The Determinants of India's Bilateral Trade: A Comparative Gravity Model Analysis of 2011 and 2017

Kratika Kashyap[1] and Suvid Tiwari[2*]
[1] Operations Management & Quantitative Techniques Area, Indian Institute of Management Indore, India-453556.
[2]Finance and Accounting Area, Indian Institute of Management Indore, India-453556.

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Abstract

This paper applies the gravity model for bilateral trade to examine the determinants of India's bilateral trade flows with 234 partner countries in 2011 and 2017. Using cross-sectional data and log-linear ordinary least squares (OLS), we analyse the effects of partner-country economic size, geographic distance, ethnic/diaspora language ties, and World Trade Organization (WTO) membership on bilateral trade. As per the gravity model theory, partner GDP enters with a coefficient of 0.97 in 2011 and 0.93 in 2017, while distance is associated with a negative coefficient of -1.10 in 2011 and -0.91 in 2017. WTO membership is associated with higher trade in both years, and the estimated effect strengthens between 2011 and 2017. A shared ethnic or diaspora language shows a positive but statistically insignificant association with trade in both years.

Keywords: Gravity model, Bilateral trade, Ordinary Least Squares, WTO, Common language.

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1. Introduction

The gravity model of trade is an econometric model used in international economics to predict bilateral trade flows based on countries' economic size and the distance between them. This gravity model for trade is analogous to Newton's Law of Gravity, which states that the gravitational force between two objects is directly proportional to their masses and inversely proportional to the distance between them, as first proposed by Tinbergen (1962) and later given a theoretical derivation by Anderson (1979), which was further refined by Anderson and van Wincoop (2003) through the introduction of multilateral resistance terms.

India has undertaken a process of trade liberalisation over the last three decades involving lowering of tariffs, removal of quantitative restrictions and active involvement in the trading system through the WTO. India also has a large diaspora and ethnic-language ties with a number of its trading partners, particularly across South Asia, the Gulf and parts of Africa and Southeast Asia. This raises the question of whether such ties have a measurable trade-facilitating effect beyond that captured by standard gravity covariates.

This paper estimates a log-linear gravity model of India's bilateral trade with 234 partner countries separately for 2011 and 2017, two years that bracket a period of significant change in India's external trade environment, including the aftermath of the global financial crisis and the subsequent recovery in world trade volumes. We examine four core covariates: partner-country GDP, weighted harmonic-mean bilateral distance, a common ethnic/diaspora language indicator, and partner WTO membership status. Estimating the model separately by year allows us to assess whether the strength of these relationships changed over this period, rather than imposing a common set of coefficients across time.

2. Literature Review

After Anderson (1979)'s explanation regarding the gravity model for evaluating bilateral trade and Anderson and van Wincoop (2003)'s explanation of the inclusion of multilateral resistance terms that correctly specify the gravity model. Santos Silva & Tenreyro (2006) proposed the Poisson Pseudo Maximum Likelihood (PPML) estimation instead of the log-linearized OLS estimation of the gravity model. They identified that the log-linearized gravity model fails to deal with heteroscedasticity and zero trade values.

Subsequent work, including Baier and Bergstrand (2007), has extended the gravity framework to examine whether free trade agreements (FTAs) actually increase international trade between member countries using gravity equation analysis.

A stream of literature has applied the gravity model specifically to India's trade. Bhattacharyya and Banerjee (2006) used a panel data approach to test whether the gravity model explains India's direction of trade, and found that a partner country's development level mattered less for trade determination than other factors captured by the model. Nag and Nandi (2006) applied the gravity framework to analyze India's trade relationships with SAARC member countries. On the import side, Wani, Dhami, and Rehman (2016) used a panel data gravity approach and described their study as the first to apply a panel data approach within a gravity model framework to identify the determinants of India's import trade. Tripathi and Leitao (2013) applied static and dynamic panel gravity models to India's overall trade and found that political globalization and cultural proximity had a positive influence on bilateral trade, in addition to the standard economic-size and common-border effects. Beyond merchandise trade, Tharakan, Van Beveren, and Van Ourti (2005) applied a gravity specification to India's bilateral software exports and found that distance was insignificant when comparing Indian software exports to overall goods trade flows, while De (2013) estimated a gravity model of barriers to India's services trade and found that a one percent improvement in services trade facilitation measures was associated with a two percent increase in services exports.

More recent work has focused on addressing the limitations in identification inherent in single-reporter cross-sectional designs, such as the one used in this paper. A recent structural gravity study emphasizes that applied gravity analyses based on a single reporting economy and controlling only for the common temporal shocks with year dummies cannot separately identify the multilateral resistance of the importer and can produce trade-gap estimates that deviate from the theoretical underpinnings of the structural gravity model. That study instead estimates a full structural gravity model with exporter-time and importer-time fixed effects via Poisson pseudo-maximum-likelihood (PPML), finding that 104 of India's 197 bilateral partners exhibit systematic under-trading relative to the structural gravity benchmark. Also, the stochastic frontier gravity applications on India's trade have explored the role of institutions and free trade agreements. They concluded that the bilateral FTAs are positively associated with trade efficiency, while multilateral FTAs lead to negative or insignificant effects.

