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Determinants of Extensive and Intensive Margins of Indian Agriculture: Gravity Model Analysis

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ABSTRACT

The paper examined the intensive and extensive margin of India's agricultural exports and identified the determinants of the trade margins using a gravity trade model. Panel data on India's bilateral agricultural trade with 20 major partner countries for thirty years from 1991 to 2020 is constructed under the HS-6-digit classification of 600 agricultural products for the analysis. The intensive and extensive margins of India's agricultural exports are calculated using the Hummels and Klenow method. The determinants of extensive and intensive margins of India's agricultural trade are identified based on the gravity model of trade framework using estimation methods of Feasible Generalised Least Squares (FGLS) and Pseudo Poisson Maximum Likelihood (PPML). The results showed that the extensive margins are more dominant than the intensive margins over the thirty year period. The gravity model revealed that variables such as relative economic magnitude, relative economic freedom, distance, relative agriculture value added, relative crop production, relative purchasing power, trade agreements, and common language significantly influence the extensive and intensive margins of India's agricultural exports. The results imply that for sustained agricultural export growth, India should pursue policies for identifying new export destinations and deepen existing products by taking initiatives to strengthen the determinants identified in the study.

Keywords: Agriculture Exports; Extensive Margin; Intensive Margin; Gravity Model

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1. Introduction

Agriculture is the backbone of the Indian economy, providing food security to people, the largest employment and earning precious foreign exchange for the country. The diverse agro-climatic conditions prevailing in the country allow for cultivating various crops, including rice, wheat, pulses, fruits, and vegetables [1]. In 2023, India was the second-largest agricultural producer, with an estimated $906 billion in output, mainly from small family-run farms, which account for more than 70% of the nation's agricultural output. Over the years, India has emerged as an important player in global agricultural trade, with total agricultural exports touching approximately US$50 billion, a global agricultural trade share of 3.5%, and a year-on-year average agricultural growth rate of 8–10% [2]. India is the world's largest rice exporter and a leading exporter of spices globally, with significant raw cotton and cotton yarn exports. It also exports tea, coffee, sugar, fresh fruits and vegetables, and processed food products. Agricultural exports significantly contribute to the country's economic development. They contribute approximately 10% of total export earnings, create jobs for farmers, allied sectors, and agro-entrepreneurs, and contribute approximately 18% of GDP. In 2022–2023, India's agriculture growth was estimated to be 3.5 percent, compared to 3 percent in 2021–2022 [3]. From April to December 2022, agricultural exports increased to US$50.2 billion from US$41.3 billion in 2020–2021 [3]. The primary drivers of this growth are the favourable policy climate, agricultural research and development (R&D), adoption of better technology, public and private investments in building irrigation capacity, use of modern farm inputs, such as seeds, institutional credit supply, output price and market support, and input subsidies [4].

Despite its strong presence, the Indian agricultural sector faces many challenges across various dimensions inhibiting its potential growth. These challenges are related to supply chain and infrastructure constraints, quality and standards, policy and regulatory challenges, market-related challenges, production and resource constraints, technology and innovation gaps, and human resource and skill development. The potential for exports allows the agriculture industry to increase its level of productivity. India is one of the fastest-growing large economies in the world [5], and there are many opportunities for export-driven growth from the agriculture sector. The expansion of trade happens through two mechanisms, namely intensive and extensive margins. Even though there are many definitions of these concepts, the paper uses the most widely accepted definition provided by Melitz [6]. "The intensive margin refers to changes in the value of exports of existing products to existing markets", which can be captured through (i) changes in the average value of exports per product per destination and (ii) adjustments in the quantity or price of goods already being traded. It captures how much more (or less) of already-traded goods are being exported to current trading partners. Contrary to this, "the extensive margin refers to changes in trade due to new trade relationships or the termination of existing ones". This includes (i) new products being exported (product extensive margin), (ii) existing products entering new markets (destination extensive margin), and (iii) new firms starting to export (firm extensive margin). The extensive margin thus captures the diversity of a country's export basket in terms of products, destinations, and exporting firms.

The intensive margin of exports depends on improved agricultural productivity, quality enhancement, position in value chain participation, and sustainable agricultural practices adopted to meet global environmental challenges. On the other hand, the extensive margin focuses on diversifying agricultural products, entering new emerging markets, catering to niche market segments, and exploring the possibility of digital platforms for e-commerce. The intensive and extensive margins in agricultural exports vary across countries, greatly influenced by the changing nature of international trade, technological improvement, and consumer preferences. Developed countries concentrate more on intensive margins through their technological prowess and high-value exports, whereas developing nations rely on both margins for export growth. Emerging markets like India concentrate on the growth of intensive and extensive margins through their large economy and rapidly improving technological change. A balanced growth between the two margins indicates a strong export sector over time; intensive growth is based on economies of scale and spe-

cialisation, while extensive growth represents economic diversity and reduced vulnerability to shocks. However, trade margins can be adversely affected by protectionist policies adopted by countries, namely through the imposition of non-tariff barriers, market concentration by dominant players, and the infrastructural constraints faced by emerging developing countries. Even though many studies have been conducted on the measurement of the intensive and extensive margins of India's agricultural exports, very few studies have tried to identify factors that influence the trade margins. The paper examines the trade margins associated with India's agricultural exports (both intensive and extensive) and identifies the determinants of intensive and extensive trade margins based on a gravity trade model.

It is important to understand the determinants that affect the trade margins as they have implications for India's trade policy and export promotion measures. Identifying these determinants helps policymakers develop targeted strategies for export growth, optimally distribute resources between existing and new markets, manage risk by diversifying export markets and reducing dependency on specific trading partners and maximise export potential to identify untapped opportunities for both deepening existing relationships and establishing new ones.

A gravity model is used in the study to identify the determinants of agricultural trade margins using a panel data framework. The theoretical foundation of the gravity model is based on Newton's law of gravity, where trade flows between countries are proportional to their economic "masses" (typically GDP) and inversely related to trade costs (often proxied by distance). The gravity model is widely accepted in international trade, providing high explanatory power and significance to important independent variables. The model's empirical success in explaining bilateral trade patterns, combined with its theoretical foundations in modern trade theory, makes it an invaluable tool for understanding both the creation of new agricultural trade relationships and the intensification of existing ones.

The primary objective of the present study is to identify the determinants affecting the extensive and intensive margins of India's agricultural exports. The paper also identifies the key factors influencing new trade relationships and the dynamics of existing trade relationships and evaluates the impact of various trade determinants on trade margins. The study covers thirty years, from 1991 to 2020. Agricultural exports from India for the HS-6 product classification of UN Comtrade are considered for the study. India's twenty largest agricultural trade partners are selected for the calculation of trade margins and identification of the determinants of trade margins. The gravity model uses two estimation techniques, namely Feasible Generalized Least Squares (FGLS) and Pseudo Poisson Maximum Likelihood (PPML). The paper is divided into seven sections; the introduction section is followed by an overview of India's agricultural export performance. An extensive review of the theoretical and empirical studies is carried out in the next section. The materials and methods used in the study, the variables and data sources, results and discussion, and conclusion and policy recommendations follow subsequently.

2. Overview of India's Agricultural Export Performance

India has demonstrated a remarkable progress in agricultural production, moving from a food-scarce nation to one that is currently both food-sufficient and food-surplus. Many items produced by Indian agriculture are seeing a surge in surplus, which calls for more exports to clear the excess. India is now a net exporter of agricultural products, due to remarkable changes that have occured across institutions, incentives, and inventions. Agricultural products from India have seen multiple revolutions (green, white, blue, etc.) and are now among the top ten exporters in the world, contributing to increased agricultural production. Exporting agricultural goods has enabled farmers to tap into a broader global market, stimulating domestic output. India has become a major agri-exporter with large-volume export crops like rice, spices, and sugar, notably increasing area coverage and output progression rates, with regard to commodities like rice, tea, spices, sugar, cotton, castor oil, cashews, coffee, and fresh vegetables [5].

Over the years, India has always maintained a trade

surplus in agricultural goods. India's agricultural exports climbed at a compound annual growth rate (CAGR) of 12.98% from Rs. 7838 crores in 1991 to Rs. 305469 crores in 2020 [7]. However, due to a dip in the price of agricultural commodities globally, exports of agricultural products had a minor decline in 2019 after reaching their high level in 2013. Agricultural imports also saw significant growth, falling somewhat after reaching a peak of Rs. 164726.8 crores in 2016 from Rs. 47850.8 crores in 1991 [8]. While the percentage of agricultural exports to total exports grew from 17.8% in 1991 to 20.3% in 1996, it then showed a declining trend until 2006, when it reached 10.1%. After that, it showed erratic trends until reaching 14.2% in 2020 [8]. It should be noted that while agricultural exports grew (12.98%) less than agricultural imports (28.09%) between 1991 and 2020, agricultural trade increased more than the nation's total merchandise trade [9]. India's 20 largest destinations for agricultural exports and India's agricultural product exports at 2 digit HS level for HS 01 to 24 for 1991 & 2020 are presented in **Tables 1** and **2** respectively.

Table 1. India's 20 largest destinations for agricultural exports (1991 & 2020).

