Stochastic Frontier Analysis of India's Trade Relations with ASEAN and MERCOSUR

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Abstract

This project seeks to analyse India's trade relations with the Association of Southeast Asian Nations (ASEAN) and MERCOSUR, as well as the various policies that have emerged in recent years and how they have created new trade opportunities among the member countries or diverted trade to other members. This would provide a detailed overview of the evolution of trade patterns and analyse their different ramifications. To achieve this, we will use the stochastic frontier gravity model discussed by Ebaidalla M. Ebaidalla & Mohammed Elhaj Mustafa Ali (2023), on trade data regarding India's trade relations with the aforementioned trade blocs.

Keywords: trade, stochastic frontier gravity model, ASEAN, panel

Contents

1. Objective

Whether the formation of trading blocs like the Association of Southeast Asian Nation (ASEAN), MERCOSUR, etc has a significant impact on the trade between countries is a point of contention. There have been research papers which have derived both positive and negative inferences for trade accounting from these trading blocs. Another thing which must be studied more carefully is the hidden factors that might affect trade integration. To understand these impacts, we need to understand Trade Creation and Trade Diversion -

Trade Creation - It occurs when a member country imports a product from another member country that it previously produced for its own consumption. It offers the more efficient producer the chance to furnish the items and, in all situations, increases national welfare.

Trade Diversion - It is an occurrence that occurs when a member country imports a product from another member country that it previously imported from a non-member country. On the other side, trade diversion refers to the fact that trade might be redirected to a less efficient economy as a result of FTAs. In addition, the effect of the diversion is uncertain and frequently welfare-reducing.

India has been an active member in world trade ever since it's economic liberalization in 1991. Ever since, India has signed a number of FTA's including the MERCOSUR-India PTA, 2003 and the ASEAN-India FTA, 2010.

ASEAN-India FTA - This free trade agreement is between Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam and India. India signed a free trade agreement with these nations, which went into effect on January 1, 2010.

MERCOSUR-India PTA - This preferential trade agreement connects India to MERCOSUR, a South American commercial group comprised of Argentina, Brazil, Paraguay, and Venezuela. This agreement went into force on June 1, 2009.

2. Literature Review

In recent years, there has been a resurgence of interest in employing gravity models to estimate the determinants of trade flows, particularly in the setting of regional trade blocs. Due to the growing number of trade agreements and the availability of high-quality trade data for both developed and developing countries, several empirical studies analysing trade agreements are also accessible. The works by Tinbergen (1962) and Poyhonen (1963) deal with extremely early versions of the gravity model. First attempt to provide a theoretical comprehension

of the gravity model was made by Anderson (1979). Overall, these research fall into two categories: those that utilised the traditional gravity model and those that utilised the stochastic frontier gravity model. About the first category, there are a significant number of studies that use the conventional approach to evaluate the trade performance of various nations and areas (e.g., Anderson (1979); Kalirajan (2000); Nilsson; and Ebaidalla and Yahia (2014)). Pastore, Ferragina, and Giovannetti (2009), for instance, analysed the trade performance of European Union (EU) members with Mediterranean (MED) nations and new EU members using a two-stage gravity model of intra-EU trade including 13 members from 1995 to 2002. Using an out-of-sample method, they discovered that both categories of partners have huge untapped trade potential, but the ratio of potential to actual trade with MED nations was far greater, more scattered, and more steady than that with new EU members. In recent decades, a second stream of empirical investigations based on the stochastic frontier gravity model (SFGM) has arisen. A group of researchers, including Ravishankar and Stack (2014), Bhattacharya and Das (2014), Stack and Pentecost (2011), and Tamini, Chebbi, and Abdassi, adopted a modified version of the SFGM in which only the intercept term varies after Kalirajan (1999) introduced the first edition of the SFGM with varying coefficients (2016). Numerous papers have been published analyzing the welfare impacts of Trade Agreements. In this paper, I will try to analyze the impact on India's trade, including the factor of the trade agreements. I will conduct this analysis using the stochastic frontier gravity model developed by Ebaidalla M. Ebaidalla & Mohammed Elhaj Mustafa Ali (2023). This paper also aims to fill the research gap of analysing the hidden factors that affect trade integration, like 'behind the border' and 'beyond the border' affects.
The gravity model will also include Multilateral Trade Resistance (MTR) as a result of my study. It quantifies the amount to which a nation's commerce with one partner is influenced by its trade with other partners (Anderson and van Wincoop, 2003).

