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The Gravity Model of International Trade: India and the World

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ABSTRACT

Jan Tinbergen's gravity model is one of the most successful empirical models of international trade. Economists have used it extensively to explain international trade trends from time to time. Many researchers have applied it to the Indian context, and a consistent view in the literature is that the gravity model explains more than half of India's trading patterns. Using data from the World Bank and CEPII database on the world economy, which has been coded in stata, we estimate the gravity equation for India for the year 2013. The main conclusions that have emerged from this analysis are: Firstly, the gravity model explains nearly 53 percent of India's trading patterns. Secondly, it remarkably explains India's trading position within the ASEAN countries. Thirdly, the postulates of the gravity model hold strongly in the case of India. Finally, this paper also looks at the possible impacts that financial shocks and the Trans-Pacific Partnership can have on the gravity equation.

KEY WORDS

Gravity, International Trade, Partnership, India.

The Gravity Model of International Trade

Sir Isaac Newton, in his 1687 work "Philosophie Naturalis Principia Mathematica", stated the law of universal gravitation.[1] The law states that an entity attracts every other entity using a force that is directly proportional to their respective masses and inversely proportional to the square of the distance between their centres. Algebraically, if m_1 and m_2 are the masses

and R is the distance between them, then the force of gravitation is described by (1)

$$F = G.m_1 * m_2 / R2 \text{ ..... } (1)$$

In the context of international trade, Jan Tinbergen in his trade treatise "An Analysis of World Trade Flows: In Shaping the World" (1962)[2] suggested the trade analogue of the gravity equation. Pentii Poyhonen (1963) developed the gravity model further and the credit for the present form of gravity equation mostly accrues to the work of these trade giants.[3] The gravity equation for trade states that the volume of bilateral trade between two countries is directly proportional to their respective gross domestic products (economic masses) and inversely proportional to the square of geographical distances (centre distance) between them as described in equation (2).

$$V_{ij} = \frac{T.Y_i * Y_j}{R_{ij}^2} \quad (2)$$

Taking logs both sides and equation (2) can be reduced in log terms giving us a useful statistical relationship to estimate:

$$log(V_{ij}) = log(T) + \alpha * log(Y_i) + \beta * log(Y_j) + \gamma * log(dist_{ij}) + \epsilon_i \quad (3)$$

A reduced form of equation (3) can also be estimated as in equation (4):

$$log(V_{ij}) = log(T) + \alpha " log(Y_iY_j) + \gamma " log(dist_{ij}) + \epsilon_{ij} \quad (4)$$

A priori, bilateral trade is hypothesized to be positively related to the respective GDP of the two countries, therefore, lending positive sign to α in equation (4). Large distances between two countries, ceteris paribus, are expected to lower bilateral trade and command a negative γ. The error term ϵ_{ij} accounts for shocks and chance events that can potentially affect bilateral trade. The shock has been assumed to be normally distributed with both good and bad events having the same probability.

Variants to the Gravity Model

With subsequent technical advancement and increased data availability, the gravity model has been incorporated into many different formulations. The augmented gravity model which is being heavily used these days and can be estimated with our data set is described in equation (5). Border and cultural effects, common colonising countries can be operationalised by introducing dummies.

$$log(V_{ij}) = log(T) + \alpha " log(Y_iY_j) + \gamma " log(dist_{ij}) + \omega(border_{ij}) + \tau(lang_{ij}) + \epsilon_{ij} \quad (5)$$

The advanced gravity model, Trade Sim, developed by UNCTAD(WTO), is currently in vogue with the emergence of differential bilateral and multi-lateral treaties.[4] This has the advantage of estimating trade potential between countries with limited trading histories, such as some of the countries involved in the Trans Pacific Trade Partnership.

Data and Estimation Strategy

After compiling and analysing India's export and import data with all its 197 trading partners from the Direction of Trade Statistics (DOTS), International Monetary Fund.[5] The trade data, which was initially in the U.S. million dollars, was then standardised to trade units by normalising them with the consumer price index of the US. The GDP data for the year 2013 was compiled from the World Bank report.[6] The GDP data is in current US billion dollars. The data for distances, colonial history, and country-specific languages were collected from CEPII's resourceful database[7]. Research reiterates that CEPII's comprehensive data sets will be greatly in demand in the years to come as treaty networks increasingly become complex. Although India has trade relations with 198 countries, research estimation was done over 192 countries because of a lack of trading data with the rest of them.