1991			2020		
Country Name	**Trade Value in 1000 USD**	**Percentage Share in India's Agricultural Exports**	**Country Name**	**Trade Value in 1000 USD**	**Percentage Share in India's Agricultural Exports**
Japan	263617.58	8.20	USA	1853182	5.08
Saudi Arabia	114487.26	3.56	Saudi Arabia	1102698	3.03
USA	83145.96	2.59	China	879207.2	2.41
Netherlands	72109.46	2.24	Iran	876786	2.41
UK	61258.30	1.91	Hong Kong	786735.5	2.16
Jordan	53867.80	1.68	China	688442	1.89
Spain	45065.82	1.4	Nepal	526024.3	1.44
Iran	43280.47	1.35	Vietnam	446817.8	1.23
Malaysia	42224.30	1.31	UAE	419359.1	1.15
Singapore	40387.58	1.26	Malaysia	388237.1	1.07
Germany	37846.40	1.18	Japan	379564.4	1.04
Czechoslovakia	36413.11	1.13	Bangladesh	351693	0.96
Philippines	34825.84	1.08	Egypt	312286.5	0.86
Italy	34223.42	1.07	Indonesia	278105.7	0.76
Belgium	32200.50	1.00	Kuwait	197917.6	0.54
Indonesia	28946.92	0.9	Netherlands	185808.7	0.51
UAE	27833.52	0.87	Thailand	165468.3	0.45
Bangladesh	24449.79	0.76	Germany	156287.6	0.43
Poland	22290.82	0.69	UK	150871.7	0.41
France	21678.17	0.67	Russia	141476.7	0.39
Other countries	28946.92	67.32	Other Countries	26163316	71.78
Total India's Agricultural Exports	3213205.02		Total India's Agricultural Exports	36450285	

Source: UNCOMTRADE.

Table 1 represents India's 20 largest export destinations for 1991 and 2020 in agricultural exports. The total exports increased significantly from $3.21 billion to $36.45 billion in 2020. This increase indicates a remarkable growth in India's agricultural exports over the 30-year period, reflecting expanding global markets and possibly enhanced agricultural productivity. Despite being the top exporter in 1991, Japan's share significantly decreased by 2020, likely due to increasing competition and changing trade dynamics. The USA emerged as a significant trading partner by 2020, increasing its share from 2.59% to 5.08%, indicating enhanced bilateral trade. Countries like China, Iran and Hong Kong became prominent partners by 2020, suggesting a shift in trade relations, possibly influenced by geopolitical factors or economic agreements. The percentage share

of other countries increased from 67.32% in 1991 to 71.78% in 2020, indicating a more diversified trade portfolio but also a reliance on a larger number of countries for agricultural exports. The agricultural export landscape for India has evolved significantly from 1991 to 2020, with a substantial increase in total trade value and shifts in key trading partners. The trends point towards a more diverse and competitive agricultural export sector, with a need for India to enhance trade relationships with emerging markets while maintaining established ones.

Table 2 represents India's agricultural product exports at 2 digit HS level for HS 01 to 24 for 1991 and 2020. In 2020, total agricultural exports surged from $3.95 billion in 1991 to $40.78 billion in 2020. This reflects a massive growth in agricultural exports, indicating India's increasing focus on agricultural exports and the global demand for Indian produce. In 1991, the dominant category was Coffee, Tea, Mati & Spices, accounting for 37.34% of India's agricultural exports. Other significant contributors were Fish (14.66%), Residues (9.53%), and Cereals (9.33%). In 2020, the composition had shifted, with Cereals (21.27%) taking the lead, primarily driven by exports of rice and wheat. Oil Seeds (15.08%) and Fish (12.40%) also emerged as key export categories. The share of Coffee, Tea, Mati & Spices dropped to 8.97%. Cereals saw a massive jump, becoming the largest export category by 2020, increasing its share from 9.33% in 1991 to 21.27%. Oil Seeds also showed significant growth, from a small share of 2.66% in 1991 to 15.08% in 2020. The export of Fish remained a major category, although its percentage share decreased slightly from 14.66% to 12.40%. Several categories that had minimal or negligible contributions in 1991 became more prominent by 2020, such as Sugar (6.78% share in 2020), Animal/Veg Fat Oils (3.91%), Miscellaneous Edible Products (2.12%), Preparation of Vegetable Fruit Nut (1.67%), and Preparation of Meat/Fish (1.70%). In 1991, India's agricultural exports were more reliant on traditional products like Coffee, Tea, Spices, and Fish. By 2020, there was a shift toward a more diversified range of products, with categories like Cereals, Oil Seeds, and Processed Foods becoming more prominent, showcasing India's evolving agricultural base and diversification of export markets. The significant increase in the total export value reflects India's rising importance as a global agricultural exporter. The analysis shows a notable evolution in India's agricultural export profile between 1991 and 2020. Key findings include a shift in the leading export categories, increased diversification of products and the emergence of new markets and preferences.

Table 2. India's agricultural product exports at 2 digit HS level for HS 01 to 24 (1991 & 2020).

1991			2020		
Product Type (HS-2 Digit Classification)	**Trade Value (1000 USD)**	**Percentage Share in India's Agricultural Exports**	**Product Type (HS-2 Digit Classification)**	**Trade Value (1000 USD)**	**Percentage Share in India's Agricultural Exports**
Coffee, tea, mati & spices	1475477.53	37.34	Cereals	8671984	21.27
Fish	579325.69	14.66	Oil seeds	6148150	15.08
Residues	376494.98	9.53	Fish	5056523	12.40
Cereals	368599.27	9.33	Coffee, tea, mati & spices	3657426	8.97
Edible fruit	343850.24	8.70	Meat	3106056	7.62
Tobacco	153238.46	3.88	Sugar	2763938	6.78
Oil seeds	105026.56	2.66	Animal/veg fat oils	1594923	3.91
Edible vegetable	97444.91	2.47	Residues	1474219	3.62
Meat	93627.60	2.37	Edible fruit	1313527	3.22
Lac; gums, resins & other vegetable saps	85175.64	2.16	Edible vegetable	1218367	2.99
Animal/veg fat oils	72436.93	1.83	Miscellaneous edible	862618	2.12
Sugar	64864.87	1.64	Tobacco	847753	2.08
Products of animal origin	36425.81	0.92	Lac; gums, resins & other vegetable saps	724651	1.78
Preparation of vegetable fruit nut	17486.10	0.44	Preparation of meat/fish	691729	1.70
Miscellaneous edible	16083.20	0.41	Preparation of vegetable fruit nut	681091	1.67
Beverages	16080.84	0.41	Preparation of cereal/flour	567460	1.39
Preparation of cereal/flour	15867.08	0.40	Production mill	382601	0.94
Vegetable plaiting materials & vegetable product	15033.03	0.38	Beverages	331468	0.81
Dairy products	8472.77	0.21	Dairy products	319102	0.78
Live tree	6015.84	0.15	Cocoa	143549	0.35
Cocoa	1617.06	0.04	Products of animal origin	97367.5	0.24
Preparation of meat/fish	1413.64	0.04	Live tree	73232.5	0.18
Production mill	1188.50	0.03	Vegetable plaiting materials & vegetable product	41978.5	0.10
Live animals	345.54	0.01	Live animals	5349.62	0.01
Total agricultural exports HS 01-24	3951592.07		Total agricultural exports hs 01-24	40775063.19	

Source: UNCOMTRADE.

3. Literature Review

3.1. Theoretical Reviews

Trade expansion happens through extensive and intensive margins, and systematic studies have been conducted since the turn of the twenty-first century to understand the relative importance of each margin on trade growth. Researchers disagreed on whether the extensive or intensive margin is the main driver of trade expansion. There are three primary reasons for these differing views. First, there are differences in the definitions of the two margins, particularly the extensive margin. What is viewed as the intensive margin at the national level or the product level is equivalent to what is called the extensive margin at the product-country level [10]. According to Hummels and Klenow [11], the extensive margin has a greater impact on trade growth when specified at the product-country level. Despite defining the extensive margin at the product-country level, Amurgo-Pacbeco and Pierola [12] contend that the transient nature of many trading ties lessens the extensive margin's support to trade growth. As a result, they draw the conclusion that the intensive margin mostly drives trade progression. Second, the relative contributions of the intensive and extensive margins to a nation's trade progression might vary over time, even given a uniform definition. Liapis [13] found that among 69 agricultural exporters, these margins' contributions to the increase of agricultural exports varied considerably between 1996 and 2006. Thirdly, the contributions of intensive and extensive margins to trade development are influenced by the degree of data aggregation, as shown by Hummels and Klenow [11].

Trade theories attempt to explain how a country's economy and income expand when it exports more. International trade differs based on the country of origin and its specialization. By decreasing prices relative to their trading partner countries, they can export more, leading to favourable terms of trade effects [14]. The Krugman [15] model believes that export varieties depend on the country's GDP, and it presupposes that every country exports a quantity per range relative to its magnitude. Hence, the entire expansion in exports originates from the extensive margin, i.e., it exports the same volume per variety of products [15].

Ample literature concentrates on the correlation between intensive and extensive margins and other economic variables. Helpman, Melitz and Rubinstein [16] computed an approach to analyse the impact of trade barriers on intensive and extensive margins. Cadot, Carrere and Strauss [17] decomposed the Theil index of export application into intensive and extensive margins to study the relationship between export absorption and per capita income. The conclusions indicate an affirmative association between the two variables mainly because of specialization. Feenstra and Kee [18] computed the decomposition of export growth by defining a country's export variety of goods in trade as the percentage of a country's aggregate imports shipped by another nation. This definition was then modified by Hummels and Klenow [11]. Novel product lines are weighted according to their proportion of global trade using Hummels and Klenow's [11] method, which is more effective than the conventional method. The impact of intensive and extensive margins on manufacturing export progression was examined in a study by Besedes and Prusa [10]. Developing countries performed well on the extensive margin and found new connections compared to developed countries.

Kehoe and Ruhl [19] considered that exports of less traded goods should be a pointer of the extensive margin. The findings indicate that the extensive margin is a leading factor in export growth for many developing countries. Additionally, it was observed that basic restructuring and trade pacts exert positive and notable impacts on extensive margins. Expanding the range of newly created products for export will escalate the country's market segment worldwide. A nation's global share of exports will extend without any decline in relative export prices when that nation's export progression is determined by the extensive trade margin [20, 21].

The extensive margin contributes to a greater percentage of larger exports for larger nations [11]. For developing countries, the extensive trade margin contributes significantly more to export growth [22]. On the other hand, there are a large number of studies supporting the intensive margin's role in boosting exports like Felbermayr and Kohler [23], Helpman et al. (2008) [16],

Eaton et al.[24], and Amiti and Freund[25]. Using the method of Evenett, Venables and Anthony[22], the extensive margin is described at the nation-product level. The extensive margin will be greater if nation j exports diverse goods (i) to nation m, and the intensive margin will be greater if nation j exports greater volumes of fewer diverse goods to nation m. So, to infer, the extensive margin measures the coverage of the nation's export range, and the intensive margin indicates its depth and gravity[26]. Given its status as a productive agricultural economy, India possesses a wide range of agricultural products for global trade and can reach numerous destinations.