3. Methodology

In this paper, we plan to estimate the impacts of Trade creation and Trade Diversion on different export goods using a modified Gravtiy model. According to the standard gravity model of international commerce, the volume of trade between two nations is proportional to their economic mass and an indicator of their relative trade frictions. The gravity model has been the workhorse model of international trade for more than 50 years, perhaps due to its intuitive appeal. In this generalized model, trade is positively correlated with the economic size and population of the countries and negatively correlated with the distance between the countries involved.

$$F_{ij} = G \cdot \frac{M_i M_j}{D_{ij}} \tag{1}$$

In this formula, G represents a constant, F represents trade flow, D represents distance, and M represents the economic aspects of the countries being measured. Using logarithms, the equation can be transformed into a linear form for econometric studies. Baier and Bergstrand (2007) and Soloaga and Winters (2001) enhance the classic gravity model by introducing a set of dummy variables that capture the effect of trade policies of FTA membership nations. It is important to note that different types of dummy variables have been incorporated into the gravity models to account for unique aspects, such as geographical, cultural, and institutional factors, that can facilitate or impede bilateral flows of goods.
To address the inherent bias of the standard gravity model of trade and to estimate potential trade flows, this study use the stochastic production frontier approach presented by Kalirajan (1999) to overcome the limitations of the conventional gravity model. The SFGM measures the trade frontier as the maximum possible level of trade for a given bilateral trading pair, which is influenced by a random error term that can be positive or negative, allowing the stochastic frontier trade level to fluctuate relative to the deterministic portion of the gravity equation. The stochastic frontier gravity model incorporates the gravity model, the stochastic frontier technique, and a non-negative error factor. In particular, the non-negative error term refers to inefficiencies "behind the border" in the exporting nation that hinder it from reaching its trading frontier. On the other hand, the random word encompasses all other disturbances, including "beyond the border." We can use the gamma coefficient to understand the variation in total trade due to 'behind the border' effects.

$$\gamma = \left[\frac{\sum_t \sigma_{ut}^2}{\sum_t \sigma_{ut}^2 + \sigma_{vt}^2} \right]$$

σ_{ut}^2 is the variance of the one-sided error term at time t, whereas σ_{vt}^2 is the variance of the two-sided error term at time t. After estimating the parameters, the point estimates of technical efficiency can then be measured using Battese and Coelli's (1988) formula:

$$TE[-\mu_{ijt}|\epsilon_{ijt}] = \left[\frac{1 - (\sigma_* - \mu *_{ijt} / \sigma_*)}{1 - (-\mu *_{ijt} / \sigma_*)} \right] exp(-\mu *_{ijt} + \sigma_*^2/2)$$

where $\mu *_{ijt}^2 = \epsilon_{ijt} - \sigma_v^2/\sigma_\mu$ and (.) is the standard normal density function. Estimates of technical efficiency for each country-pair range from zero to one. A TE value of one would suggest that actual and potential trade levels are identical, however values trending towards zero would indicate that there is room to increase real trade levels. We would be analysing the **impact of entering into trade agreements on the trade efficiency**.

