities in related products to build more resilient and sophisticated export portfolios among Asian countries. Jarreau and Poncet's (2012) study shows as to how local institutional quality and infrastructure development influence export competitiveness patterns in China, whereas De Benedictis et al.'s (2014) study show the relevance for identifying diversification pathways in commodity-dependent economies in Africa.

Binswanger-Mkhize et al. (2010) examine Africa's agricultural transformation, highlighting constraints to productivity growth and structural change. Jankowska et al. (2012) compare Asian and Latin American experiences, arguing that countries escaping the middle-income trap diversify into more sophisticated exports, reinforcing the Product Space Theory. Ishchukova & Smutka (2013) and Topçu & Sarıgül (2015) apply comparative advantage analysis to Russian agricultural exports and Turkish manufacturing, respectively, identifying key competitive sectors. Bayudan-Dacuycuy & Lim (2017) link export sophistication to growth in Asian economies, while Verter et al. (2020) analyze Nigeria-EU agri-food trade using product mapping. Rezende et al. (2023) demonstrate how Brazil's Minas Gerais state can leverage the Product Space for export diversification, and Saxena et al. (2024) assess India's horticultural exports through seasonality and product mapping. All these studies emphasised the importance of export diversification, capability accumulation, and strategic industrial policy in driving economic transformation, particularly in emerging markets.

Despite the studies conducted in the area, there is a knowledge gap on India's agricultural export competitiveness at a disaggregated level, explaining the trade dynamics and competitive positioning. Existing studies predominantly employ aggregated HS-2 digit classifications or focus on specific commodity groups, thereby overlooking critical product-level variations that fundamentally shape trade dynamics and competitive positioning. Studies combining comparative advantage metrics with network-based product space analysis are rare, which is useful for differentiating temporary market fluctuations and fundamental structural shifts in competitiveness. The paper provides methodological innovation and policy insights by combining product mapping and spacing methodologies at the HS-4 digit level across an extended thirty-year period (1991-2020), which helped in the identification of both current competitive advantages and strategic pathways for future diversification and value addition of agricultural products.

III
MATERIALS AND METHODS

'Product mapping' and the 'Product Space' are complementary frameworks that together provide a comprehensive view of agricultural export competitiveness. Product mapping method, using Revealed Comparative Advantage (RCA) and export performance indicators, highlights the products in which a country currently excels in exports, and the possible vulnerabilities linked to overreliance on a few commodities. In contrast, the product space framework, developed by Hidalgo, Hausmann, and Klinger, uses a network-based approach to show how related products are and how easily a country can diversify into higher-value exports by leveraging existing capabilities. Combined, these approaches help policymakers identify both current strengths and feasible diversification pathways, guiding strategies that enhance productivity, build resilience, and support transitions into more sophisticated agricultural exports, while also addressing structural constraints where necessary.

3.1 Data Sources and Construction

The study is based on India's agricultural export data for the period 1991–2020. Trade data were obtained from the United Nations Commodity Trade Statistics Database (UN COMTRADE) through the World Integrated Trade Solution (WITS) platform. Export flows reported by India to the world were used throughout the analysis. Since the study focuses on India's aggregate exports to the world rather than bilateral trade flows, mirror trade data from partner countries were not utilized. To ensure consistency over the study period, data were extracted using the HS 1988/92 classification system at the four-digit level of disaggregation. The use of a common HS classification framework across all years minimized discrepancies arising from subsequent revisions of the Harmonized System and allowed the construction of a consistent panel of agricultural products for 1991–2020. Consequently, no additional concordance or harmonization procedures were required.

The dataset consists of 200 agricultural products classified at the HS-4 level. Agricultural products were defined according to HS Chapters 01–24, and all HS-4 products falling within these chapters were included in the analysis. These products represent the complete set of agricultural products available within the selected classification framework. Products with zero exports throughout the entire study period were excluded from the analysis, while year-specific zero export observations were retained as valid trade outcomes. All trade values are expressed in current United States dollars (US$). No deflation or constant-price adjustments were applied because the principal indicators employed in the study-Revealed Comparative Advantage (RCA), Revealed Symmetric Comparative Advantage (RSCA), Trade Balance Index (TBI), and Product Space measures-are ratio-based indicators. As these measures are derived from relative export shares rather than absolute values, the effects of inflation and price changes are substantially mitigated.

The resulting database provides a consistent and comparable series for examining the competitiveness, specialization patterns, and diversification opportunities of India's agricultural exports over the three-decade study period.

3.2 Product Mapping Methodology

3.2.1 Indexes Used in Product Mapping

a) Revealed Comparative Advantage (RCA): The RCA index of country I for product j is often measured by the product's share in the country's exports in relation to its share in world trade (Balassa, 1965):

$$RCA\ i\ j = (x\ i\ j/X\ i\ t) / (x\ w\ j/X\ w\ t) \quad (1)$$

Where

xij and xwj are the values of country i's exports of product j and world exports of product j and Xit and Xwt refer to the country's total exports and world total exports.

A value of less than unity implies that the country has a revealed comparative disadvantage in the product. Similarly, if the index exceeds unity, the country is said to have a revealed comparative advantage in the product.

b) Revealed Symmetric Comparative Advantage (RSCA): RSCA normalizes RCA between -1 and +1 for better interpretation. RSCA is calculated from Balassa's Revealed Comparative Advantage (RCA) as follows:

$$RSCA\ j\ k = (RCA\ j\ k - 1) / (RCA\ j\ k + 1) \quad (2)$$

The standards of the RSCA jk index vary from -1 to +1 (-1 RSCA jk +1). If RSCA jk is less than 0, then the nation j does not have a relative gain in product set k. In contrast, if RSCA jk is more than 0, then the country j has a relative gain in product set k (Widodo, 2009).

c) Trade Balance Index (TBI): Lafay claims that TBI is used to determine whether a nation has become specialised in either exporting (as a net-exporter) or importing (as a net-importer) a specific product group (Widodo, 2009). The Trade Balance index measures the specialization and relative advantage of a nation's select product.

