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Factors Influencing Export of Soya Bean Oil from India: A Panel Gravity Model Analysis

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Soya bean, the 'miracle bean', belongs to the family Leguminoceae, subfamily Papilionoidea. Soya bean oil is one of the most widely consumed cooking oils and is rich in linolenic acid. In the past 20 years the export of soya bean oil from India was mainly focused on Bhutan, Jordan, Canada, Singapore and Myanmar. The data was collected from 2002-03 to2021-22. The sources of data were Food and Agriculture Organization Statistics (FAOSTAT), Directorate General of Commercial Intelligence and Statistics (DGCIS), International Monetary Fund (IMF), Statista and Trade map. The panel data was estimated by the Feasible Generalized Least Squares (FGLS) method. For soya bean oil the per capita GDP of India's trading partners, distance, trade openness, and exchange rates are the most significant factors affecting bilateral trade. While partner countries'

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prosperity and liberal trade policies boost trade, greater distances and unfavorable exchange rates hinder it. India's GDP and domestic inflation show minimal impact on trade flows. Wooldridge test indicated no first-order auto-correlation.

Keywords: Soya bean oil; India; factors influencing; exports; gravity model; FGLS.

1. INTRODUCTION

"The soya bean (*Glycine max. L.)* the 'miracle bean', is reported to be originated from China. In India, soya bean was introduced from China in the tenth century AD through the Himalayan routes. Soya bean has been traditionally grown on a small scale in Himachal Pradesh, the Kumaon Hills of Uttar Pradesh (now Uttaranchal), eastern Bengal, the Khasi Hills, Manipur, the Naga Hills, and parts of central India covering Madhya Pradesh. Soya bean has a dual character as oilseeds and pulses but basically legume and comes under oilseed crop. It belongs to the family Leguminoceae, subfamily Papilionoidea. Soya bean has emerged as the golden bean of the 21st century and it is largely used as oilseed. Soya bean is the fastest growing crop in India which replaced crops like maize, cotton, and pulses. Soya bean is the cheapest source of high-quality protein. It is valued for its high (38-45 per cent) protein content as well as its high (approximately 20 per cent) oil content. The major soya bean growing states are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka and Telangana" (Parmar and Devi, 2021). This "king of beans" is mostly crushed into soy oil and meal and is found in hundreds of edible and non-edible products, ranging from cooking oil, animal grains, vegan food, and milk to biodiesel and other industrial applications. Soya bean oil is a vegetable oil extracted from the soya bean seeds (*glycine max*). "It is one of the most widely consumed cooking oils and is rich in linolenic acid. Soya bean oil contains 7–10 per cent palmitic acid, 2–5 per cent stearic acid, 1–3 per cent arachidic acid, 22–30 per cent oleic acid, 50–60 per cent linoleic acid, and 5–9 per cent linolenic acid" (Anon, 2024a).

The contribution of soya bean in the growth of area (16.32%) and production (17.91%) has been phenomenal, as compared to the rest of the oilseed crops, indicating that the crop has played a key role in increased production of oilseeds and in meeting the edible oil requirements in the country. The soya bean started contributing to total oilseeds production from 1970 onwards. By 1985-86, when the Technology Mission was launched to promote oilseeds production reached more than double (22.11 million tons over that of 1985-86). "Currently, total oilseeds production has reached 27.8 million tons. Soya bean contributes 35 per cent and 25 per cent respectively to the total oilseeds and edible oil produced in the country. The contribution of soya beans is estimated to reach 40 per cent by 2025 as per the projections made based on the growth rates over the past period" (Anon, 2024b).

2. SOYA BEAN PRODUCTION

"In the world, Brazil ranks first in soya bean production with 121.80 million tonnes followed by the United States of America (112.55 million tonnes), Argentina (48.80 million tonnes), China (19.60 million tonnes) and India (11.23 million tonnes) accounting for 34, 32, 14, 6 and 3 percent of world production. India ranks fourth in area with 12.12 million hectares (29.94 million acres) accounting for 8.86 per cent of the world area and fifth in production with 11.23 million tonnes in 2020-21" (Anon, 2024c).