The conventional gravity model can be converted to an SFGM variant as follows:

$\text{Trade}_{ijt} = f(GDP_{it}; GDP_{jt}; POPit; POP_{jt}; DIS_{ij}; Z_{ij}; X_{ijt})$
$exp(V_{ijt} - u_{ij})$

$Trade_{ijt}$ is the bilateral trade between two countries i and j over a period of time t; GDP_{it} and GDP_{jt} are the economic sizes of both countries; POP_{it} and POP_{jt} are the populations of countries i and j, respectively; and DIS_{ij} is the distance between two countries. There are two components to the error term: the two-sided (V_{ijt}) and one-sided error terms (u_{ijt}). The two-sided error element (V_{ijt}) represents the influence on trade flows of other variables, such as measurement mistakes and the implicit beyond-the-border constraints that are beyond the control of the exporting country and are randomly distributed throughout the sample data. Whereas the one-sided error term (u_{ijt}) reveals the cumulative effects of "behind the border" restraints on trade and identifies the degree to which actual trade volumes depart from the maximum possible level.
The full gravity model to investigate the determinants of India's trade performance can be stated as follows, based on the available literature and the preceding discussion. I will utilise both time and country fixed effects to add the MTR term.

$$\ln \text{Trade}_{ijt} = \alpha_{ij} + \beta_1 \ln\text{GDP}_{it} + \beta_2 \ln\text{GDP}_{jt} + \beta_3 \ln\text{POP}_{it} + \beta_4 \ln\text{POP}_{jt} + \beta_5 \ln\text{DIS}_{ij} + \beta_6 \ln\text{REX}_{it} + \beta_7 \ln\text{REX}_{jt} + \beta_{10} \ln\text{MR}_{ij} + \text{v}_{ij} - \mu$$

Here, MR_{ij} is the multilateral trade resistance term defined as follows -

$$MR_{ij} = \sum_k \left(\frac{Y_k}{Y}\right)^{\theta} \left(1 + D_{ik}^{\gamma}\right)^{-\alpha} \left(1 + D_{jk}^{\gamma}\right)^{-\beta} \tag{4}$$

where Y_k is the economic size of country k, Y is the total world GDP. θ, α, β are parameters to be estimated. γ is a distance decay parameter.

TA_{ij} is a dummy variable that indicates membership in a trade integration; it has a value of one if both the reporting country and the partner country are members of the same sub-regional trade integration. In addition, a vector of time-varying explanatory factors, such as the actual exchange rate are added to the model. Finally, $v_{ijt} - \mu$ is the error term as previously defined. I will estimate the above model using Maximum Likelihood Estimation technique.

4. Data Sources

Data on trade and exports - Direction of Trade Statistics (DOTS), IMF data
Data on Population - International Financial Statistics Yearbook, IMF
GDP statistics - IMF's World Economic Outlook database
Distance, border data - Centre for Prospective Studies and International Information database.

5. Codes and Methodology

We conducted stochastic frontier gravity analysis for two trading blocs - ASEAN and MERCOSUR. For my analysis, I used the command :

```
sfpanel logY logX1 logX2 logX3 logX4 logX5
logX6 logX7 logX10, model(tfe) dist(tn)
emean(ta_ij) ort(o)
```

Here, **sfpanel** command is used to conduct Stochastic Frontier Analysis on a panel dataset. Then we have **logY** which is the dependent variable which is log of Export from India to country i. Then we have the independent variables **logX1, logX2, ... logX10** which are as defined above. We use a **True Fixed Effects** model, as determined by **model(tfe)**. We use this model to account for effects that are fixed for each individual trading relationship. The command **dist(tn)** defined a truncated normal distribution for the technical efficiency, **emean(ta-ij)** specifies that technical effiency must be measured with respect to participation in the ASEAN/MERCOSUR trading agreements, and finally **ort(o)** specifies an output-oriented technical efficiency.

6. Empirical Results and Discussion

The following results were achieved for **ASEAN**:

- GDP of both countries comes out to be significant in case of the ASEAN trading bloc.
- Also, a significant negative impact of multilateral trade resistance term.
- Positively correlated with population and negatively with exchange rate but results not significant.
- The coefficient for Technical Inefficiency comes out to be negative. Thus, we can say that entering into Trade Agreements has a positive impact on the Technical Efficiency.
- Checking the proportion of variation in trade accounted for by technical inefficiency: $\gamma = \frac{\sigma_\mu^2}{\sigma_\mu^2 + \sigma_v^2} = 0.6617$
- Thus, almost 66% of the variation in exports from India to members of ASEAN arises due to Technical Inefficiency.