TBI is calculated as follows:

$$TBI\ j\ k = (X\ j\ k - M\ j\ k) / (X\ j\ k + M\ j\ k) \quad (3)$$

TBI j k stands for the country j's trade balance index for product group k. The index values are between -1 and +1. TBI is extremely equivalent to -1 for countries that are solely importing (net importers) and +1 for those that are solely exporting (net-exporters). According to Widodo (2009), values between -1 and +1 signify that a country is concurrently importing and exporting goods.

d) Trade Competitiveness (TC): Volrath (1991) proposed a composite method to evaluate a country's trade competitiveness by combining two indicators: the Revealed

Symmetric Comparative Advantage (RSCA) and the Trade Balance Index (TBI). RSCA measures a country's relative comparative advantage in a given product, while TBI indicates its trade orientation—whether it acts as a net exporter or importer. Together, these dimensions form the Trade Competitiveness (TC) Index, offering a more comprehensive assessment of export strength and specialization.

$$TC_i = RSCA_i + TBI_i \quad (4)$$

The RSCA measures a product's comparative advantage on a scale from –1 to +1, while the TBI captures its trade balance within the same range. When combined, a positive TC value reflects products where the country holds a comparative advantage and is export-oriented, whereas a negative TC value points to comparative disadvantage and import dependence. This integrated index thus provides a clearer and more nuanced picture of leading export sectors and patterns of trade specialization.

3.3 Product Mapping Framework

Using RSCA (competitiveness) and TBI (trade balance), we can classify HS-4-digit agricultural products into four quadrants, namely A, B, C, and D. The combined use of RSCA and TBI provides a two-dimensional view of trade competitiveness, with RSCA capturing relative advantage and TBI distinguishing net export or import positions. Conducting the analysis at the HS-4 level ensures sufficient product specificity to identify sectoral opportunities, offering more detail than broad systems like SITC or BEC while avoiding the excessive fragmentation of HS-6. The four-category classification framework derived from RSCA and TBI further simplifies results by grouping products into competitive or non-competitive net exporters and importers, thereby clarifying strengths, weaknesses, and policy priorities in India's agricultural exports.

TABLE 1. PRODUCT MAPPING MATRIX

		Net Importer	Net Exporter
RSCA (Comparative Advantage / Disadvantage)	RSCA > 0	Class B: Comparative Advantage No Export Specialisation (RSCA>0, TBI<0)	Class A: Comparative Advantage Export Specialisation (RSCA>0, TBI>0)
	RSCA < 0	Class D: Comparative Disadvantage No Export Specialisation (RSCA<0, TBI<0)	Class C: Comparative Disadvantage Export Specialisation (RSCA<0, TBI>0)
		TBI < 0	TBI > 0
		TBI (Net Importer/ Net Exporter)	

Source: Widodo, 2009

Comparative advantage and export specialization are the two main parameters for the classification of product mapping into four groups.

Class A (Strong Competitive Exports): Products with both comparative advantage and export specialization are categorised under Class A. In this category, the country will be a net exporter of goods, indicating the level of export specialization in the country. The leading export categories are determined from this class A.

Class B (Competitive but Import Dependent): Category of goods that have a comparative advantage but no export specialization is classified as Class B. In this group, the country will be a net importer of products.

Class C (Emerging Niche Exports): Category of products with export specialization but no comparative advantage is grouped under Class C. In this case, the nation is a net exporter of a particular product.

Class D (Weak and Import Reliant): Category of products with neither comparative advantage nor export specialization belongs to class D. In this category, the nation is a net importer of the determined product.

In order to determine the agricultural export competitiveness of India's exports with the rest of the world, the RCA, RSCA, and TBI indices were computed for the HS-4 classification of 200 agricultural products over a time period of thirty years, from 1991 to 2020. RSCA and TBI index values of select years of 1991, 2000, 2010, and 2020 were analysed. Based on the RSCA and TBI index values of the respective years, a product mapping matrix was computed to determine India's top 10 agricultural products for the respective years. Leading export products will be determined through product mapping. A product is considered to be a leading export if its export share of both domestic and global exports is high. In addition, an attempt was made to analyse the type and number of commodities belonging to groups A, B, C, and D, mainly focusing on products that have a positive RSCA (comparative advantage) and positive TBI (export specialization).

3.4 Product Spacing Methodology

To complement the static product mapping analysis, a dynamic network-based product spacing methodology was employed to understand India's agricultural export diversification potential. While product mapping and product space may appear methodologically distinct, they are in fact complementary in capturing the full picture of India's agricultural export dynamics. Product mapping provides a static yet detailed snapshot of competitiveness by situating products within trade indicators such as RCA, RSCA, and TBI, offering clarity on current strengths and weaknesses across markets. In contrast, the product space framework adds a dynamic, forward-looking perspective by assessing how closely related different products are in terms of capabilities and potential diversification paths. Taken together, the two methods reinforce each other: mapping highlights the existing structure of India's agricultural trade, while the product space identifies feasible and strategic avenues for expansion. This integration ensures that analysis is not limited to what India exports today, but also considers the pathways

through which it can transition into more sophisticated and competitive products tomorrow.

The "Product Space" methodology, developed by Hidalgo et al., (2007), analyse the relatedness and complexity of products in an economy to determine export diversification potential. Unlike traditional RCA-based approaches, the product space method helps to identify which products are nearby (easier to transition into) and which products are distant (require structural changes). With regard to India's agricultural exports, the method identifies high-potential diversification opportunities, prioritise products that align with existing capabilities, and avoids unfeasible jumps into unrelated sectors. This methodology focuses on measuring the relatedness between products, based on the principle that countries are more likely to competitively export products that are "close" to those they already export with a comparative advantage. The core of this approach relies on constructing a product proximity matrix, which represents the pairwise closeness between HS-4 level products based on co-export patterns observed globally. Two products are considered proximate if countries that export one tend to export the other. From this matrix, a product space network is created, where nodes represent products and edges signify high proximity (capability similarity). India's Revealed Comparative Advantage (RCA) data is overlaid onto this network to analyse the position and connectivity of India's export basket.

3.4.1 Network Construction and Visualization

The product space network was constructed following the framework proposed by Hausmann and Hidalgo (2007). First, a binary export advantage matrix (Mcp) was generated, where a value of 1 was assigned if India's Revealed Comparative Advantage (RCA) in a product was equal to or greater than one, and 0 otherwise. Based on the co-occurrence of products with comparative advantage across countries, a product proximity matrix (Φ) was constructed to measure the degree of relatedness between pairs of agricultural products.

The proximity matrix was transformed into a network in which each node represents an HS-4 agricultural product and each edge denotes a significant proximity relationship. To reduce visual clutter and retain only meaningful linkages, a proximity threshold of $\varphi > 0.55$ was applied while ensuring a parsimonious and interpretable network structure. This value lies within the range commonly used in product space literature and provides a balance between network density and clarity of visualization. Separate product space networks were generated for the periods 1991–2005 and 2006–2020 to examine the evolution of India's agricultural export structure. Products with RCA ≥ 1 were highlighted to identify areas of established comparative advantage and their proximity to potential diversification opportunities. Network metrics including Density, Distance, and Agri-PCI were subsequently calculated to assess diversification potential and capability accumulation.