Figure 01: The correlation between trade volume and GDP of import country

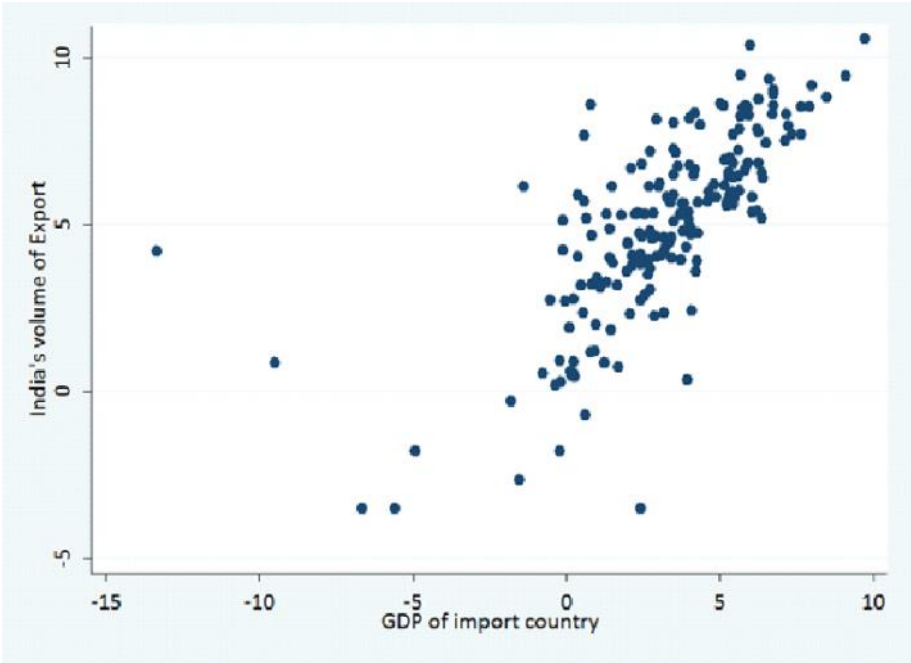
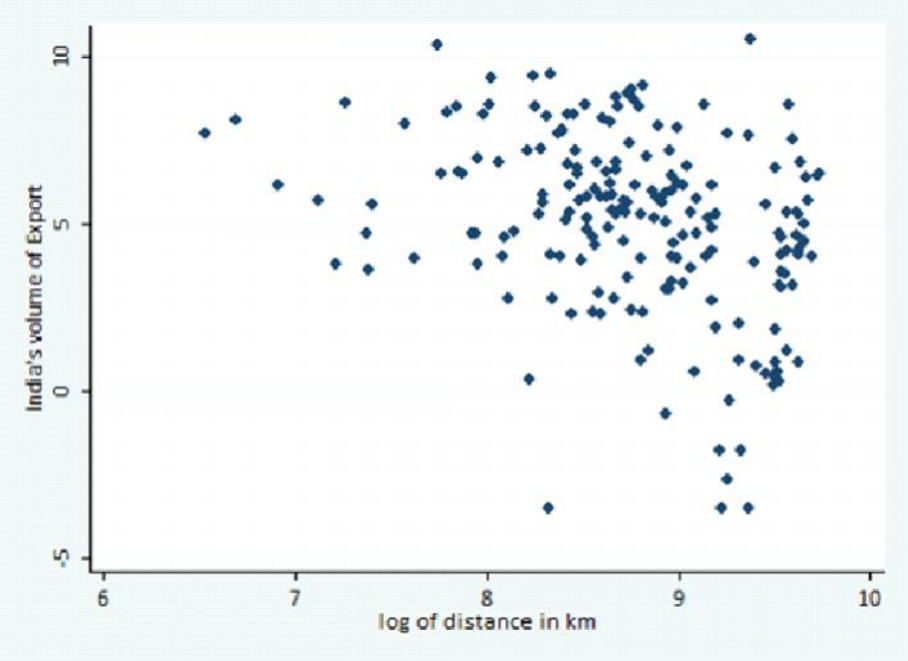


Figure 2: The correlation between trade volume and the distance between them.



Research estimate equation (5) and supplement it with the work of other authors as a check for estimated results. Research also break these results to the ASEAN group of countries and see how the gravity model explains trade in these regions.