Table 1. Area and production of soya bean in major producing states

State	2017-18		2018-19		2019-20		2020-21	
	Area	Production	Area	Production	Area	Production	Area	Production
Madhya Pradesh	5.0	5.32	5.42	6.67	6.19	4.89	6.50	4.61
Maharashtra	3.69	3.80	4.08	4.61	4.12	4.83	4.36	6.20
Rajasthan	0.89	1.07	0.93	1.17	1.12	0.52	1.13	1.09
Telangana	0.15	0.25	0.15	0.23	0.17	0.31	0.16	0.24
Karnataka	0.28	0.25	0.25	0.26	0.32	0.38	0.31	0.38
Chattisgarh	0.10	0.05	0.09	0.07	0.07	0.08	0.07	0.05
Others	0.21	0.19	0.21	0.26	0.2	0.22	0.28	0.33
India	10.30	10.93	11.23	13.27	12.19	11.23	12.90	12.90

(Area in million hectares and Production in million tonnes)

Source: Anon, 2024e

In India Madhya Pradesh, Maharashtra and Rajasthan states together contribute to about 93 per cent of the area and production of soya bean. However, the cultivation of soya beans is fast expanding in the states of Telangana, Karnataka and Gujarat. Madhya Pradesh is a leading producer of soya beans with about 54 per cent of the country's total soya bean production, hence known as 'Soy State' (Anon, 2024d).

In 2022, India exported $29M of Soya bean oil, making it the 42nd largest exporter of soya bean oil in the world. In the same year, soya bean oil was the 676th most exported product in India.

3. METHODOLOGY

Renjini et al., (2017) analysed "the potential of agricultural trade between India and ASEAN members for the period 1995-2014. The gravity model has been employed to find the overall agricultural trade potential between India and ASEAN countries. The model estimates have indicated that partners' income and free trade agreement are positively influencing the bilateral trade. The border trade had found no significance in the bilateral trade pointing weak infrastructure at Indo-Myanmar border. Trade potential estimates had shown that India had exceeded the trade potential with Cambodia, Indonesia, Malaysia, Myanmar and Vietnam while there is an opportunity to harness the trade potential with Brunei, Lao, Philippines, Singapore, and Thailand".

Baker and Yuya, (2020) examined "the determinant factors of Ethiopia's sesame exports performance, in the aspect of export trade, by the use of a more realistic model approach, a panel gravity model. It used short panel data that cover 11 countries of consistent Ethiopia's sesame importers for the period of 13 years from 2002 to 2014. The random effect model results suggested that real gross domestic product of importing countries; Ethiopian real gross domestic product, real exchange rate and weighted distance are found to be the determinant factors of

Ethiopia's sesame exports performance. The estimated results revealed that as real gross domestic product of importing countries increase by 1 per cent, the flows of Ethiopia's sesame exports performance increase by 1.63 per cent".

Ismaiel et al., (2023) studied "the determinants and potential of Egyptian rice trade using the gravity model approach with 11 rice importing countries. The Egyptian GDP variable had a negative effect on the total value of Egyptian imports and agriculture by increasing the value of total exports, agricultural exports, and rice exports to Egypt. Egyptian imports, exports, and population growth were all hurt by the Egyptian population variable. The study also shows that a 1 per cent increase in export prices leads to a 3.97 per cent increase in shipments of Egyptian rice to partner countries. The variable distance between capitals has a negative effect on Egyptian exports. Based on the main investigation, the study made several important recommendations, including the need to take several measures to defect the pace of economic growth of both the Egyptian total and agricultural export variables and rice export value, focusing on countries with high monetary and real GDP and a close geographical distribution".

Sundari et al., (2023) "analyzed factors influencing chilli export in Indonesia. The gravity model was used for the analysis and the data was collected from 1990 to 2020. Indonesian chili exports was influenced by Indonesia's real GDP/capita, real GDP/capita of destination countries, rupiah exchange rate against destination countries, and geographical distance. Factors that positively affect the volume of chilli exports were Indonesia's real GDP/ capita and the exchange rate against the destination country. On the other hand, the factors that had a negative effect on the volume of chilli exports were the real GDP/capita of the destination country and geographical distance. The most dominant factor was the exchange rate against the destination country. Efforts to increase exports will be made by increasing the exchange rate (depreciation) so that the price of export goods will be lower and benefit the export destination country. Meanwhile, interest rates and the involvement of destination countries in the WTO do not significantly affect the volume of Indonesian chilli exports".