As a robustness check, a sensitivity analysis was conducted using an alternative threshold of φ > 0.60. The resulting structure showed only minor changes in connectivity, while the key findings related to Density, Distance, Agri-PCI, and core product composition remained broadly stable, indicating that the results are robust to reasonable variations in the proximity threshold.

3.4.2 Indexes Used in Product Spacing

To analyse the temporal evolution of India's agricultural export capabilities, product space networks are generated for two distinct time periods. This helps track shifts in India's positioning and connectivity in the agricultural product space, shedding light on changes in specialization patterns, diversification opportunities, and capability accumulation. The analysis uses three core indicators: Density, Distance, and Agri-Product Complexity Index (Agri-PCI).

a. Density: For each product that India already exports with RCA ≥ 1 (i.e., india_advantage_products), a density score is computed. This metric measures the average proximity of a non-exported product to India's current export basket and reflects how easily India can move into new products based on its existing capabilities. Formally, for product p:

$$Density_{\mathrm{p}} = \left(\frac{1}{|N(p)|}\right) \times \sum_{q \in Np} \phi_{\mathrm{p}} q) \qquad (5)$$

Where N(p) are neighbouring products in the product space, and ϕ_{p}q is the proximity between product p and q. High-density values indicate products that are "close" to India's current exports and thus easier to transition into.

b. Distance: To assess how challenging it is for India to begin exporting a new product based on its current export structure, the Distance metric is used. Unlike proximity or density, which measure closeness to the current export basket, Distance is a capability gap indicator — it tells us how far a product is from India's existing strengths.

For a non-exported product p, Distance is defined as:

$$\text{Distance } p = 1 - \frac{\sum q \in N(p) \phi pq \,.\, Mq}{\sum q \in N(p) \phi pq} \qquad (6)$$

Where N(p) is the set of neighbouring products in the product space, Φpq is the proximity between product p and neighbouring product q, and Mq is 1 if India has RCA ≥ 1 in product q, and 0 otherwise. A higher distance implies that the product is farther from India's current capabilities, making it harder to develop. Conversely, low-distance products are closer to the country's existing know-how and may represent low-hanging fruits for export expansion.

c. Agri-Product Complexity Index (Agri-PCI): The Agri-PCI captures the sophistication and embedded knowledge requirements of each agricultural product. Agri-PCI is calculated via eigenvector centrality on the product proximity matrix. It

reflects how exclusive the product is in global trade and the level of productive capabilities required to competitively export it. Formally, Agri-PCI values are derived from the dominant eigenvectors of the proximity matrix Φ, capturing the interconnectedness and strategic importance of each product within the agricultural export network.

$$\text{Agri-PCI}_p = v_{2p} \qquad (7)$$

Where v_{2p} is the p-th element of the second eigenvector of the standardized product similarity matrix Φ. The matrix Φ is constructed from the binary RCA matrix M_{cp} using:

$$\Phi_{pp'} = \sum_c Mcp \cdot Mcp' / \sum_p Mcp \qquad (8)$$

This captures the sophistication of agricultural product p based on who exports it and how diversified those exporters are, reflecting its capability intensity in agriculture. Higher Agri-PCI scores imply that the product is: Less ubiquitous (i.e., exported by fewer countries), more knowledge-intensive and more likely to contribute to long-term economic upgrading.

IV

RESULTS AND DISCUSSION

4.1 Product Mapping of India's Agricultural Products

The product mapping class groups of A, B, C, and D of India's HS-4 agricultural products for select years are tabulated.

Figure 1 illustrates the product mapping groups (A, B, C, and D) of India's agricultural exports across select years, categorizing products by their comparative advantage and export specialization. Group A, combining both comparative advantage and specialization, reflects India's most competitive exports, accounting for 26–32% over the years, with a peak of 31% in 2000 and 26.7% in 2020. Group B, with comparative advantage but no specialization, remained the smallest share (3–4%), representing untapped potential requiring branding and infrastructure support. Group C, showing specialization without comparative advantage, consistently dominated, peaking at 43% in 2010 and still comprising 36.6% in 2020, indicating reliance on products well-integrated into export markets but not globally competitive. Group D, with neither advantage nor specialization, accounted for 28–33%, rising to 32.7% in 2020, highlighting persistent structural weaknesses. Overall, the trends suggest four key takeaways: Group A's stability calls for reinforcing strong exports; Group C's dominance signals the need to improve competitiveness through value addition and certification; Group D's growth points to deep-rooted inefficiencies requiring structural reforms; and Group B's small share represents an opportunity to develop underutilized but promising products. A targeted product-specific strategy focusing on trade policy, market diversification, and competitiveness enhancement is essential to strengthen India's agricultural export performance.

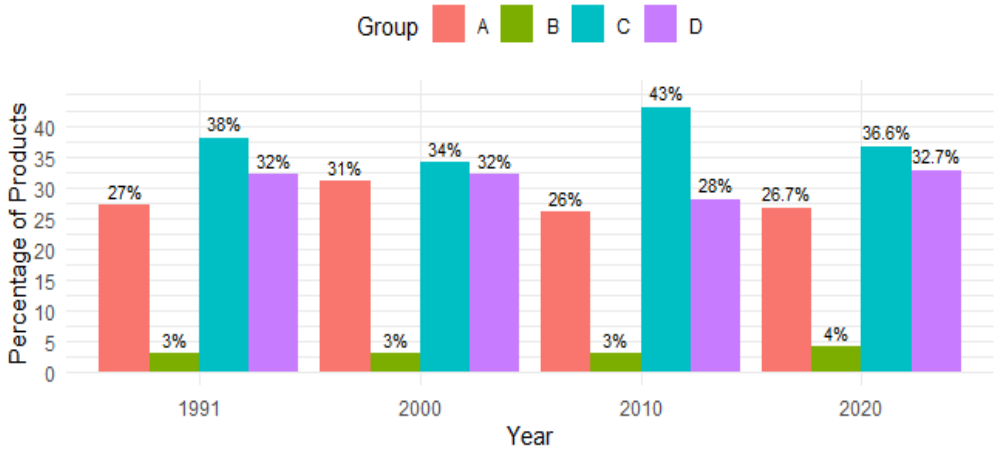

FIGURE 1. PRODUCT MAPPING OF INDIA'S AGRICULTURAL PRODUCTS (IN PERCENTAGE)