True fixed-effects model (truncated-normal) — Number of obs = 189
Group variable: id — Number of groups = 9
Time variable: year — Obs per group: min = 21
avg = 21.0
max = 21

Log likelihood = -148.8485 — Prob > chi2 = 0.0000
Wald chi2(8) = 164.19

logY	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Frontier						
logX1	4.757177	2.04586	-2.33	0.020	-8.76699	-.7473646
logX2	1.611843	.3596995	4.48	0.000	.9068448	2.316841
logX3	-.8066622	1.995638	-0.40	0.686	-4.718041	3.104716
logX4	10.65323	9.047342	1.18	0.239	-7.079229	28.3857
logX5	.3276802	1.763918	0.19	0.853	-3.129536	3.784897
logX6	-.7996091	.5866949	-1.36	0.173	-1.94951	.3502918
logX7	-.0796549	.0685374	-1.16	0.245	-.2139858	.0546761
logX10	-4.281548	3.36092	1.27	0.003	-2.305734	10.86883
Mu						
ta_ij	-.0453684	.1847915	0.25	0.000	-.3168163	.4075531
_cons	3.330271	.1916764	8.45	0.000	1.243365	1.99472
Usigma						
_cons	-.9781882	.2918744	-1.19	0.235	-.9189004	.2252262
Vsigma						
_cons	-282.461	1.058342	-4.00	0.000	-6.312937	-2.164314
sigma_u	.6131816	.1227019	6.85	0.000	.6316308	1.11919
sigma_v	.4383674	.0635609	1.89	0.059	.0425758	.338863
lambda	1.33e+61	.1502385	46.59	0.000	6.705428	7.29435

Figure 1: SFA results for ASEAN

- The **technical efficiency** for most trades came out to be nearly **60%**.
- The trading data for India v Indonesia showed the lowest T.E. while India v Myanmar had the highest T.E.

```
. predict eff, u

. sort eff

. predict effi, te

. egen fegrp = cut(effi), at(0,.3,.6,.9,1)

. tab fegrp
```

fegrp	Freq.	Percent	Cum.
.3	6	7.14	7.14
.6	71	84.52	91.67
.9	7	8.33	100.00
Total	84	100.00	

Figure 2: Technical Efficiency for ASEAN

The following results were achieved for MERCOSUR:

- GDP of both countries comes out to be significant in case of the MERCOSUR trading bloc.
- Also, a significant negative impact of multilateral trade resistance term.
- Positively correlated with population and the Indian exchange rate.
- The coefficient for Technical Inefficiency comes out to be negative. Thus, we can say that entering into Trade Agreements has a positive impact on the Technical Efficiency .
- Checking the proportion of variation in trade accounted for by technical inefficiency: $\gamma = \frac{\sigma_\mu^2}{\sigma_\mu^2+\sigma_v^2} = 0.7176$
- Thus, almost 71% of the variation in exports from India to members of MERCOSUR arises due to Technical Inefficiency.

True fixed-effects model (truncated-normal) — Number of obs = 84
Group variable: id — Number of groups = 4
Time variable: year — Obs per group: min = 21
avg = 21.0
logX6 | .9940682 .2957687 3.36 0.001 .4143722 1.573764