3.2. Empirical Reviews

Several studies investigate the factors inducing the dual margins of export expansion. One important factor is the productivity of the firm, which influences the firm's decision to move into overseas markets. With higher productivity, firms can meet the expenses of entering overseas markets. High-productive firms will specialise in exporting products, thereby determining the country's dual margins[27]. Differences in trade cost are caused by efficiency, economic magnitude, and trade cost. The trade cost variable rises proportionally with the remoteness from the source nation to the destination nation[28]. Variable and fixed trade costs influence intensive and extensive margins. Extensive margins are more significantly influenced by fixed costs of trade[29]. Some factors influencing extensive margins are free trade agreements, structural reforms, and trade policy[18, 19]. Conversely, a decrease in trade expenses will impact the intensive margin of homogeneous merchandise and the extensive margin of varied merchandise due to deviations in the elasticities of exchange between merchandise[2, 30].

An important factor in measuring trade margins is GDP, which has an affirmative bearing on both margins[11]. Higher GDP indicates a higher demand for differentiated products (extensive trade margin) and a variety of amounts demanded (intensive trade margin). Evenett and Venables[30] found that elements including proximity, a shared border between nations, and the usage of a similar language all contribute to the growth of exports by giving exporters a chance to discover new customers. Zahler[31] found that factors impacting export growth included new product types and new export markets. New destinations provided a stronger effect on export growth within the extensive trade margin, while the intensive trade margin contributed more for emerging countries. Furthermore, it was shown that each nation's competitive industries had difficulty expanding into new markets because of a negative correlation with variables like GDP per capita and population size. The remoteness index calculates the distance to the destination country. A higher index suggests that companies will find exporting to the intended markets challenging. This suggests that the remoteness index has a detrimental effect on trade profits[27]. Additionally, even though it is predicted that economic uncertainty would negatively disrupt the trade margins, free trade agreements and the existence of a common boundary will improve and positively influence dual margins.

There are many studies conducted on trade margins across different countries. The determinants of the intensive and extensive margin of Saudi exports were analyzed using a multiplicative gravity model, focusing on old products to novel markets and novel products to novel markets[32]. The determinants of China's agricultural export margins include larger trading partners, destination countries with high labor productivity and low trade costs, and varying impacts based on product characteristics[33]. The gravity model for Turkish agricultural exports to the EU shows a positive correlation with economy size, importer population, Turkish diaspora, non-Mediterranean climate, and Customs Union membership, while negatively correlated with arable land and distance[34].

3.3. Reviews on Agricultural Exports

India has maintained a trade surplus in agricultural products over the years, and in the thirty-years period from 1991 to 2020, the country's exports nearly doubled. The economic reforms in 1991 made the Indian economy more competitive which revolutionised its agricultural trade sector by reshaping the economy into a globally oriented, service-based structure and focusing on liberalisation as part of its structural adjustment pro-

gramme. Indian agriculture was able to become more export-oriented and more globally competitive thanks to the new government regulations. India's competitive advantage in the international market is demonstrated by the rise in its exports of important agricultural commodities. From 1991 to 2020, India's export performance of main agricultural commodities was considered good in quantity and value [7]. India, in particular, stands to gain a lot by employing reforms to boost agricultural commodity exports and promote comparative advantage in the global market [35]. India's export portfolio has significantly improved, with gains seen in volume, composition, and value. Agro-based products are expected to lead the country's export portfolio and become market leaders worldwide [36].

India's foreign trade has noted significant shifts in recent years, attributed to the major liberalization and globalization initiatives. In addition to the primary conventional export goods such as engineering products, petroleum-related items, various chemicals, and some allied products, which comprise approximately 80% of the total export portfolio, agricultural and allied products account for the remaining 20% [37]. India can increase its market share and demand better prices for its agricultural exports by moving up in the value chain [38, 39].

With the help of small exporters and government backing, India's agricultural exports are growing in both the extensive (product diversity) and intensive (increasing value per product) margins [40]. Changes in the extensive (quantity) and intensive (quality) margins of agricultural exports are indicated by India's comparative advantage in key agricultural exports after reforms [41]. With a small rise in intra-industry trade, India's agricultural exports increased through the intensive margin (growing export volume) at the expense of imports [42]. India's agricultural exports, particularly in commodities like meat, rice, and oilseeds, exhibit potential in both extensive (growing the variety of products) and intensive (raising the value of current products) margins [43]. Products such as tea, coffee, oilseeds, and wheat are among those from India's agricultural exports that have a comparative advantage. This suggests that there is room for development in both intensive (raising the value of current exports) and extensive (diversifying exports) margins [44].

Building on the findings from earlier assessments, the goal of this study is to carefully examine the critical factors that significantly impact the success of India's agricultural exports in the international market. The literature presents actual data on the origins of agricultural export development from various nations, differentiating between the intensive and extensive margins. The research hopes to enhance the facts already available about India's agricultural trade. The study has many significant contributions to make. First, using an enhanced gravity model for agricultural trade expands on previous research. Second, using a large dataset including 20 nations, the research fills a significant gap in the literature by analysing the factors influencing India's exports over 30 years (1991–2020). By expanding the coverage of both time and countries, the study enhances the robustness and applicability of its findings. This temporal and geographical breadth enables a nuanced understanding of the evolving trade dynamics and the factors influencing them. To the best of our knowledge, not many empirical studies are available that attempt to explicitly analyse the determinants of India's agricultural trade margins along these channels.

4. Materials and Methods

4.1. Measurement of Intensive and Extensive Margins

The part of a nation's export in the world's aggregate export is a creation of the intensive and extensive margin of trade. The current study will use the Hummels and Klenow method of decomposition of extensive and intensive margins which is formulated as:

$$EM = \frac{\sum I^c P_i^w X_i^w}{\sum I^w P_i^w X_i^w} \tag{1}$$

$$IM = \frac{\sum I^c P_i^c X_i^c}{\sum I^c P_i^w X_i^w} \tag{2}$$

where X_i^c and X_i^w and P_i^c and P_i^w are the export value and price value of country c's and world exports, respectively. I^c is the selected range of positive export set of goods exported by country c while I^w is the selected

range that contains all the goods exported in the world. Therefore, I^c is a subclass of I^w. The value of extensive and intensive margin ranges from 0 to 1. The extensive margin is a fraction of a country's export product category in the global export category. The intensive margin is a fraction of a country's global exports through export products. The extensive trade margin measures the growth of trade due to a rise in the number of product varieties exported to each destination country, focusing on the width of exports, i.e., whether a trading relationship exists. The intensive margin measures the average value of exports by variety, focusing on the depth of exports, i.e., how much is traded in the existing relationship.

Equations (1) and (2) are used to relate a country's intensive and extensive margin for a given period. On the other hand, the export growth of a country can be subdivided between years t and t + n in order to derive the extensive and intensive margin as[19]:

$$g = g_{EM} * g_{IM} \tag{3}$$

where g is the export growth rate, g_{EM} is the extensive margin growth rate and g_{IM} is the intensive margin growth rate.

4.2. Determinants of Intensive and Extensive Margins

A nation's export growth can be partially attributed to the expansion of global commerce, the specific trading partners the nation has chosen, or the items the nation sells most frequently. In addition, export growth depends upon the country's economic environment and the performance of alternate factors supporting export growth. The growth strategies promoting exports have tried to examine the factors determining export growth. India's agricultural export dual margins from 1991–2020 are analysed. The definition of significant variables that have been used to determine the intensive and extensive margins of trade are presented in **Table 3** as follows:

4.3. Gravity Trade Model

The gravity trade model[33, 45] is extensively used to determine the important factors influencing trade for the trading nation. The gravity model explains how bilateral trade is a result of the geographical space and remoteness between the two nations, which is a representation of transportation expenses, and the two nations combined an economic size measured by the Gross Domestic Product (GDP). According to this model, the exchange of goods between two nations is certainly correlated with their dimension of income stages and inversely correlated with their remoteness[46]. The model is expanded by incorporating incorporating variables that consider additional factors influencing trade such as the population of the partner country, relative agriculture value added, relative economic freedom, distance, relative crop production and relative purchasing power. Dummy variables representing trade agreements and common language have also been introduced to address other factors impacting trade levels over the basic model. The estimated equation of intensive and extensive trade margins is as follows:

$$\begin{aligned} EM_{jp} = {} & \beta_0 + \beta_1 RES_{jp} + \beta_2 Pop_p + \beta_3 RAV_{jp} \\ & + \beta_4 REF_{jp} + \beta_5 LnDist_{jp} + \beta_6 RCP_{jp} + \\ & \beta_7 RPP_{jp} + \beta_8 D_{1\_}TA + \beta_9 D_{2\_}CL + \epsilon_{jp} \end{aligned} \tag{4}$$

$$\begin{aligned} IM_{jp} = {} & \alpha_0 + \alpha_1 RES_{jp} + \alpha_2 Pop_p + \alpha_3 RAV_{jp} \\ & + \alpha_4 REF_{jp} + \alpha_5 LnDist_{jp} + \alpha_6 RCP_{jp} + \\ & \alpha_7 RPP_{jp} + \alpha_8 D_{1\_}TA + \alpha_9 D_{2\_}CL + \mu_{jp} \end{aligned} \tag{5}$$

where RES_{jp} is the relative economic size; Pop_p is the population of the partner country; RAV_{jp} is the relative agriculture value added; REF_{jp} is the relative economic freedom; $Dist_{jp}$ is the distance; RCP_{jp} is the relative crop production; RPP_{jp} is the relative purchasing power and $D_{1\_}TA$ and $D_{2\_}CL$ are dummy variables representing trade agreements and common language. The vectors of factors to be estimated are α and β. The stochastic error terms include ϵ_{jp} and μ_{jp}.The dependent variables are extensive and intensive trade margins of agricultural bilateral exports from India to 20 nations.