Source: Computed by authors

4.2 India's Core Agro-Export Strengths: Long-Term Competitiveness and Specialization in Group A Products (1991–2020)

The products that have maintained a Revealed Symmetric Comparative Advantage (RSCA > 0) and a Trade Balance Index (TBI > 0) consistently from 1991 to 2020 include fresh or chilled fish (0300), frozen fish (0303), frozen crustaceans (0306), preserved molluscs and aquatic invertebrates (0307), horsehair (0501), bones and horn-cores (0506), ivory and similar materials (0507), onions and garlic (0703), provisionally preserved vegetables (0711), dried vegetables (0712), coffee (0900), tea (0902), pepper and capsicum (0904), nutmeg and cardamoms (0908), anise and fennel seeds (0909), spices like ginger and turmeric (0910), rice (1006), buckwheat, millet, and canary seed (1008), wheat and meslin (1000), rye (1200), groundnuts (1202), other oil seeds and oleaginous fruits (1207), medicinal and aromatic plants (1211), barley (1300), natural gums and resins (1302), vegetable products not elsewhere specified (1404), fixed vegetable oils (1515), cane or beet sugar (1703), jams and fruit pastes (2007), coffee and tea extracts (2101), residues from food industries (2300), soya-bean oil (2304), groundnut oil (2305), other vegetable oils (2306), unmanufactured tobacco (2401), manufactured tobacco products (2403), and vegetable materials for plaiting (2400).

The sustained competitiveness of 39 agricultural products in Group A (RSCA > 0 and TBI > 0) from 1991 to 2020 highlights India's enduring strengths in key agro-export sectors. This stability is underpinned by multiple factors: diverse agro-climatic conditions that enable the cultivation of a wide variety of crops such as rice, spices, oilseeds, and medicinal plants; traditional expertise and long-established practices in products like tea, turmeric, and pepper that enhance quality and global reputation; and

consistent global demand for staples like rice as well as high-demand products such as spices, fish, and oils. Added to this are policy support, low labor costs, and improvements in infrastructure, which together have bolstered India's global competitiveness, securing stable export revenues, generating rural employment, and strengthening the long-term resilience of its agricultural trade sector.

4.3 Product Mapping of Top-Ten Agricultural Products from 1991 to 2020

Tables 2-5 and Figures 2-5 present the product mapping results for India's agricultural exports at the HS-4 level for the selected years 1991, 2000, 2010, and 2020. Product mapping combines comparative advantage (RSCA) and trade balance (TBI) to classify products into four groups (A, B, C, and D), enabling the identification of products with both export specialization and global competitiveness. The top ten export products are derived from Group A, representing products with positive RSCA and TBI values, indicating comparative advantage and net export status.

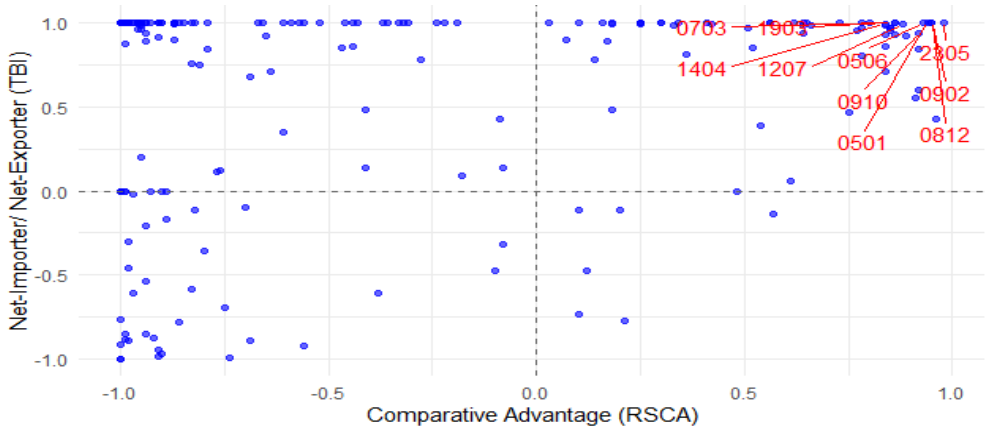

FIGURE 2. PRODUCT MAPPING- 1991

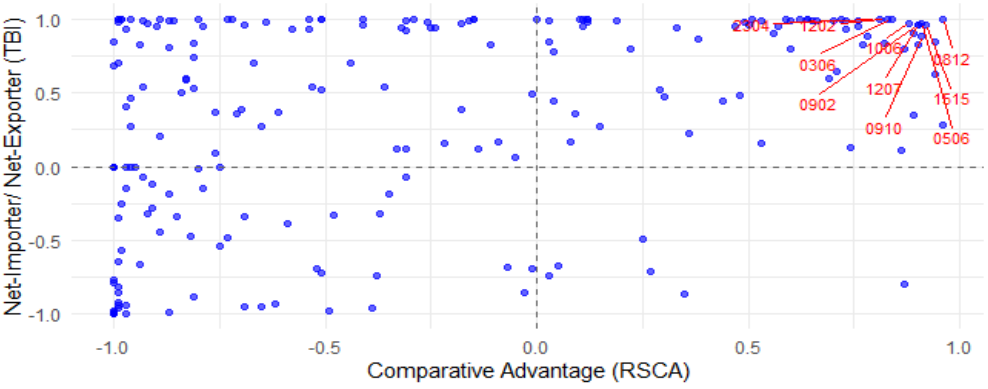

FIGURE 3. PRODUCT MAPPING- 2000

TABLE 2. TOP 10 LEADING EXPORT PRODUCTS- 1991

HS-4 Code	Commodity Description	RS CA	TBI	TC
2305	Oil-cake and other solid residues of ground-nut	0.98	1.00	1.98
0812	Fruit and nuts, provisionally preserved	0.95	1.00	1.95
0902	Tea, whether or not flavoured	0.95	1.00	1.95
0501	Human hair and waste	0.94	1.00	1.94
0506	Bones and horn-cores, unworked, defatted, simply prepared	0.93	1.00	1.93
1207	Other oil seeds and oleaginous fruits	0.88	0.99	1.87
1903	Tapioca and substitutes prepared from starch	0.86	1.00	1.86
0703	Onions, garlic, shallots, leeks	0.86	1.00	1.86
0910	Ginger, saffron, turmeric, thyme, bay leaves, curry and other spices	0.92	0.94	1.86
1404	Vegetable products not elsewhere specified or included	0.84	0.99	1.83