Log likelihood = -30.0617 — Prob > chi2 = 0.0000
Wald chi2(3) = 2.58e+07

logY	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Frontier						
logX1	2.471105	1.34e-06	-1.8e+06	0.000	-2.471107	-2.471102
logX2	.4383674	.3070603	1.43	0.153	-.1634597	1.040195
logX3	-.0176997	.0631404	0.28	0.779	-.1060533	.1414527
logX4	9.409444	.965235	9.75	0.000	7.517618	11.30127
logX5	.2342481	.1029168	2.28	0.023	.0325348	.4359614
logX6	.9940682	.2957687	3.36	0.001	.4143722	1.573764
logX7	-.148473	.267798	-0.55	0.579	-.6733475	.3764014
logX10	-2.404188	9.23e-07	-2.6e+06	0.000	-2.40419	-2.404186
Mu						
ta_ij	-1.951988	.5215729	-3.74	0.000	-2.974252	-.9297242
_cons	.9511592	.3536672	2.69	0.007	.2579842	1.644334
Usigma						
_cons	-.727705	.4155485	-1.75	0.080	-1.542165	.086755
Vsigma						
_cons	-21.48001	25.1287	-0.85	0.393	-70.73135	27.77134
sigma_u	.6949937	.1444018	4.81	0.000	.4625121	1.044332
sigma_v	.4359614	.0002722	0.08	0.937	4.37e-16	1072679
lambda	32085.21	.1444028	2.2e+05	0.000	32084.93	32085.49

Figure 3: SFA Results for MERCOSUR

- The **technical efficiency** for most trades came out to be split nearly equally between **40%** and **80%**.
- The trading data for India v Brazil and India v Argentina showed the lower T.E. while India v Uruguay and India v Paraguay had the higher T.E.

f2	Freq.	Percent	Cum.
0	1	1.19	1.19
.4	48	57.14	58.33
.8	35	41.67	100.00
Total	84	100.00	

Figure 4: Technical Efficiency for MERCOSUR

7. Visualization

For ASEAN:

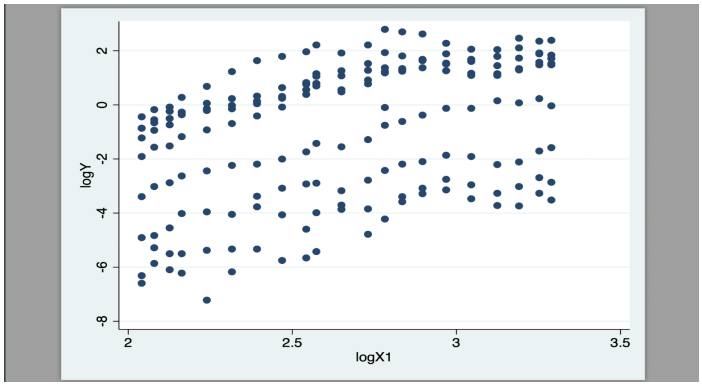

Figure 5: log(Trade) v log(Indian GDP)

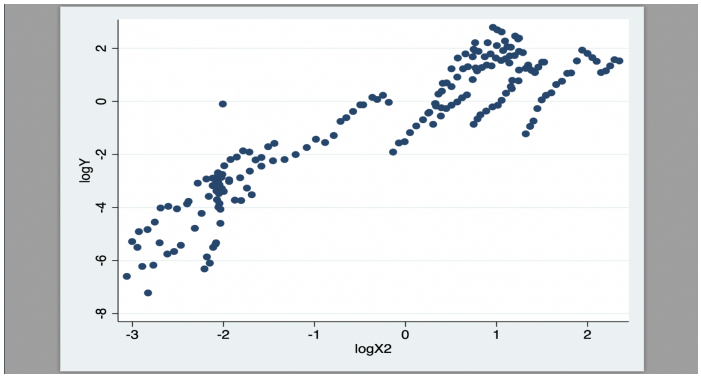

Figure 6: log(Trade) v log(GDP of other nations)

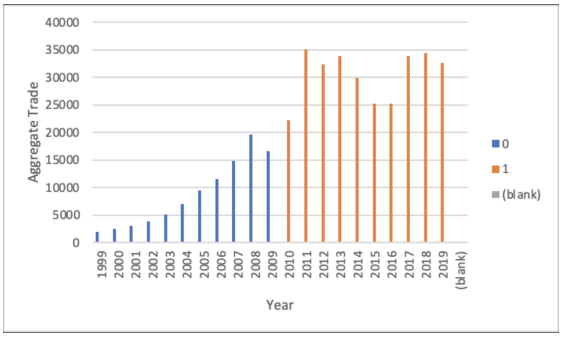

Figure 7: Impact of joining India-ASEAN FTA on India's Exports

- We can clearly see from the first two graphics the positive correlation between GDP and Trade, be it India's GDP, or of a member nation of ASEAN.
- The third graphic confirms our hypothesis that entering into an FTA/PTA increases trade.