4.4. Estimation Methods: Feasible Generalized Least Squares and Pseudo Poisson Maximum Likelihood

To ensure reliable and effective estimators, the panel data were analysed using the Feasible General-

Table 3. Description of variables.

Variables	Source of Variable	Descriptions
1. Intensive margin	Elumalai and Kumar., 2022 [45]	The fraction of a country's exports in global exports in a country's basket of export products.
2. Extensive margin	Veeramani, Aerath and Gupta, 2018 [26]	The fraction of a country's export product category in the global export category.
3. Relative economic size	Zhang et al., 2017 [33]; Veeramani, Aerath and Gupta, 2018 [26]	The proportion of the partner's GDP to India's GDP.
4. Population	Elumalai and Kumar., 2022 [45]	Bilateral trade partner's population growth.
5. Relative agriculture value added	Liapis, 2009 [12]	The proportion of partner's agriculture value added to India's agriculture value added.
6. Relative economic freedom	Zhang et al., 2017 [33]	The proportion of the partner's economic freedom index to India's economic freedom index.
7. Distance	Zhang et al., 2017 [33]; Elumalai and Kumar., 2022 [45]	The two-sided distance in kilometres between the partner and India.
8. Relative crop production	Defined by author	The ratio of the partner's crop production index to India's crop production index.
9. Relative purchasing power	Defined by author	The ratio of the partner's net terms of trade index to India's net terms of trade index.
10. Trade agreement	Zhang et al., 2017 [33]; Veeramani, Aerath and Gupta, 2018 [26].	1 for trade agreement in action.
11. Common language	Elumalai and Kumar, 2022 [45]	1 for the presence of a common language.

ized Least Squares (FGLS) and Pseudo Poisson Maximum Likelihood (PPML) methods. These approaches assume that all components of the model are accurately specified. The FGLS estimation offers the advantage of addressing heteroscedasticity and serial correlation. It proves particularly suitable when the precise form of heteroscedasticity in the data is unknown, as it assigns weights to observations based on the square root of their variances, demonstrating robustness against various forms of heteroscedasticity. In this context, it considers disturbances with varying variances across panels and constant within each panel. FGLS estimates the coefficients of a multiple linear regression model and their covariance matrix in the presence of non-spherical innovations with an unknown covariance matrix. The PPML model provides two key benefits: first, estimates will not be biased due to heteroscedasticity. PPML provides consistent estimates in the presence of heteroskedasticity, which is common in trade data. The estimator gives the same weight to all observations. Secondly, zero-trade observations may be included, and the PPML estimator is consistent both with and without the inclusion of the zero-trade observations.

To run Feasible Generalized Least Squares (FGLS), the first step involves estimating the model using Ordinary Least Squares (OLS) to obtain residuals. These residuals help check for the presence of heteroscedasticity, which can be tested using tools such as the Breusch-Pagan test or the White test. After identifying heteroscedasticity, the next step is to estimate the error variance from the OLS residuals. This variance estimation can reveal patterns of heteroscedasticity or autocorrelation in the error terms. Once the error variance is estimated, the next step is to transform the data. This involves using the estimated variance-covariance matrix to standardize or adjust the errors, thus correcting for heteroscedasticity or autocorrelation. With the data transformed, the model can now be re-estimated using Generalized Least Squares (GLS). In cases where the variance estimation needs updating iteratively, Feasible Generalized Least Squares (FGLS) is employed. Lastly, it's a good practice to check the robustness of the estimates, which can be done by using robust standard errors. This helps ensure the reliability of the FGLS model in han-

dling potential issues related to heteroscedasticity or autocorrelation.

To run Poisson Pseudo Maximum Likelihood (PPML), the process begins with specifying the model, ensuring that it is suitable for count data or trade models, especially in contexts like gravity models where trade flows can include zero values. In this type of model, the log-linear specification is commonly used, where the dependent variable is in level form, while independent variables, such as GDP and distance, are typically transformed using logs. Next, run the PPML estimation, which involves using statistical software packages like Stata, R, or Python. These packages provide built-in commands to facilitate PPML estimation. The advantage of PPML over traditional OLS is that it can handle zero trade flows and does not require taking the log of the dependent variable, which would be problematic in such cases. It is essential to check for convergence after running the estimation, particularly in large or complex datasets, to ensure that the algorithm has properly converged. Finally, evaluate the fit of the model by performing diagnostic tests, such as examining residuals and checking for overdispersion, to verify that the PPML assumptions hold and the model accurately represents the data.

5. Data

A panel dataset capturing the bilateral agricultural trade between India and 20 important trade partners over 30 years was compiled. The data used is in nominal terms. The HS-6-digit classification of agricultural goods is used to analyse India's bilateral trade with these 20 countries (2020), which include Bangladesh, Nepal, China, Hong Kong, Malaysia, Indonesia, Vietnam, Singapore, Thailand, Japan, Russia, Egypt, UAE, Iran, Kuwait, Saudi Arabia, UK, Netherlands, Germany, and the USA. This group of countries has been selected because of their high trade value of agricultural trade with India. The extensive and intensive margins are in value terms (USD) and are computed on STATA 16 based on the data collected from UNCOMTRADE. The data for other variables of relative economic size, population of the partner country, relative agriculture value added, economic freedom, distance, relative crop production, relative purchasing power, and dummy variables representing trade agreements and common language were collected from the World Bank source and the summary statistics of variables is presented in **Table 4**.

5.1. Summary Statistics of Variables

Table 4 summarises the core economic variables used in the statistical analyses. During the study period, the dependent variables of intensive and extensive margins had means of 0.054 and 0.922, respectively. The corresponding standard deviations of the intensive and extensive margins were 0.114 and 0.082. The gap between the minimum and maximum values of both margins implies that there has been an increase in the export volumes of agricultural goods during the period of study. The relative economic size mean value of 0.939, close to 1, suggests that, on average, the countries in the dataset have similar economic sizes relative to India. This implies a balanced economic context among trading partners. The population mean of 1.449 implies that on average, the populations of the trading countries could influence demand for India's agricultural products and trade volumes. The relative economic freedom, with a mean of 0.783, indicates moderate economic freedom. This can reflect the ability of countries to engage freely in trade and could be correlated with agricultural export volumes. The distance variable, with a mean of 4430.85, indicates that trade partners are, on average, quite far from India. This could impact transportation costs and trade dynamics.

5.2. Diagnostic Tests

In panel data, common issues such as heteroscedasticity and autocorrelation were encountered. The Breusch-Pagan test was employed to identify groupwise heteroscedasticity, assessing the hypothesis of homoscedasticity that assumes consistent variances of the error term across units. The test yielded a statistically significant result ($\chi2$ (1) = 381.49, $p < 0.05$ for extensive margin and $\chi2$ (1) = 142.12, $p < 0.05$ for intensive margin), leading to the rejection of the homoscedasticity assumption. This implies that the variances of residuals are not independent of explanatory variables, indicating

Table 4. Summary statistics of variables.

Variables	Mean	Maximum	Minimum	Standard Deviation
1. Intensive margin	0.054	0.876	0	0.114
2. Extensive margin	0.922	0.999	0	0.082
3. Relative economic size	0.939	33.990	–8.855	2.213
4. Population	1.449	19.052	–22.347	2.137
5. Relative agriculture value added	0.402	1.948	0.001	0.447
6. Relative economic freedom	0.783	1.598	0.609	0.523
7. Distance	4430.85	13568	1012	2746
8. Relative crop production	1.151	5.399	0.105	0.501
9. Relative purchasing power	0.946	2.425	0.622	0.319
10. Trade agreement	0.3	1	0	0.459
11. Common language	0.4	1	0	0.490

the presence of heteroscedasticity. The White test, with a value of $\chi2$ (52) = 104.66 for extensive margin and $\chi2$ (52) = 351.32 for intensive margin, similarly rejects the null hypothesis ($p < 0.05$) that the variances of residuals are independent of explanatory variables, providing further evidence of heteroscedasticity. The Woolridge test was employed to detect serial correlation. According to the test results ($\chi2$ (20) = 3315.19, $p < 0.05$ for extensive margin and $\chi2$ (20) = 98.37, $p < 0.05$ for intensive margin), the null hypothesis was rejected, representing the existence of autocorrelation in the error term.

6. Results and Discussion

The contribution of the growth of intensive and extensive margins to India's agricultural exports is presented in two parts. The first part discusses the trade margins for product-wise presented in **Table 5** and destination-wise. This analysis is conducted at HS-2 presented in **Table 5** and HS-6 digit level presented in **Tables 6** and **7**. The second section covers the identification of factors influencing the trade margins of India. It was found that the extensive margins are more dominant than the intensive margins over the thirty periods. The extensive margin serves as a growth factor for agricultural exports. Given its status as a productive agricultural economy, India possesses a wide range of agricultural products for global trade and has the potential to reach numerous destinations.