Islam et al., (2024) studied factors affecting Indian agriculture exports with SAARC economies using the gravity model approach. The data was collected from secondary sources for the period of 32 years from 1990 to 2021. The findings indicated that determinant variables, including GDP, per capita GDP, per capita GDP differential, trade openness, and India's exchange rate, had a positive and statistically significant impact on India's agricultural exports to SAARC countries. Conversely, the exchange rate of SAARC nations and the distance between

India and SAARC member nations negatively affect India's agricultural exports. The findings of the study signified that a higher GDP and per capita GDP in both India and the importing SAARC countries indicated stronger purchasing power and economic activity. This likely leads to increased demand for agricultural products, thereby positively impacting India's agricultural exports to these nations.

3.1 Data Collection

"The present study is based on secondary data collected from year 2002-03 to 2012-22. The sources of data were Food and Agriculture Organization Statistics (FAOSTAT), Directorate General of Commercial Intelligence and Statistics (DGCIS), International Monetary Fund (IMF), Statista and Trade map. From 2002-03 to 2021-22, India's major export destinations for soya bean oil were Bhutan, Jordan, Canada, Singapore and Myanmar. To obtain consistent and efficient estimators, the panel data was estimated by the Feasible Generalized Least Squares (FGLS) method. The assumption behind FGLS is that all aspects of the model are completely specified; here that includes that the disturbances have different variances for each panel and are constant within the panel. The advantage of FGLS estimation is that it can handle both heteroscedasticity and serial correlation" (Akhter and Ghani, 2010; Mulenga, 2012). "The FGLS is the most appropriate model if the exact form of heteroscedasticity in the data is ignored since it weighs the observations according to the square root of their variances and is robust to any form of heteroscedasticity" (Zarzoso et al*.,* 2007).

3.2 Analytical Framework Gravity Model

The factors influencing soya bean oil export were determined using the trade gravity model. The trade gravity model was the econometric model based on the idea that overall trade volumes between the two nations depend on the size of the two nations and the distance they are apart. The gravity model was first developed following the physics gravity model derived by Newton in 1687 (Newton, 1687) and was then used by economists in the 1960s to analyze international trade flows, such as, Linder (1961), Tinbergen (1962) and Linneman, (1966).

Thus, it is postulated that the trade flow between the two countries is directly proportional to the two country's income and inversely proportional to the distance between them. The basic form of the gravity model is given by Equation

$$\mathbf{X_{ij}=K\frac{Y_i^{\beta 1}Y_j^{\beta 2}}{D_{ij}^{\beta 3}}}$$

Where
Xij= the value of exports between countries i and j,
Yi = economic growth of country i,
Yj= economic growth of countries j,
Dij=denotes the geographical distance between county i and countries j, K = constant proportionality and β's are response parameters
For sake of simplicity, equation was often transformed into linear form by using natural logarithm so that it confirmed to the usual regression analysis

$$\mathbf{ln\ Xij=} \beta\mathbf{0+}\ \beta\mathbf{1\ lnY1} + \beta\mathbf{2lnY2} + \beta\mathbf{3lnY3}$$

Where
β's are the coefficients estimated.
Finally, with regard to the gravity model of India's export of soya bean oil, the following model was used:

$$\mathbf{lnXijt} = \beta\mathbf{0} + \beta\mathbf{1\ ln\ GDPit} + \beta\mathbf{2\ ln\ GDPjt} + \beta\mathbf{3\ ln\ POPit} + \beta\mathbf{4\ ln\ POPjt} + \beta\mathbf{5\ ln\ RERijt} + \beta\mathbf{6\ ln\ INFit} + \beta\mathbf{7\ ln\ DISijt} + \alpha\mathbf{i} + \varepsilon\mathbf{ijt}$$

Where ,
Xijt= India's soya bean oil export at time t,
GDPit= real GDP of the exporting country (India) at time t, GDPjt= real GDP of the importing country at time t, POPit= population of exporting country at time t,
POPjt= population of importing country at time t,
RERijt= real exchange rate between countries i and j at time t,
INFit= domestic inflation of exporting country at time t and
DIS_{ijt}= time-invariant physical distance between the economic center of exporting and importing country.