Source: Computed by author

TABLE 3. TOP 10 LEADING EXPORT PRODUCTS- 2000

HS-4 Code	Commodity Description	RSCA	TBI	TC
0812	Fruit and nuts provisionally preserved	0.96	1.00	1.96
0506	Bones and horn-cores, unworked, defatted, simply prepared	0.91	0.97	1.88
1515	Other fixed vegetable fats and oils (e.g., maize, rice bran oil)	0.92	0.96	1.88
0902	Tea	0.90	0.96	1.86
1207	Other oil seeds and oleaginous fruits	0.90	0.96	1.86
1006	Rice	0.88	0.97	1.85
0306	Crustaceans (e.g., shrimps, prawns), frozen, dried, salted	0.84	1.00	1.84
1202	Ground-nuts (peanuts), not roasted or cooked	0.83	1.00	1.83
2304	Oilcake and other solid residues of soyabean	0.81	1.00	1.81
0910	Ginger, saffron, turmeric, thyme, bay leaves, curry, other spices	0.91	0.88	1.79

Source: Computed by author

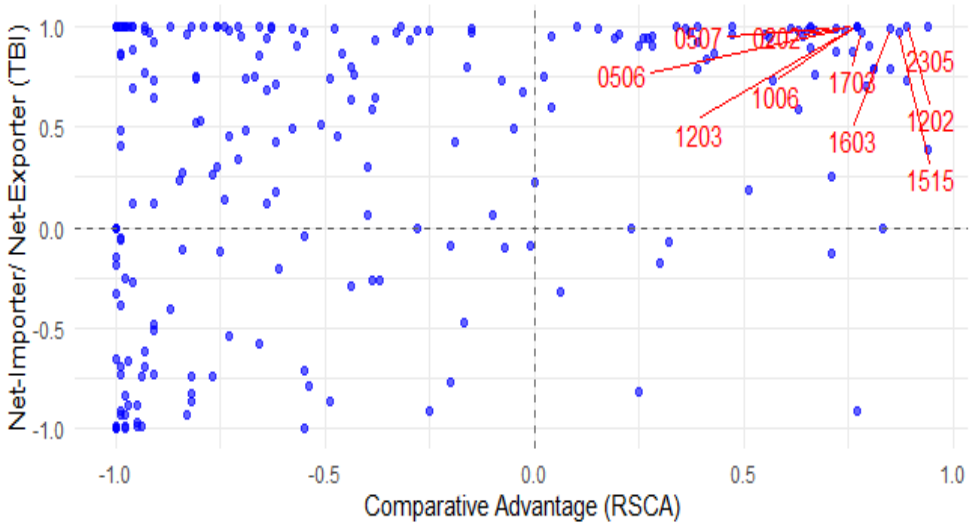

FIGURE 4. PRODUCT MAPPING- 2010

TABLE 4. TOP 10 LEADING EXPORT PRODUCTS- 2010

HS-4 Code	Commodity Description	RSCA	TBI	TC
2305	Oil-cake and other solid residues of ground-nut	0.94	1.00	1.94
1202	Ground-nuts, not roasted or cooked	0.89	1.00	1.89
1515	Other fixed vegetable fats and oils	0.87	0.97	1.84
1603	Extracts and juices of meat, fish, crustaceans	0.85	0.99	1.84
1006	Rice	0.77	1.00	1.77
1203	Copra	0.77	1.00	1.77
0202	Frozen bovine meat	0.77	1.00	1.77
1703	Molasses resulting from extraction or refining sugar	0.78	0.97	1.75
0506	Bones and horn-cores, unworked	0.74	0.98	1.72
0507	Ivory, animal teeth, unworked or simply prepared	0.72	0.99	1.71

Source: Computed by author

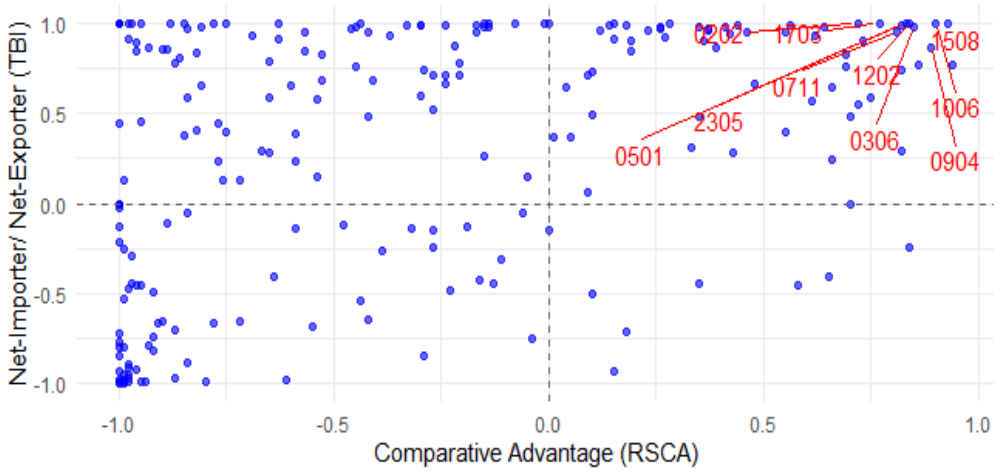

FIGURE 5. PRODUCT MAPPING- 2020

TABLE 5. TOP 10 LEADING EXPORT PRODUCTS- 2020

HS4 Code	Commodity Description	RSCA	TBI	TC
1508	Ground-nut oil and its fractions	0.93	1.00	1.93
1006	Rice	0.90	1.00	1.90
1202	Ground-nuts, not roasted or otherwise cooked	0.84	1.00	1.84
2305	Oil-cake and other solid residues of ground-nut	0.83	1.00	1.83
0306	Crustaceans (e.g., shrimp, prawns), frozen, dried, salted	0.85	0.98	1.83
0501	Human hair, unworked; waste of human hair	0.82	0.99	1.81
1703	Molasses resulting from the extraction or refining of sugar	0.77	1.00	1.77
0711	Vegetables provisionally preserved (e.g., in brine or sulphur)	0.81	0.95	1.76
0904	Pepper (black, white) and capsicum or pimento	0.89	0.86	1.75
0202	Frozen meat of bovine animals	0.72	1.00	1.72

Source: Computed by author

India's agricultural exports have displayed a strong and persistent specialization in several product categories over the last three decades. This performance has been supported by trade liberalization measures introduced after 1991, export promotion policies, investments in agricultural infrastructure and research, and improved access to international markets through regional trade agreements. These developments strengthened India's comparative advantage and encouraged export diversification.