Table 5 represents the classification of HS-2 digit commodities (HS-6 is included in these broad categories of HS-2) along with their respective intensive margin (%) and extensive margin (%) across three decades: 1991–2000, 2001–2010 and 2011–2020. The intensive margin of Live Animals increased from 0.02% to 0.17%, showing a rise in production and trade interest. Meat rose significantly from 0.62% to 4.72%, indicating a growing market for meat products. In the case of Fish the intensive margin fluctuated slightly, starting at 4.35%, dropping to 3.35%, and then increasing to 7.24%. This suggests variability in production but an overall upward trend. Dairy Products grew from 0.29% to 0.75%, and then slightly decreased to 0.66%, reflecting a stable market with minor fluctuations. Products of Animal Origin declined from 3.93% to 1.54%, indicating decreased production or market demand. Live Trees increased from 0.30% to 0.60%, showing growing interest in live tree production. Edible Vegetables rose from 1.12% to 1.75%, indicating a growing market for these products. Edible Fruits decreased from 3.44% to 2.08%, suggesting challenges in production or market saturation. Coffee, Tea, Mati & Spices increased slightly from 7.68% to 8.51%, indicating stable production levels. Cereals grew from 4.52% to 9.77%, reflecting enhanced production capabilities and demand. Production Mill rose significantly from 0.55% to 2.26%, indicating major advancements in production processes. Oilseeds increased from 1.46% to 1.86%, showing stability in the oilseed market. Lac, Gums, Resins & Other Vegetable Saps saw a major increase from 15.59% to 33.76%, indicating strong demand. Vegetable Plaiting Materials & Vegetable Products increased from 3.04% to 8.69%, reflecting a growing market. Animal/Veg Fat Oils rose from 1.03% to 2.05%, indicating increased market acceptance. Prepa-

Table 5. Share of intensive and extensive margin of India's agricultural products.

Product Type (HS-2 Digit Classification)	Intensive Margin (%)			Extensive Margin (%)		
	1991–2000	2001–2010	2011–2020	1991–2000	2001–2010	2011–2020
1.Live animals	0.02	0.10	0.17	39.33	75.33	76.67
2.Meat	0.62	1.13	4.72	46.12	65.03	54.38
3.Fish	4.35	3.35	7.24	54.90	75.47	74.37
4.Dairy Products	0.29	0.75	0.66	98.34	94.00	94.00
5.Products of animal origin	3.93	1.38	1.54	92.37	81.33	98.19
6.Live tree	0.30	0.60	0.50	89.67	91.22	91.36
7.Edible vegetable	1.12	1.67	1.75	62.67	87.84	92.47
8.Edible fruit	3.44	2.51	2.08	69.10	88.82	95.09
9. Coffee, tea, mati & spices	7.68	6.63	8.51	94.18	97.23	92.84
10. Cereals	4.52	7.45	9.77	63.75	96.25	98.75
11. Production mill	0.55	1.09	2.26	57.06	86.05	95.94
12. Oil seeds	1.46	1.54	1.86	49.45	80.53	82.95
13. Lac; gums, resins & other vegetable saps	15.59	17.88	33.76	67.50	84.09	90.00
14. Vegetable plaiting materials & vegetable product	3.04	4.99	8.69	56.55	77.14	75.95
15. Animal/veg fat oils	1.03	1.32	2.05	48.43	84.82	85.47
16. Preparation of meat/fish	0.04	0.47	0.87	27.6	65.20	61.20
17. Sugar	0.64	2.21	2.65	66.00	94.67	99.33
18. Cocoa	0.03	0.05	0.46	47.27	76.36	86.36
19. Preparation of cereal/flour	0.40	0.56	0.88	78.75	98.13	99.87
20. Preparation of vegetable fruit nut	0.28	0.59	1.15	50.89	81.83	88.69
21. Miscellaneous edible	1.02	1.02	1.32	80.7	97.00	99.12
22. Beverages	0.13	0.11	0.27	71.43	93.59	93.00
23. Residues	5.53	5.67	3.80	60.83	86.85	91.66
24. Tobacco	1.39	2.24	2.90	83.33	95.56	98.89

Source: Compiled by author.

ration of Meat/Fish increased from 0.04% to 0.87%, showing significant growth in prepared meat and fish products. Sugar grew from 0.64% to 2.65%, indicating a strong market potential. Cocoa increased from 0.03% to 0.46%, reflecting rising consumer interest. Preparation of Cereal/ Flour rose from 0.40% to 0.88%, showing growth in processed cereals.

In the case of the extensive margin, Live Animals increased from 39.33% in 1991–2000 to 76.67% by 2011–2020, indicating strong growth in the market for live animals, reflecting increased production and trade opportunities. Meat grew from 46.12% to 54.38%, showing a steady demand for meat products, although it saw a slight decrease in the last decade. Fish rose from 54.90% to 74.37%, indicating robust and growing interest in fish products, particularly in the latter years. Dairy Products started at a high 98.34% and stabilized at 94.00% in both the 2001–2010 and 2011–2020 periods, reflecting a consistent presence in the market. Products of Animal Origin increased from 92.37% to 98.19%, suggesting a significant expansion in this category, highlighting strong market potential. Live Trees increased from 89.67% to 91.36%, showing stability and consistent interest in live trees for trade and production. Edible Vegetables rose from 62.67% to 92.47%, reflecting increased market participation and demand for vegetables over the decades. Edible Fruits increased from 69.10% to 95.09%, indicating a strong upward trend in the market for edible fruits. Coffee, Tea, Mati & Spices started at 94.18% and slightly declined to 92.84% by 2011–2020, indicating stable but slightly diminishing market saturation. Cereals grew significantly from 63.75% to 98.75%, indicating a strong increase in the demand and production of cereals. Production Mill increased from 57.06% to 95.94%, showing a strong growth trajectory in production capabilities. Oilseeds rose from 49.45% to 82.95%, indicating a growing market for oilseeds and their derivatives. Lac, Gums, Resins & Other Vegetable Saps increased from 67.50% to 90.00%, suggesting robust market growth in this niche category. Vegetable Plaiting Materials & Vegetable Products increased from 56.55% to 75.95%, indicating a steady growth in demand. Animal/ Veg Fat Oils grew from 48.43% to 85.47%, reflecting a strong acceptance and growth in this market. Prepa-

ration of Meat/Fish increased from 27.6% to 61.20%, showing a significant increase in prepared products over time. Sugar rose from 66.00% to 99.33%, indicating a very high level of market participation and demand in the sugar category. Cocoa increased from 47.27% to 86.36%, indicating significant growth in this market. Preparation of Cereal/Flour increased from 78.75% to 99.87%, showing near-total market coverage and acceptance for processed cereals. Preparation of Vegetable Fruit Nut increased from 50.89% to 88.69%, suggesting growing market demand for these products. Miscellaneous Edible increased from 80.70% to 99.12%, indicating a very high level of interest and production. Beverages increased from 71.43% to 93.00%, showing a solid growth trend in the beverage market. Residues increased from 60.83% to 91.66%, indicating a strong market for residues, which may reflect increasing efficiency in production processes. Tobacco increased from 83.33% to 98.89%, suggesting sustained and growing interest in tobacco products.

Overall, many product types showed significant increases in the intensive margin, particularly meat, cereals, and lac products. However, some, like edible fruits and animal-origin products, showed declines. This highlights the dynamic nature of agricultural markets over the decades. The extensive margin percentages indicate a general trend of increasing market presence across many product categories, particularly in cereals, sugar, and animal products. Notably, the consistent high percentages in categories like dairy and animal products reflect their stable importance in the market. However, slight declines in products like meat and coffee indicate shifting consumer preferences or market saturation.

The data reveals varying trends in both intensive and extensive margins across product types. While some products show significant growth in market reach and production efficiency, others indicate fluctuations or declines, reflecting the dynamics of consumer preferences and market conditions over the three decades.

The following section of **Tables 6** and **7** presents an analysis of the top 20 products (HS-6) with a large share in extensive margin and intensive margin by comparing two time periods of 2019 and 2023.

Table 6 represents the major HS-6 agricultural products contributing to extensive growth margin for two time periods of 2019 and 2023. Products like soya beans, maize, and boneless frozen meat have increased their extensive margin, reflecting higher production and stronger market demand. Traditional products like wheat and palm oil have seen a reduction in their share of exports, indicating possible changes in global market conditions or shifts in India's export priorities. The rise in exports of food preparations suggests India is moving towards exporting more processed and value-added products, in line with global trends in the food industry.

India's agricultural export strategy between 2019 and 2023 reflects both continuity in core exports (e.g., soya beans, maize) and adaptability, with an increasing share of processed and value-added products.

Table 7 represents major HS-6 agricultural products contributing to intensive growth margin for two time periods of 2019 and 2023. Products such as rice in the husk, castor oil, and cane molasses reveal increases in intensive margins, suggesting growing export volumes for these products. This reflects strong demand in both raw and processed agricultural products. The introduction of crude groundnut oil as a significant export in 2023 underscores India's diversification in vegetable oils. While products like flour of dried legumes and frozen sheep meat remain key exports, their intensive margins saw slight reductions, indicating relatively stable but perhaps stagnating demand. India's agricultural exports between 2019 and 2023 show dynamic shifts, with some traditional products continuing to hold strong, while newer exports (e.g., crude groundnut oil) gain prominence. The country is increasingly focusing on diversifying its agricultural output to meet changing global demand.

Table 8 represents the intensive margin (%) and extensive margin (%) in terms of India's bilateral exports across three decades: 1991–2000, 2001–2010 and 2011–2020. For the intensive margin, countries like Nepal (from 24.35% to 65.02%) and Iran (from 1.56% to 8.46%) showed significant increases in margin. Bangladesh, however, experienced a slight decline from 16.14% to 15.15%. For the extensive margin, countries like Bangladesh (from 85.67% to 99.16%) and Egypt

Table 6. Major HS-6 Agricultural products contributing to extensive growth margin.