Results of Analysis

Research presents the estimated results in this section. Figures 1 and 2 depict the correlations between trade volumes and the arguments in equations 4 and 5, namely GDP and distances. Figure 1, as hypothesised, suggests a positive correlation between the volume of trade and the GDP of import countries. The correlation factor comes out to be 0.7134, which is significant at a 5% level. Similarly, Figure 2 displays a mild negative

relationship between the volume of trade and distance with a correlation factor of 0.34, which is also significant at a 5% level. Paper here will present the OLS results for our regression.

Research results sharply corroborate the hypothesis of the gravity equation. The coefficients for GDP and distances are significant with high t-values. Moreover, the most insightful information that comes from the estimation exercise is the high R^2 value. The gravity model can explain nearly 53% of India's trading patterns with the rest of the world. Research also tried different specifications for our estimating equation, but an R^2 of more than 50% has been consistent in all of them. We tried to compare our results with the works of other authors who have estimated the gravity equation in the Indian context although over different time periods. Tathagata and Banerjee (2006) carried out a similar exercise and found out the R^2 in excess of 45% over the entire span of the second half of the twentieth century[8]. Amita Batra (2004) suggests that nearly 70% of India's trade flows can be explained by the gravity equation. Seen in this context, our estimation results seem fairly sensible.[9]

Figure 3: OLS results from estimating equation

Source	SS	df	MS		
Model	761.871531	2	380.935766	Number of obs =	192
Residual	669.090664	189	3.54016224	F(2, 189) =	107.60
Total	1430.9622	191	7.49194867	Prob > F =	0.0000
				R-squared =	0.5324
				Adj R-squared =	0.5275
				Root MSE =	1.8815

lnvx	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lngdp_ce	0	(omitted)				
lngdp_ci	.620479	.0476377	13.02	0.000	.5265091	.714449
lndist	-.6790002	.2200975	-3.08	0.002	-1.113163	-.2448369
_cons	8.986966	1.979265	4.54	0.000	5.082678	12.89126

India and ASEAN

The Association of Southeast Asian Nations (ASEAN) is a political and economic entity of ten Southeast nations comprising Singapore, Thailand, Indonesia, Philippines etc. Due to Brunei's unavailability of data, we estimated the gravity equation with these nine countries. Since the distance factor is much the same for ASEAN countries, our results hinged on the GDP mass. Malaysia, Singapore and Indonesia are major trading partners of India, and the gravity equation justifies this. However, with Vietnam, the Philippines, and Cambodia, India has yet to realize its full trade potential.

Modelling the Trans Pacific Agreement (TPP) in the Gravity Equation

On February 5th 2016, delegates from 12 countries in the Pacific Arc signed the Trans-Pacific Partnership (TPP) agreement.[10] The treaty is aimed at easing the flow of goods, services and investments among them, and to strengthen the rules on labor compliance, environmental compliance, origin criteria, intellectual property rights, government procurement. The treaty is significant as it caters to a population of nearly 1 billion, with trading partners contributing to nearly half of the GDP. India is yet to sign on TPP accord. However, with panel data, one could have a dummy indicator variable for the TPP treaty. However, Research paper here discusses how we could model TPP in the framework of equation (5) by exploiting the error term. The Perception of TPP in the Indian context has been mostly negative. The preferential treatment among TPP partners is likely to outcaste India's goods among its trading partners. The TPP seeks to override.

The structure was set by the WTO, and it brought its own private standards of trade. It is very likely that India will lose more than gain by not being a part of the TPP. Therefore, the error term needs to be

modelled as a negative shock for the years in which TPP becomes active. Currently, the TPP hasn't been fully adopted, and we will have to wait for its initial effects.

CONCLUSION

In our study, we delve into the intricate dance of commerce through the lens of the renowned gravitational equation, applied within the vibrant marketplace of India. Our journey of exploration utilizes a rich tapestry of data, drawn from the vast repositories of the World Bank and CEPII, which we have meticulously organized and analyzed using Stata. Focused on the year 2013, our findings unveil compelling insights into the dynamics of India's trade.

Foremost among our discoveries is the profound resonance of the gravity model with India's commercial exchange, accounting for an impressive 53 percent of its trade patterns. This model not only sheds light on India's trade flows but also illuminates its commercial relationships with the ASEAN bloc, revealing a remarkable alignment.

Our investigation reaffirms the robust applicability of the gravity model's principles within the Indian context, providing a sturdy scaffold upon which future analyses can build. As we look ahead, we underscore the significance of refining our approach to the model's error term. This refinement is pivotal for integrating considerations such as TPP-like agreements and the impact of financial fluctuations, thereby enriching our understanding and predictive capability regarding India's trade dynamics.

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