In 1991, India's export basket was dominated by traditional agricultural commodities and by-products such as groundnut oil-cake, provisionally preserved fruits and nuts, tea, human hair, bones and horn-cores, onions, garlic, and spices. By 2000, the export structure showed greater diversification with the emergence of rice,

crustaceans, vegetable oils, groundnuts, and soybean oil-cake, reflecting growth in agro-processing and marine exports.

The export profile evolved further by 2010, with groundnut oil-cake, rice, groundnuts, vegetable oils, processed animal products, and frozen meat gaining prominence. By 2020, exports became more concentrated around globally competitive products such as groundnut oil, rice, groundnuts, groundnut oil-cake, crustaceans, molasses, preserved vegetables, pepper, capsicum, and frozen bovine meat, indicating stronger integration into international agricultural markets.

Several products consistently appeared among India's leading agricultural exports throughout the study period, including groundnut oil-cake, groundnuts, rice, tea, spices, human hair, bones and horn-cores, crustaceans, and preserved fruits and vegetables. Their persistence reflects India's enduring comparative advantage arising from favourable agro-climatic conditions, established production systems, abundant raw material availability, and cost competitiveness. At the same time, the growing presence of processed and value-added products suggests a gradual shift towards higher-value agricultural exports. Overall, the results indicate that while traditional commodities continue to underpin India's export competitiveness, increasing diversification and value addition have contributed to the structural transformation of the agricultural export sector.

4.4 Product Spacing of India's Agricultural Products

The product space diagram for India's agricultural exports in the periods 1991–2005 and 2006–2020 visually depicts the network of products based on revealed comparative advantage (RCA) and proximity, mapping India's agricultural exports within the global product space. These two time periods have been selected to capture the structural transformation of India's agricultural sector—from the early post-liberalization phase to a more capability-driven and diversified export profile. Each node in the diagram represents an HS-4 level product, and links indicate relatedness based on co-export patterns. Core products are densely connected goods where India has already developed export capabilities and RCA, while peripheral products are loosely connected and reflect a weaker export presence. Density measures how closely a product is linked to India's current export basket, indicating ease of diversification; Distance shows how far a new product lies from existing capabilities; and Agri-PCI (Agricultural Product Complexity Index) captures the knowledge intensity and sophistication of a product. Together, these metrics reveal how India's position in the product space evolved from a scattered, low-complexity structure toward a more connected and capability-rich export landscape.

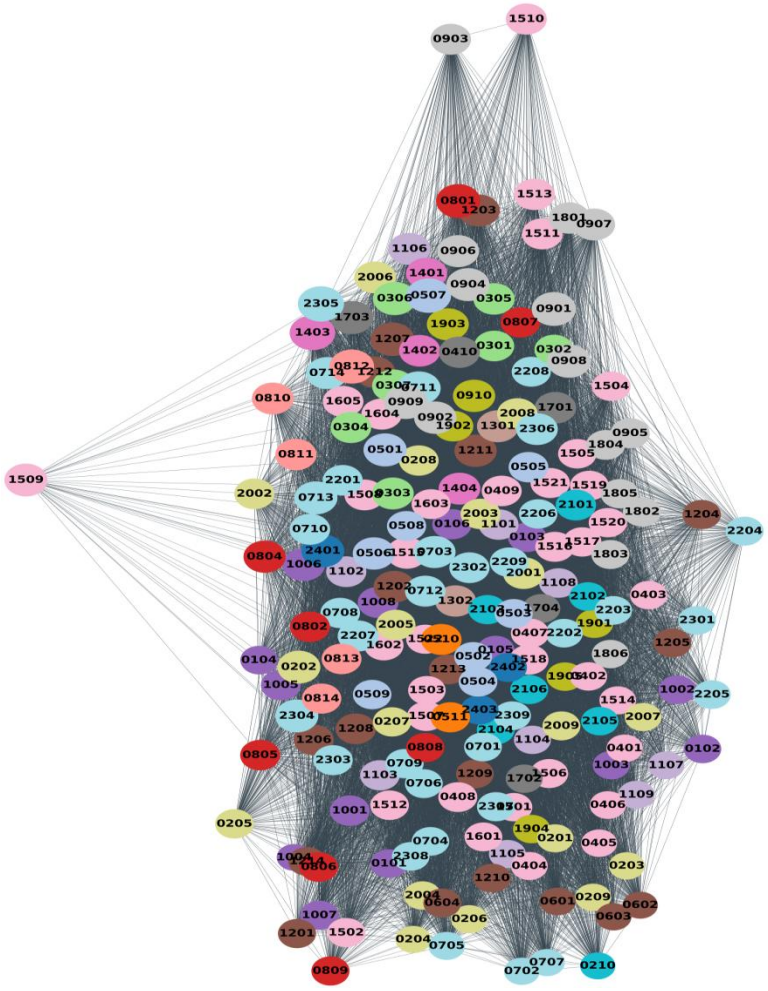

FIGURE 6. INDIA'S PRODUCT SPACE 1991-2005

Source: Computed by author

In Figure 6, the Product Space diagram for 1991–2005 reveals a vertically elongated structure with a sparse core, indicating a limited set of interconnected agricultural export products. The nodes representing individual HS-4 products are primarily concentrated in small, tight-knit clusters, while many peripheral products remain isolated or loosely connected to the main export basket. In terms of density, this period reflects India's narrow capability set; most products with RCA $\geq$ 1 are surrounded by a relatively low number of proximate products, limiting India's immediate diversification opportunities. India's export structure during this period was concentrated in traditional sectors such as sugars, cereal preparations, and select fruits

and nuts, which formed the dense core of its product space, while many other categories remained peripheral and underdeveloped.

From a distance perspective, most potential diversification opportunities were located far from India's existing export capabilities, indicating that the country's capability infrastructure was insufficient to support a shift into more sophisticated agricultural products. As a result, the export basket remained focused on low-complexity commodities with few avenues for upgrading. In terms of the Agricultural Product Complexity Index (Agri-PCI), the 1991–2005 product space was dominated by low- to medium-complexity products, while high-complexity goods such as beverages and miscellaneous edible preparations were positioned at the margins and weakly connected to the core, underscoring India's limited integration into complex agri-food value chains during this period.