2019			2023		
HS Code	**Product Type (HS-6 Digit Classification)**	**Extensive Margin (%)**	**HS Code**	**Product Type (HS-6 Digit Classification)**	**Extensive Margin (%)**
120100	Soya beans, whether or not broken	31.91	120100	Soya beans, whether or not broken	41.23
100190	Wheat and meslin	25.51	100590	Maize (corn), other than seed corn	22.09
100630	Semi-milled or wholly milled rice	19.11	100190	Wheat and meslin, other than durum wheat	15.61
100590	Maize (corn), other than seed	18.61	170111	Raw cane sugar, in solid form, not containing flavor	15.56
151190	Palm oil and its fractions, other	13.62	230400	Soya-bean oilcake & solid residues from extraction	14.31
230400	Oil-cake and solid residues of soy	11.56	100630	Semi-milled/wholly milled rice, polished/glazed	13.00
170111	Raw cane sugar, in solid form	11.00	100610	Rice in the husk (paddy or rough)	12.59
150710	Soybean oil and its fractions	9.01	150710	Crude soya-bean oil	11.28
020230	Frozen boneless meat of bovine	8.59	210690	Food preparations, not elsewhere specified	10.13
100300	Barley	7.71	020230	Boneless frozen bovine meat	9.72
210690	Food preparations, not elsewhere specified	7.40	151800	Animal/vegetable oils & fats, chemically modified	9.22
220820	Spirits obtained by distilling grape wine	7.38	220820	Spirits obtained by distilling grape wine	6.17
190110	Food preparations for infant use	7.37	220830	Whiskies	6.17
180100	Cocoa beans, whole or broken, raw or roasted	7.17	220421	Wine of fresh grapes, containers	6.13
100610	Rice in the husk (paddy or rough)	6.70	020721	Frozen, not cut in pieces, chickens	6.07
240220	Cigarettes containing tobacco	6.38	220300	Beer made from malt	5.49
20329	Meat of swine, other than fresh, chilled	6.14	190590	Bakers' wares, not elsewhere specified	5.41
10410	Live sheep and goats	6.03	150200	Fats of bovine, sheep, or goats, not chemically mod	5.34
220421	Wine of fresh grapes, in containers holding 2L or less	6.02	160590	Crustaceans, prepared or preserved, not elsewhere	5.15
220300	Beer made from malt	5.78	180100	Cocoa beans, whole or broken, raw or roasted	5.07

Source: Compiled by author.

(from 82.66% to 98.08%) showcased significant growth in product diversity, highlighting successful efforts in expanding their agricultural portfolios. Most countries, including China (from 82.20% to 94.38%) and Saudi Arabia (from 82.72% to 98.32%), displayed strong trends in the extensive margin, indicating effective diversification strategies. Countries like Germany and Japan also showed consistent increases in extensive margin percentages, suggesting robust diversification in India's agricultural markets.

Overall, for the intensive margin, some countries showed growth while others faced stagnation or slight declines. The extensive margin reflects a trend toward greater product diversification across most countries, enhancing resilience and market opportunities in agriculture. Countries like Nepal, Iran, and Bangladesh demonstrated particularly high growth rates in their extensive margins. On the other hand, the intensive margin displayed more variability, with some countries like Nepal and the UAE showing marked improvements in productivity, while others like Russia exhibited fluctuations. The data indicates a significant push toward diversifying agricultural products while also striving for productivity enhancements, crucial for economic stability and food security.

This section of **Table 9** analyses the determinants influencing India's agricultural trade margins.

Table 9 represents the FGLS and PPML results of the impact of variables such as relative economic size, population of the partner country, relative agriculture value added, relative economic freedom, distance, relative crop production, relative purchasing power, and dummy variables representing trade agreements and common language on the intensive and extensive trade margins. The FGLS results indicate that the relative economic size, relative agricultural value added, relative

Table 7. Major HS-6 Agricultural products contributing to intensive growth margin.

2019			2023		
HS Code	**Product Type (HS-6 Digit Classification)**	**Intensive Margin (%)**	**HS Code**	**Product Type (HS-6 Digit Classification)**	**Intensive Margin (%)**
100610	Rice in the husk (paddy or rough)	62.61	100610	Rice in the husk (paddy or rough)	79.68
120730	Castor oil seeds	55.60	120300	Copra	60.22
151530	Castor oil and its fractions	47.45	151530	Castor oil and its fractions	55.42
020421	Meat of sheep, frozen	40.06	150810	Crude groundnut oil	47.23
010420	Live goats	28.70	020421	Fresh or chilled sheep cuts with bone	38.63
130232	Mucilages and thickeners, from locust beans	28.20	010420	Lamb carcasses and half-carcasses, fresh/chilled	34.94
130232	Oil-cake from vegetable fats and oils, other	23.71	230230	Bran, sharps, and other residues of wheat	30.81
110610	Flour and meal of the dried leguminous veg	21.56	230500	Oil-cake and other solid residues from ground-nuts	28.65
230610	Oil-cake and other solid residues from cotton	17.68	230690	Oil-cake and other solid residues, vegetable fats	25.25
100630	Semi-milled or wholly milled rice	17.44	120730	Castor oil seeds	24.77
130211	Opium extract and derivatives	15.76	240399	Manufactured tobacco	23.72
130190	Natural gums, resins, other than lac	15.14	110610	Flour of dried legumes (peas, beans, lentils)	19.76
140420	Cotton linters	13.44	130190	Natural gums, resins, and balsams	19.45
150890	Groundnut oil and fractions, refined	12.61	140420	Cotton linters	17.47
170310	Cane molasses	12.03	160520	Shrimps and prawns, prepared or preserved	17.46
120220	Ground-nuts, in shell	11.94	130232	Mucilages and thickeners, derived from locust beans	17.43
130219	Vegetable saps and extracts	11.25	170310	Cane molasses	16.86
210130	Roasted chicory and other roasted coffee substitutes	11.00	110812	Starch of maize (corn)	16.67
160540	Crustaceans, molluscs, other aquatic invertebrates, prepared/preserved	10.74	170390	Molasses, other than cane	15.84
200110	Cucumbers and gherkins, prepared or preserved	10.31	200110	Cucumbers and gherkins, prepared or preserved	14.67

Source: Compiled by author.

economic freedom, distance, relative crop production, relative purchasing power, trade agreements and common language significantly affect India's export of extensive and intensive margins. The variable relative economic size is significant and negative, indicating that a large size of the economy would lead to a smaller amount of progression in India's export of extensive trade margins [12, 26, 45]. An increase in the relative economic size relates to a decline of 0.005 percent in the extensive trade margin and 0.001 percent in the intensive trade margin in India's agriculture exports. The coefficient of the population yielded positive results for the intensive margin and the extensive margin [26]. This implies that an increase in a partner country's population encourages diversifying the range of products rather than the intensification of exporting existing agricultural products. This phenomenon could be attributed to the long-term trading relationships India has established with its partner countries, which primarily involve the export of diverse products. The relative agriculture value added has a significant impact on the intensive and extensive margins of trade [13]. The significant effects show that the intensive margin of India's agricultural exports will grow by 0.112 percent and the extensive margin of India's agricultural exports will decline by 0.016 percent with an increase in relative agriculture value added. Nonetheless, the relative economic freedom has a significant impact of 0.040 on the intensive margin and 0.038 on the extensive margin. Similarly, distance has significant undesirable impacts on trade margins. As anticipated, the coefficient for distance was negative and exhibited statistical significance [12, 45, 47, 48]. As distance is considered a proxy for trade cost, an increase in trade cost results in a reduction of bilateral trade flows between the countries. The relative crop production has a negative impact of 0.011 percent on extensive margins and a positive impact of 0.007 percent on the intensive trade margin. The relative purchasing power has a sig-

Table 8. Share of the intensive and extensive margin with respect to bilateral trade partners.

Country	Intensive Margin (%)			Extensive Margin (%)		
	1991–2000	2001–2010	2011–2020	1991–2000	2001–2010	2011–2020
1. Bangladesh	16.14	15.79	15.15	85.67	97.47	99.16
2. China	0.47	2.33	1.09	82.20	95.86	94.38
3. Egypt	1.37	2.55	4.00	82.66	94.37	98.08
4. Germany	0.63	0.52	0.78	84.86	95.61	96.53
5. Hong Kong	1.33	1.54	2.10	88.27	97.40	98.08
6. Indonesia	1.35	2.34	2.82	85.87	96.52	97.32
7. Iran	1.56	3.64	8.46	88.55	97.07	99.28
8. Japan	0.92	0.68	0.93	76.11	94.44	95.17
9. Kuwait	2.53	4.22	5.25	80.52	95.16	98.52
10. Malaysia	0.68	1.53	2.64	87.42	97.46	96.92
11. Nepal	24.35	51.28	65.02	84.39	96.92	99.42
12. Netherlands	0.46	0.79	1.38	81.68	95.09	92.47
13. Russia	2.08	0.77	0.98	76.07	94.56	98.14
14. Saudi Arabia	2.16	3.89	5.79	82.72	95.17	98.32
15. Singapore	0.91	2.72	4.03	84.46	96.47	96.62
16. Thailand	0.92	1.42	2.02	82.42	96.60	96.17
17. UAE	7.23	11.45	15.65	87.47	94.30	98.03
18. UK	0.85	0.99	1.52	82.64	94.99	95.51
19. USA	0.89	1.13	2.13	82.40	95.68	95.83
20. Vietnam	1.26	2.17	3.06	83.25	95.80	98.63

Source: Compiled by author.

nificant influence on the double margins of trade. The coefficient of trade agreements has a positive and significant impact on the extensive trade margin [13, 26]. Likewise, the language variable is conducive to the intensive margin of trade [45, 48]. The presence of a common language facilitates easy communication between nations and reduces the costs of trade.

Additionally, **Table 9** represents the PPML results of the impact of variables on the intensive and extensive trade margins. The PPML results indicate that relative economic freedom, distance, relative crop production, relative purchasing power, trade agreements and common language significantly affect India's export of extensive and intensive margins. The variable relative economic size is negative for both margins. The coefficient of the population yielded positive and significant results for the intensive margin [26]. The relative agriculture value added has a negative impact on the extensive margin of trade [13]. The relative economic freedom variable has a significant impact on both the margins. Similarly, distance has significant undesirable impacts on both trade margins [12, 45, 47, 48]. The relative crop production, relative purchasing power and trade agreement have a significant impact on both trade margins [12, 26, 45, 48]. The coefficient of the language variable is significant and conducive to the intensive margin of trade. The statistically significant impact of distance, trade agreement, and common language in both models suggests that when trading partners are in closer proximity, share a trade agreement, or have a common language, they are more likely to engage in greater trade compared to countries without close distance, trade agreements or a common language.