For MERCOSUR:

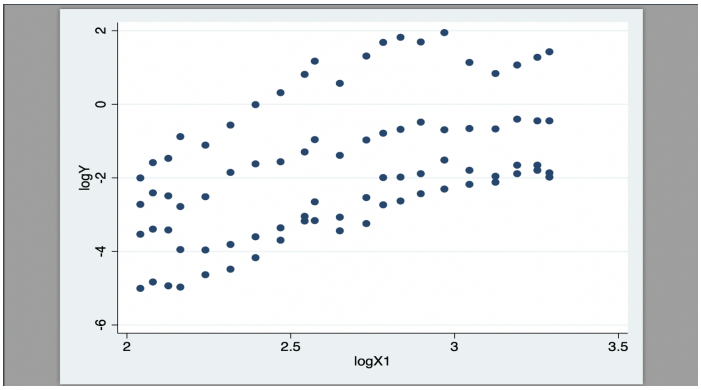

Figure 8: log(Trade) v log(Indian GDP)

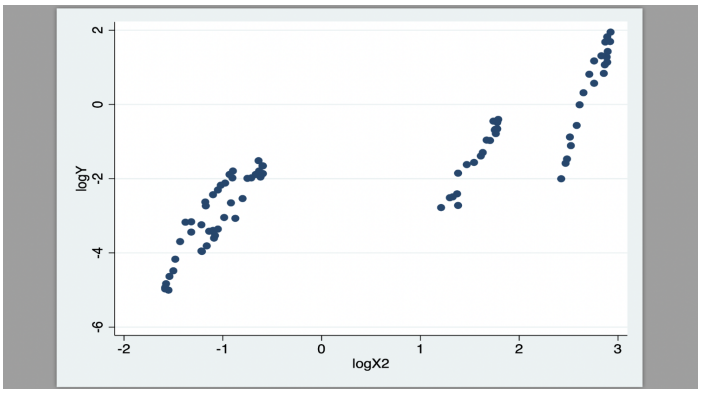

Figure 9: log(Trade) v log(GDP of other nations)

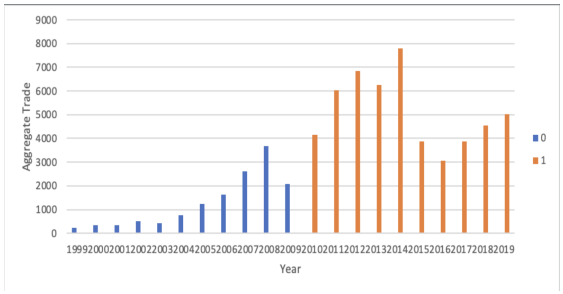

Figure 10: Impact of joining India-MERCOSUR PTA on India's Exports

- We can clearly see from the first two graphics the positive correlation between GDP and Trade, be it India's GDP, or of a member nation of MERCOSUR.
- The third graphic confirms our hypothesis that entering into an FTA/PTA increases trade.

8. Conclusion

- Results are mostly in line with the established economic theory.
- India's participation in ASEAN and MERCOSUR have increased the efficiency of their trade with these nations.
- Variation in output levels can be explained due to significant impacts of technical inefficiency.
- The India-ASEAN Free Trade Agreement (FTA) is more susceptible to multilateral trade resistance than the India-MERCOSUR Preferential Trade Agreement (PTA).
- Population size and exchange rate fluctuations have a greater impact on trade in India-MERCOSUR PTA than on trade in India-ASEAN FTA.

9. References

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