4.5 Top 10 Core Products 1991–2005

TABLE 6. RCA, DENSITY, DISTANCE & AGRI-PCI OF TOP 10 CORE PRODUCTS (1991-2005)

HS-Code	Product Name	RCA	Density	Distance	Agri-PCI
2305	Oil-Cake of Groundnuts	32.913	0.547	0.453	0.066
0801	Coconuts, Brazil Nuts and Cashews	27.374	0.459	0.541	0.245
0812	Apples, Pears and Quinces	18.358	0.474	0.526	0.043
0501	Horsehair and Waste of Horsehair	16.385	0.409	0.591	0.077
0909	Seeds of Fennel, Juniper and others	11.420	0.436	0.564	0.119
1006	Rice	9.830	0.389	0.611	0.176
0904	Pepper of the genus Piper	9.796	0.404	0.596	0.038
1207	Other Oil Seeds and Oleaginous Fruits	8.327	0.440	0.560	0.136
1403	Vegetable Materials for Brooms	7.310	0.521	0.479	0.088
0908	Nutmeg, Mace and Cardamoms	5.815	0.427	0.573	0.101

Source: Computed by author

During 1991–2005, India's top core agricultural exports were dominated by primary commodities with strong trade competitiveness but limited diversification potential. Products like Oil-Cake of Groundnuts (HS-2305) and Coconuts, Brazil Nuts, and Cashews (HS-0801) showed very high RCA values (32.91 and 27.37), reflecting India's global strength in these sectors, yet their density scores were moderate (around 0.45 to 0.54), indicating only partial connectivity to other products within the export network. Most core products, including Rice (HS-1006) and Pepper (HS-0904), had high distance values (above 0.59), revealing their peripheral position in the product space and suggesting that India lacked the capability infrastructure to easily diversify into adjacent sectors. Furthermore, the Agri-PCI values were generally low (mostly below 0.15), signalling that India's export basket was concentrated in low-complexity,

commodity-based products with minimal value addition. This combination of high RCA, moderate density, high Distance, and low product complexity reflects a structurally constrained export profile, where India's agricultural export growth was heavily reliant on a narrow set of traditional commodities with limited pathways for upgrading into more sophisticated, value-added agri-products.

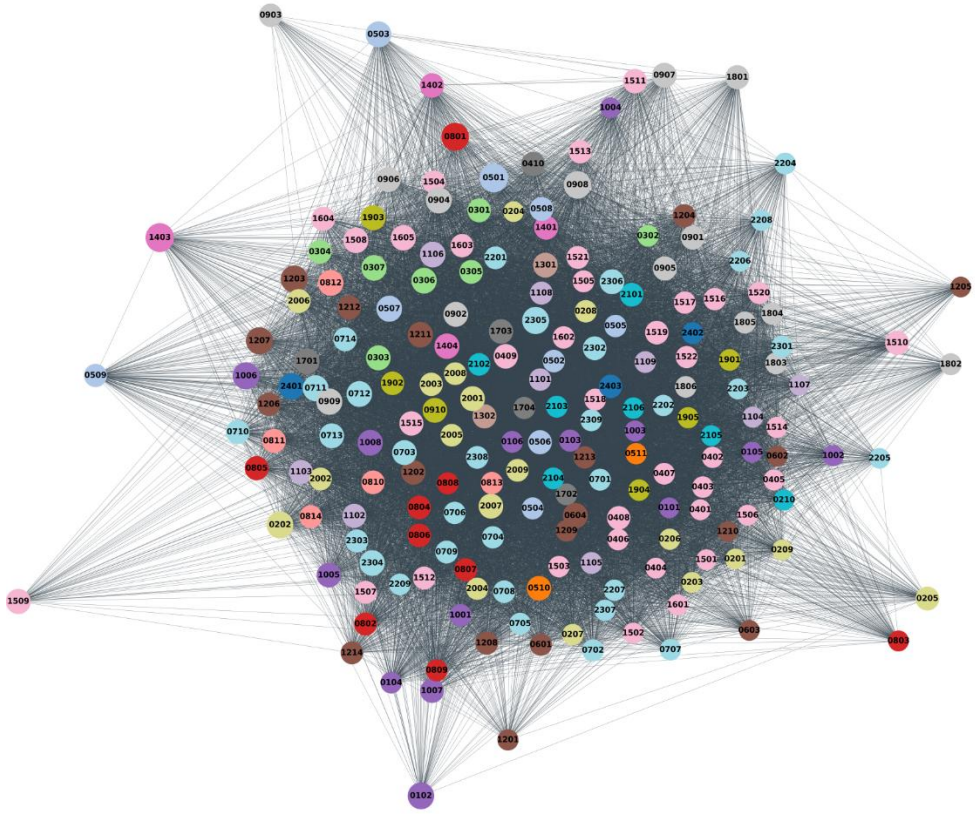

FIGURE 7. INDIA'S PRODUCT SPACE 2006-2020

Source: Computed by author

In Figure 7, the Product Space for 2006–2020 displays a significant structural evolution. The diagram takes on a radially expanded, circular shape with a dense and cohesive core, reflecting a significant rise in interconnectivity among India's agricultural exports. Nodes are more evenly distributed, and formerly peripheral products now show stronger links to the core, suggesting an enriched capability base. Export density has improved notably, as India's current products are surrounded by a wider range of proximate options, indicating greater ease of diversification into new agricultural sectors. The expansion of core clusters, particularly in vegetable preparations, edible preparations, and beverages, highlights this enhanced density and broader diversification potential. From a distance perspective, the 2006–2020 structure

reveals a marked reduction in the average Distance between existing exports and potential new products. Previously isolated items have moved closer to the core, pointing to the closing of capability gaps and greater feasibility of diversification. The Agri-PCI dimension further underscores this progress, with a clear shift toward mid- to high-complexity products. Items such as beverages, lac & resins, and processed edibles, once peripheral, are now better integrated into India's export network. This demonstrates a transition from basic commodities to more sophisticated, value-added exports, with the strengthened Agri-PCI distribution signalling a significant rise in India's agricultural export sophistication in the post-2005 period.