When the gravity model is estimated using the FGLS and PPML approaches, it was found that the PPML results for intensive and extensive margins are not consistent and in agreement with the FGLS model. The PPML model has a significantly greater magnitude of coefficients of the independent variables than the FGLS model indicating that the PPML model explains more variation in trade margins compared to FGLS. The variables of relative economic freedom, distance, relative crop production, relative purchasing power, trade agreements and common language are significant in both estimation models. However, under the FGLS model, the relative agriculture value added, relative economic free-

Table 9. FGLS and PPML results for the intensive and extensive margins of India's agricultural exports.

	FGLS		PPML	
Explanatory Variables	**Intensive Margin**	**Extensive Margin**	**Intensive Margin**	**Extensive Margin**
Relative economic size	−0.001 (0.423)	−0.005 (0.000)***	−0.043 (0.132)	−0.004 (0.151)
Population	0.001 (0.464)	0.001 (0.536)	0.023 (0.072)*	0.001 (0.632)
Relative agriculture value added	0.112 (0.000)***	−0.016 (0.092)*	0.152 (0.338)	−0.008 (0.410)
Economic freedom	0.040 (0.000)***	0.038 (0.000)***	0.242 (0.000)***	0.082 (0.000)***
Ln_Distance	−0.059 (0.000)***	−0.023 (0.001)***	−1.588 (0.000)***	−0.273 (0.000)***
Relative crop production	0.007 (0.308)	−0.011 (0.026)**	0.787 (0.074)*	−0.115 (0.042)**
Relative purchasing power	−0.014 (0.049)**	0.522 (0.000)***	0.458 (0.000)***	0.537 (0.000)***
D1_Trade agreement	−0.009 (0.278)	0.0176 (0.016)**	0.421 (0.000)***	0.0147 (0.025)**
D2_Common language	0.064 (0.000)***	0.003 (0.561)	0.724 (0.000)***	0.007 (0.228)
Constant	0.453 (0.000)***	1.051 (0.000)***	8.148 (0.000)***	0.376 (0.510)
$\chi 2$ (9)	741.22	353.94	12.17	3.156
Number of observations	600	600	600	600
Log-likelihood	692.74	911.47	−86.94	−579.75

Notes: *, **, and *** signify significance levels of 10%, 5%, and 1%, respectively.

dom, distance, and relative purchasing power are significant for both margins but under the PPML model, relative agriculture value added is insignificant for both margins, relative crop production is significant for both margins, trade agreements are significant for both margins, and common language is significant for the intensive margin.

All the variables are significant at least 10% in either one of the two margins in either one of the two models. The gravity model of trade flows is divided into intensive and extensive trade margins. Bilateral export growth can be maintained at a steady level by making necessary structural adjustments to promote India's exports.

7. Conclusions and Policy Recommendations

The objective of the paper is to identify the margins and factors influencing India's agricultural export margins through panel data analysis. The findings indicate that the extensive margins are more dominant than the intensive margins over the thirty year period. Growth in exports at extensive margins is relatively high for all product types and countries as compared to intensive margins. Also, the results indicate that the variables of relative economic magnitude, relative economic freedom, distance, relative crop production, relative agriculture value added, relative purchasing power, trade agreements and common language significantly affect India's extensive and intensive export margins.

India's export success will be driven by growth in the volume of varied kinds of products in the agricultural sector. Actions can be taken to transform the extensive trade margin progression into the intensive trade margin progression and encourage sustainable advancements in India's agricultural segment. Firstly, product innovation can be encouraged by providing financial support for research and innovation of agricultural products.

Secondly, bilateral trade can be promoted by reducing transaction costs by establishing a free trade area, which will help countries gain market access, promote regionalism, reduce transaction costs, and enhance effective regionalism. Thirdly, companies that export agricultural products should consider new technologies and innovations while creating an export plan.

India's exports to conventional markets will expose it to external shocks, affecting its financial stability and economic activity. India should continue to diversify its export product basket to new markets, as focusing on a small number of goods or locations would guarantee long-term development in the country's trade and economy. It is possible to identify efficient investment and agricultural strategies that will optimise competitive advantage and encourage export diversification. Indian companies may sell to various markets by utilising export promotion organisations. Other methods that may be employed include providing financial services at cheaper rates, especially for novice exporters, streamlining customs processes, offering export incentives and increasing product standards. Maintaining intensive margin growth is crucial for developing countries' sustainable export growth, and the government should support export promotion activities by working to maximise high-quality chains in current export partners. The focus should be on the enduring sustainability of export expansion along with current products and breaking into new markets.

For agricultural exports to become more integrated and competitive worldwide, a balanced, well-coordinated and strategic approach will be necessary to balance both trade margins[49]. The intensive margin approach includes improving productivity through better farming techniques and technology[50], enhancing quality control to meet international standards[51], reducing production costs to increase competitiveness[52], streamlining supply chains and logistics[53] and investing in post-harvest infrastructure to reduce losses[54]. The extensive margin approach includes identifying and developing new high-value crops suitable for export[55]; exploring untapped markets, especially in Africa and Southeast Asia[56, 57]; diversifying product offerings, e.g., processed foods, organic products[58]; negotiating favourable trade agreements with potential new partners[59] and promoting Indian agricultural products in new markets[60]. India must take into account several factors in order to increase agricultural exports, including the growing demand for food products worldwide, the size of its agricultural sector with its diverse agro-climatic zones, the need to create jobs and income in rural areas, the country's reputation for certain products (like rice and spices), and the difficulties in meeting international quality standards[61]. Using a mixed strategy in light of these factors will best serve a large agricultural economy like India. To diversify its export portfolio, India shall concentrate on increasing the number of its robust products in existing markets while concurrently looking into new markets and product categories.

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References

[1] FAO, 2010a. Agricultural trade, trade policies and the global food system. FAO Agricultural Trade and Policy Series, Report No. 2010/1, June 2010. Available from: https://www.fao.org/4/y4252e/y4252e11.html

[2] DGCI, 2020. Foreign trade of India. Report No. 2020/12, December 2020. Available from: https://www.dgciskol.gov.in/foreign_trade_statistics.aspx

[3] Chand, R., Singh, J., 2023. From Green Revolution to Amrit Kaal lessons and way forward for Indian agriculture. NITI. WP 02/2023. DOI: https://doi.org/10.13140/RG.2.2.24291.12320

[4] IMF, 2024. World economic outlook: The global economy in a sticky spot. IMF World Economic Outlook Report No. 2024/1, April 2024.

[5] Bhatia, J., Mehta V.P., Bhardwaj, N., et al., 2021. Export-import performance of major agricultural commodities in India. Economic Affairs. 66. 117–126. Available from: https://www.researchgate.net/publication/351605501_ExportImport_Performance_of_Major_Agricultural_Commodities_in_India

[6] Melitz, M., 2003. The impact of trade on intra-industry reallocations and aggregate industry productivity. Econometrica. 71(6), 1695–1725. DOI: https://doi.org/10.1111/1468-0262.00467

[7] Kumar, K.N.R., 2022. Competitiveness of Indian Agricultural Exports: A Constant Market Share Analysis. Research on World Agricultural Economy. 3(2), 514. DOI: http://dx.doi.org/10.36956/rwae.v3i2.514

[8] United Nations, 2021. UN Comtrade database. New York: United Nations Commodity Trade Statistics Database. Available from: https://comtrade.un.org/

[9] WTO, 2020. World trade statistical review 2020. WTO Report No. 2020/1, October 2020. Available from: https://www.wto-ilibrary.org/content/series/25186981

[10] Besedes, T., Prusa , T., 2010. The role of extensive and intensive margins and export growth. Journal of Development Economics. 96(2), 371–379. DOI: https://doi.org/10.1016/j.jdeveco.2010.08.013

[11] Hummels, D., Klenow, P., 2005. The variety and quality of a nations exports. American Economic Review. 95(3), 704–723. DOI: https://doi.org/10.1257/0002828054201396

[12] Liapis, P., 2009. Extensive Margins in Agriculture. OECD Food, Agriculture and Fisheries Papers. WP no. 17, 01 April 2009. DOI: https://doi.org/10.1787/224422031753

[13] Pacheco, A.A, Pierola, M., 2008. Patterns of export diversification in developing countries: Intensive and extensive margins. DOI: https://doi.org/10.1596/1813-9450-4473

[14] Armington, P.S., 1969. A theory of demand for products distinguishes by place of production. IMF Staff Papers. 16(1), 159–178. DOI: https://doi.org/10.2307/3866403

[15] Krugman, P., 1981. Intra industry specialization and gains from trade. Journal of Political Economy. 89(5), 959–973. Available from: https://www.journals.uchicago.edu/doi/abs/10.1086/261015

[16] Helpman, E., Melitz, M., Rubinstein, Y., 2008. Estimating trade flows: Trading partners and trading volumes. The Quarterly Journal of Economics. 123(2), 441–487. DOI: https://doi.org/10.1162/qjec.2008.123.2.441

[17] Cadot, O., Carrere, C., Strauss, K., 2011. Export diversification: What's behind the hump?. The Review of Economics and Statistics. 93(2), 590–605. DOI: https://doi.org/10.1162/REST_a_00078

[18] Feenstra, R., Kee, H., 2007. Trade liberalization and export variety: A comparison of Mexico and China. The World Economy. 30(1), 5–21. DOI: https://doi.org/10.1111/j.1467-9701.2007.00869.x

[19] Kehoe, T., Ruhl , K., 2013. How important is the new goods margin in international trade?. Journal of Political Economy. 121(2), 358–392. Available from: https://www.journals.uchicago.edu/doi/abs/10.1086/670272

[20] Corsetti, G., Martin, P., Pesenti, P., 2007. Productivity, terms of trade and the home market effect. Journal of International Economics. 73, 99–127. DOI: https://doi.org/10.1016/j.jinteco.2006.08.005

[21] Galstyan, V., Lane, P., 2008. External imbalances and the extensive margin of trade. Economic Notes. 37(3), 241–257. DOI: https://doi.org/10.1111/j.1468-0300.2008.00200.x