The GDP represents the market size and purchasing power of the trading partners which postulates that the countries are expected to trade more with the increase in their economic size. The distance variable indicates not only higher transportation costs, but also is correlated with larger cultural differences, which can retard the transfer of information and establishment of trust. Therefore, the distance variable is negatively correlated with the bilateral trade.

Table 2. Estimates of the gravity model of Indian soya bean oil

VARIABLES	COEFFICIENT	SE	Z	P>Z
Constant	10.113	6.110	1.660	0.098
India GDP	-0.401	2.441	-0.160	0.870
Per capita GDP of India	6.299	33.546	0.190	0.851
Per capita GDP of partners	1.166*	0.664	1.760	0.079
Distance between India and partners	-1.048*	0.555	-1.890	0.059
Trade openness of partners	0.238*	0.132	1.810	0.071
Domestic Inflation	0.308	0.343	0.900	0.369
Exchange rate between India and partners	-1.109***	0.282	-3.930	0.000

*Note: 1. *, ** and ***indicate significance at 10%, 5% and 1% respectively.*
2. Wald $chi^2(6)$ = 61.86; Prob > chi^2 = 0.000; Log likelihood = -224.7728

4. RESULTS AND DISCUSSION

The results of the Feasible Generalised Least Square method (FGLS) examined the relationship between various predictors and an unspecified dependent variable. The trade between the countries during the past 20 years might be influenced by many factors that can be assessed by the gravity model (Table 2).

The variable India's GDP showed a negative but non-significant effect (-0.401, p = 0.870), indicating that changes in India's GDP may not substantially impact trade flows. Similarly, the per capita GDP of India was positive but insignificant (6.299, p = 0.851), while the per capita GDP of trading partners had a positive and marginally significant effect (1.166, p = 0.079), suggesting that higher economic prosperity in partner countries encourages more trade.

The variable distance was observed to be negative and significant, which shows that trade will decrease by 1.048 per cent with increase in bilateral distance which is in accordance with Renjini et al (2017). Trade openness of partners positively influenced trade (0.238, p = 0.071), suggesting that more liberal trade policies in partner countries foster increased bilateral trade. Domestic inflation had a positive but non-significant effect (0.308, p = 0.369), while the exchange rate showed a highly significant negative effect on trade (-1.109, p = 0.000), indicating that unfavorable exchange rates reduced trade flows between India and its partners. Overall, the analysis revealed that partner country prosperity, distance, trade openness, and exchange rates played critical roles in India's bilateral trade, while factors like India's GDP and inflation had less influence.

However, in the results, the Wooldridge test for autocorrelation was observed. As observed Table 3, showed that the estimation failed to reject the null hypothesis and concluded that the data did not have first-order autocorrelation.

Table 3. Autocorrelation Lagrangian Multiplier (LM) Test

Wooldridge test for autocorrelation	
H0: No first-order correlation	
Test statistic: F(1,4)	6.383
Prob > F	0.1649

5. CONCLUSION

The study concluded that partner countries' economic prosperity and trade openness positively impact exports, while greater bilateral distance and unfavorable exchange rates significantly reduce trade flows. In contrast, India's GDP and inflation have limited impact on export performance, emphasizing the importance of external market conditions in shaping bilateral trade.

6. SUGGESTIONS

India should invest in trade infrastructure to reduce transportation costs and address the challenges posed by distance, especially in markets like Canada. Hedging against unfavorable exchange rates, along with negotiating free trade agreements (FTAs) or preferential trade agreements (PTAs), will further enhance market access. Finally, focusing on branding Indian soya bean oil as a premium, health-focused product across all markets, supported by strong marketing campaigns, can significantly boost export performance.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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