4.6 Top 10 Core Products 2006–2020

TABLE 7. RCA, DENSITY, DISTANCE & AGRI-PCI OF TOP 10 CORE PRODUCTS (2006-2020)

HS-Code	Product Name	RCA	Density	Distance	Agri-PCI
1403	Vegetable Materials for Brooms	24.493	0.584	0.416	0.030
0501	Horsehair and Waste of Horsehair	21.017	0.588	0.412	0.033
0909	Seeds of Fennel, Juniper and others	20.000	0.435	0.565	0.022
2305	Oil-Cake of Groundnuts	17.444	0.485	0.515	0.032
1006	Rice	10.491	0.485	0.515	1.235
0904	Pepper of the genus Piper	9.241	0.429	0.571	0.204
0503	Coconut Copra	8.979	0.417	0.583	0.030
1207	Other Oil Seeds and Oleaginous Fruits	7.076	0.488	0.512	0.525
0202	Meat of Bovine Animals	6.386	0.476	0.524	0.541
0908	Nutmeg, Mace and Cardamoms	5.611	0.506	0.494	0.030

Source: Computed by author

During the period 2006–2020, India's core agricultural export structure exhibited signs of gradual diversification and increased export sophistication compared to the earlier decade, though still rooted in traditional commodities. High RCA products like Vegetable Materials for Brooms (HS-1403) and Horsehair Waste (HS-0501) maintained their dominance with RCA values of 24.49 and 21.01, but their density scores improved to above 0.58, indicating stronger integration within the product space and greater potential to facilitate diversification into adjacent sectors. Unlike the previous period, the inclusion of products like Rice (HS-1006) with a remarkably high Agri-PCI of 1.2349 and Meat of Bovine Animals (HS-0202) with 0.5407 Agri-PCI suggests a shift towards more sophisticated, value-added exports. While some products like Pepper (HS-0904) and Other Oil Seeds (HS-1207) continued to have moderate density (around 0.48) and high RCA, their Agri-PCI values (0.2035 and 0.5255, respectively) highlight India's improved position in higher complexity agricultural segments. However, a few core products, such as Coconut Copra (HS-0503) and Nutmeg, Mace, and Cardamoms (HS-0908), still exhibited low Agri-PCI

values, indicating persistent reliance on certain low-complexity commodities. Between 1991 and 2005 and 2006 and 2020, India's agricultural export structure shifted from a narrow, low-complexity commodity base to a more diversified and interconnected product space. The latter period shows higher density, reduced Distance, and rising Agri-PCI values, reflecting stronger capabilities and greater access to complex, value-added products. While traditional commodities remained important, exports like rice (HS-1006) and bovine meat (HS-0202) gained prominence, signalling a movement toward sophistication. Overall, India's agricultural exports evolved from dependence on primary goods to a more capability-driven and diversified structure, highlighting readiness to expand into higher-value sectors with supportive policies.

V

CONCLUSION & POLICY RECOMMENDATIONS

This study applies the product mapping approach to evaluate India's agricultural export competitiveness at the HS-4 digit level over 1991–2020. Products are classified into four groups (A, B, C, and D) using the Revealed Symmetric Comparative Advantage (RSCA) and Trade Balance Index (TBI), allowing assessment of key export strengths and global positioning. Results show that Group C—products with export specialization but lacking comparative advantage—consistently dominated India's exports, accounting for 34–43% across the years. This indicates that India exports large volumes of agricultural goods that remain less competitive in global markets. Group D, representing products with neither comparative advantage nor export specialization, had the second-highest share (26%–33%), signalling a growing challenge in maintaining export competitiveness. On the other hand, Group A, which consists of products with both comparative advantage and export specialization, remained stable, fluctuating between 26% and 31%, demonstrating consistent competitiveness in select agricultural commodities. Group B, representing products with comparative advantage but no export specialization, had the smallest share (2%–4%), indicating untapped potential in certain export categories.

The top ten agricultural export products consistently included groundnut oil-cake, groundnuts, rice, tea, spices (turmeric, curry, pepper, capsicum), human hair, bones and horn-cores, crustaceans, and provisionally preserved fruits and vegetables. Across the decades, 9 core products repeatedly appeared in India's top export list, reflecting a sustained comparative advantage in oilseeds, plantation crops, livestock by-products, marine products, and traditional agro-commodities. This persistent concentration supports Ricardo's (1817) theory of comparative advantage, where India's export competitiveness has been anchored in sectors aligned with its natural resource endowments, low-cost labor, and agro-climatic suitability, reinforcing the positive linkage between comparative advantage and export performance.

Between 1991 and 2005 and 2006 and 2020, India's agricultural product space underwent a significant transformation from a sparse, vertically elongated structure with limited interconnections to a denser, radially expanded network reflecting

enhanced diversification and capability development. The early period was marked by a narrow set of traditional commodity exports-such as groundnut oil-cake, rice, and spices-with high RCA but low density and high Distance, indicating constrained pathways for product upgrading. By 2006–2020, the product space exhibited improved density, reduced Distance, and greater integration of value-added products like rice (with high Agri-PCI) and processed meat, signifying India's gradual shift towards more sophisticated agricultural exports. However, the continued dominance of certain low-complexity products highlights that, while India's export structure has matured, persistent capability gaps and infrastructure bottlenecks still limit the full exploitation of its diversification potential into high-complexity agri-products.

The predominance of Group C products suggests that India's agricultural exports are driven more by production scale and traditional export orientation than by strong international competitiveness. The absence of comparative advantage in these products may reflect structural constraints such as fragmented landholdings, low productivity, inadequate post-harvest infrastructure, high logistics costs, and limited value addition, which reduce competitiveness despite substantial export volumes. In addition, stringent sanitary and phytosanitary standards, quality certification requirements, and market access barriers in developed-country markets may further constrain India's relative export performance. From a product space perspective, the observed increase in density and connectivity after 2006 indicates gradual capability accumulation and diversification; however, the persistence of low-complexity products in the export basket suggests that capability upgrading has been uneven, with institutional and infrastructural bottlenecks limiting movement into higher-value agricultural products.

To enhance the competitiveness of India's agricultural exports, policy interventions should be tailored to the characteristics of each product group. For Group A products, including rice, groundnuts, crustaceans, spices, tea, and groundnut oil-cake, efforts should focus on strengthening export leadership through geographical indication (GI) protection, branding, quality certification, and improved market access through trade negotiations. For Group B products, which exhibit comparative advantage but remain net importers, targeted export promotion, cold-chain infrastructure, and logistics support are needed to convert latent competitiveness into export specialization. Given the dominance of Group C products in India's export basket, priority should be placed on productivity enhancement through improved seed varieties, precision agriculture, post-harvest management, SPS compliance, and agro-processing to strengthen comparative advantage. For Group D products, policy support should be selective, focusing on product-level assessment of strategic importance while reallocating resources toward more competitive sectors. Furthermore, the product space analysis indicates growing capabilities in higher-complexity agricultural products after 2006; therefore, investments in agro-processing clusters and value-

added segments such as processed foods, beverages, and edible preparations can facilitate diversification into more sophisticated and resilient export products.

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