[22] Evenett, S., Venables, J., Anthony, J., 2002. Export growth in developing countries: Market entry and bilateral trade flows. WP No. 2908, 10 June 2022. Available from: https://www.researchgate.net/publication/36386198

[23] Felbermayr, G., Kohler, W., 2006. Exploring the intensive and extensive margins of world trade. Review of World Economics. 142(4), 642–674. DOI: https://doi.org/10.1007/s10290-006-0087-3

[24] Eaton, J., Eslava, M., Kugler, M., et al., 2007. The margins of entry into export markets: Evidence from Colombia. Proceedings of the Globalization and the Organization of Firms and Markets; February 10–11, 2007; Munich, Germany. Available from: https://www.researchgate.net/publication/238494191_The_Margins_of_Entry_into_Export_Markets_Evidence_from_Colombia

[25] Amiti, M., Freund, C., 2010. The anatomy of

China's export growth. China's growing role in world trade. University of Chicago Printing Press: Chicago, IL, USA. pp. 35–62. Available from: https://ssrn.com/abstract=1149131

[26] Veeramani, C., Aerath, L., Gupta, P., 2018. Intensive and extensive margins of exports: What can India learn from China?. The World Economy. 41(5), 1196–1222. DOI: https://doi.org/10.1111/twec.12592

[27] Kancs, A., 2007. Trade growth in a heterogeneous firm model: Evidence from South-Eastern Europe. The World Economy. 30(7), 1139–1169. DOI: https://doi.org/10.1111/j.1467-9701.2007.01035.x

[28] Anderson, M., 2007. Entry costs and adjustments on the extensive margin in export growth: An analysis of how familiarity breeds exports. WP No. 81. Available from: https://RePEc:hhs:cesisp:008

[29] Chaney, T., 2008. Distorted gravity: The intensive and extensive margins of international trade. American Economic Review. 98(4), 1707–1721. DOI: https://doi.org/10.1257/aer.98.4.1707

[30] Evenett, S., Venables, J., 2002. Export growth in developing countries: Market entry and bilateral trade. World Bank Policy Research WP No. 2908. Available from: https://www.researchgate.net/publication/36386198

[31] Zahler, A., 2007. Decomposing world export growth and the relevance of new destinations. World Bank Policy Research. WP No. 4151. Available from: https://www.hks.harvard.edu/centers/cid/publications/fellow-graduate-student-working-papers

[32] Rahmouni, O., 2020. The impact of the geographical diversification of Saudi Exports: An intensive and extensive margin approach. Asian Economic and Financial Review. 10(6), 713–728. DOI: https://doi.org/10.18488/JOURNAL.AEFR.2020.1010.1077.1087

[33] Zhang, X., Zhou Y., Geng X., et al., 2017. The intensive and extensive margins of China's agricultural trade. Canadian Journal of Agricultural Economics. 65(3), 431–451. DOI: https://doi.org/10.1111/cjag.12122

[34] Ekrem, E., Saban, N., 2008. Gravity model of Turkish agricultural exports to the European Union. International Trade and Finance Association, International Trade and Finance Association Conference Papers. WP no. 21. Available from: https://www.researchgate.net/publication/46468975_Gravity_Model_of_Turkish_Agricultural_Exports_to_the_European_Union

[35] Singh, N., 2011. Indian agriculture: Before and after economic reforms. European Journal of Business and Management. 3(4), 292–298. Available from: https://www.researchgate.net/publication/343306960_Indian_Agriculture_Before_and_After_Economic_Reforms

[36] Sahni, P., 2014. Trends in India's exports: A comparative study of pre and post reform period. IOSR Journal of Economics and Finance (IOSRJEF). 3(2), 5925. Available from: https://www.researchgate.net/publication/314369831_Trends_In_India's_Exports_A_Comparative_Study_Of_Pre_And_Post_Reform_Period

[37] Kumar, R., Singh, U., 2023. Performance of India's foreign trade since 2015. 11, i18–i27. Available from: https://www.researchgate.net/publication/378479918_PERFORMANCE_OF_INDIA'S_FOREIGN_TRADE_SINCE_2015

[38] Dalmia A., Sharma, V., Rajgaria, S., et al., 2019. A case study on privatization of agriculture in the states of Odisha and Chhattisgarh. JETIR. 6(3), 543–556. Available from: https://www.jetir.org/papers/JETIR1903890.pdf

[39] Rehman, S., 2012. Privatization in Indian agriculture—An overview. SSRN Electronic Journal. DOI: https://doi.org/10.2139/ssrn.2387278

[40] Prahadeeswaran, M., Balaji, R., Senthilnathan, S., et al., 2022. Trends in export of major agricultural commodities and products from India. Asian Journal of Agricultural Extension, Economics and Sociology. 40(9), 367–373. DOI: https://doi.org/10.9734/ajaees/2022/v40i931016

[41] Kanaka, S., Chinadurai, M., 2012. A study of comparative advantage of Indian agricultural exports. Journal of Management Science. 2(1), 56–70. DOI: https://doi.org/10.26524/JMS.2012.19

[42] Varma, P., 2012. An analysis of India's bilateral intra-industry trade in agricultural products. International Journal of Economics and Business Research. 4(1–2), 83–95. DOI: https://doi.org/10.1504/IJEBR.2012.044246

[43] Saghir, A., Khan, W., 2015. India's agricultural trade potential in post-WTO period. Agricultural Economics Research Review. 28, 93–100. DOI: https://doi.org/10.5958/0974-0279.2015.00025.7

[44] Bansal, R., 2021. WTO and India's agricultural trade potential. Turkish Journal of Computer and Mathematics Education (TURCOMAT). 12(5), 1934–1942. DOI: https://doi.org/10.17762/TURCOMAT.V12I5.2274

[45] Elumalai, K., Kumar, A., 2022. Intensive and extensive margins of India's agricultural trade: Implications for export diversification and development. Journal of Agribusiness in Developing and Emerging Economies. 12(4), 489–504. DOI: https://doi.org/10.1108/JADEE-04-2023-0095

[46] Tinbergen, J., 1966. Shaping the world economy: Suggestions for an international economic policy. Economic Journal. 76(301), 92–95. DOI:

https://doi.org/10.1002/tie.5060050113

[47] Lawless, M., 2010. Deconstructing gravity: Trade costs and extensive and intensive margins. Canadian Journal of Economics. 43(4), 1149–1172. DOI: https://doi.org/10.1111/j.1540-5982.2010.01609.x

[48] Ngugi, T.W., 2015. Extensive and intensive margins: An analysis of Kenyan exports [Unpublished undergraduate project]. Nairobi, Kenya: Strathmore University. Available from: https://su-plus.strathmore.edu/handle/11071/5034

[49] Veeramani, C., Saini, G., 2011. Impact of ASEAN-India preferential trade Agreement on plantation commodities: A simulation analysis. Economic and Political Weekly. 46(10), 83–92. Available from: https://www.epw.in/journal/2011/10/special-articles/impact-asean-india-preferential-trade-agreement-plantation

[50] Birthal, P., Roy, D., Negi, D., 2015. Assessing the impact of crop diversification on farm poverty in India. World Development, Elsevier. 72(C), 70–92. DOI: https://doi.org/10.1016/j.worlddev.2015.02.015

[51] Jaffee, S., Henson, S., 2004. Standards and agro-food exports from developing countries: Rebalancing the debate. World Bank Policy Research. WP no. 3348, June 2004. Available from: https://www.researchgate.net/publication/23722950_Standards_and_Agro-Food_Exports_from_Developing_Countries_Rebalancing_the_Debate

[52] Narayan, S., Bhattacharya, P., 2019. Relative export competitiveness of agricultural commodities and its determinants: Some evidence from India. World Development, Elsevier. 117(C), 29–47. DOI: https://doi.org/10.1016/j.worlddev.2018.12.013

[53] Reardon, T., Minten, B., 2011. Surprised by supermarkets: Diffusion of modern food retail in India. Journal of Agribusiness in Developing and Emerging Economies. 1(2), 134–161. Available from: https://www.researchgate.net/publication/235272245_Surprised_by_supermarkets_Diffusion_of_modern_food_retail_in_India

[54] Kumar, D., Kalita, P., 2017. Reducing post harvest losses during storage of grain crops to strengthen food security in developing countries. Foods. 6(1), 8. DOI: https://doi.org/10.3390/foods6010008

[55] Kumar, S., Gupta, S., 2015. Crop Diversification towards High-value Crops in India: A State Level Empirical Analysis. Agricultural Economics Research Review. 28, 339. DOI: https://doi.org/10.5958/0974-0279.2016.00012.4

[56] Roy, D., Thorat, A., 2008. Success in high value horticultural export markets for the small farmers: The case of Mahagrapes in India. World Development. 36(10), 1874–1890. Available from: https://www.researchgate.net/publication/23691157_Success_in_High_Value_Horticultural_Export_Markets_for_the_Small_Farmers_The_Case_of_Mahagrapes_in_India

[57] Renjini, V., Kar, A., Jha, G., et al., 2017. Agricultural trade potential between India and ASEAN: An application of gravity model. Agricultural Economics Research Review. 30, 105. DOI: https://doi.org/10.5958/0974-0279.2017.00009.X

[58] Eyhorn, F., Ramakrishnan, M., Mäder, P., 2007. The viability of cotton-based organic farming systems in India. International Journal of Agricultural Sustainability. 5(1), 25–38. Available from: https://www.researchgate.net/publication/28684817_The_viability_of_cotton-based_organic_farming_systems_in_India

[59] Gulati, A., Pursell, G., 2008. Trade policies and Indian agriculture. Economic and Political Weekly. 43(52), 72–79.

[60] Mehta, R., 2009. India's agricultural trade: Trends and prospects. Indian Journal of Agricultural Economics. 64(3), 417–435.

[61] Kumar, A., Sharma, P., 2013. Impact of climate variation on agricultural productivity and food security in rural India. Economics Discussion Papers. Paper no. 43. Available from: https://ideas.repec.org/p/zbw/ifwedp/201343.html