3. Data and Methodology

3.1 Data

The dataset is from the CEPII Gravity database (Conte, Cotterlaz and Mayer, 2023) and comprises India's bilateral trade (the sum of exports and imports) with 234 trading partners for the years 2011 and 2017. It is a compiled database that merges bilateral trade and other gravity-model relevant variables from many sources into one complete dataset. In this compiled dataset, the bilateral trade variable is taken from CEPII's BACI database; GDP values of partner and India are taken primarily from the World Bank's World Development Indicators; the harmonic-mean weighted bilateral distance measure is sourced from CEPII's GeoDist database. We used the harmonic mean measure for distance because, according to CEPII Gravity documentation, the ideal distance measure is to approximate GDP shares with population shares, and this is the theoretically consistent way to measure distance between two countries. The indicator for shared ethnic/diaspora language (equal to 1, where at least 9% of the population in both countries speaks a common language, capturing linguistic and diaspora ties that go beyond official state languages, otherwise equal to 0) is also sourced from CEPII's GeoDist database and WTO membership status is sourced from the WTO's official membership records.

Since the gravity equation is estimated in logarithms, country pairs with zero recorded bilateral trade cannot be included in the log-linear specification. After removing zero-trade observations and observations with missing partner GDP or common-language data, the final sample consists of 191 country pairs in 2011 and 198 country pairs in 2017, out of 234 possible partners in each year. Table 1 contains summary statistics for the estimation sample.

Descriptive Statistics of Bilateral Trade Variables

2011 (N=191)				
Variable	**Min**	**Max**	**Mean**	**Median**
Bilateral trade (US$)	$1,247	$71.00 bn	$4.01bn	$360.9 m

Distance, harmonic (km)	920	17,046	7,756	6,702
GDP, partner (US$)	$39.3m	$15.52tn	$366.85bn	$25.84bn
2017 (N=198)				
Variable	**Min**	**Max**	**Mean**	**Median**
Bilateral trade (US$)	$118,190	$81.77bn	$3.67bn	$390.2m
Distance, harmonic (km)	928	17,041	7,810	6,710
GDP, partner (US$)	$45.2m	$19.48tn	$395.38bn	$29.73bn

Table 1. Descriptive statistics for continuous gravity variables, 2011 and 2017. Bilateral trade and partner GDP are converted from the source data's native units (thousands of current US$) into US$ for readability (m = million, bn = billion, tn = trillion)

Variable	2011	2017
Common language = 1 (share)	0.314	0.313
WTO member = 1 (share)	0.785	1
Top partner by trade value	UAE ($71.00bn)	China ($81.77bn)
Bottom partner by trade value	Tuvalu ($1,250)	Tuvalu ($118,190)

Table 1b. Categorical variable shares and top/bottom trading partners by value, 2011 and 2017.

3.2 Model Specification

The estimated model is the standard log-linear gravity specification:

$$ln(Trade)_i) = \beta_0 + \beta_1 \, ln(GDP_{partner,i}) + \beta_2 \, ln(Distance_{\,i}) + \beta_3 \, CommonLanguage_i + \beta_4 \, WTOmember_i + \varepsilon_i$$

where $Trade_i$ denotes the total bilateral trade between India and partner country i, measured as the sum of India's exports to and imports from the partner country. $GDP_{partner,i}$ represents the gross domestic product (GDP) of partner country i, while $Distance_i$ denotes the harmonic mean weighted geographical distance between India and the partner country. $CommonLanguage_i$ is a dummy variable that takes the value 1 if India and the partner country share a common ethnic or diaspora language and 0 otherwise. Similarly, $WTOmember_i$ is a dummy variable equal to 1 if the partner country was a member of the World Trade Organization (WTO) in the corresponding year and 0 otherwise. Finally, ε_i represents the random error term capturing the effects of omitted factors. The model is estimated separately for the years 2011 and 2017 using the Ordinary Least Squares (OLS) estimation method.

India's own GDP is omitted from the estimating equation. Because, India's GDP takes an identical value across all 234 observations within that year; it therefore has zero within-year variance and is perfectly collinear with the regression intercept.

This is a standard and expected feature of single-exporter (or single-importer) cross-sectional gravity models: the exporting country's own characteristics, including its GDP and its multilateral resistance term, are absorbed into the constant and cannot be separately identified in a given year's cross-section. This does not indicate a data error; rather, it reflects the structure of a single-country cross-sectional gravity design, as distinct from a multi-country panel where exporter and importer fixed effects can be estimated jointly.

All regressions are estimated with heteroskedasticity consistent (HC1, White-type) standard errors, considering that the residuals of the gravity model are widely known to be heteroskedastic in relation to the size of the country and is officially confirmed for both years using the Breusch-Pagan test. To test for multi-collinearity among the regressors, the variance inflation factors (VIF) are provided.

4. Results

4.1 Regression Estimates

Table 2 contains the gravity model estimates for 2011 and 2017, with heteroskedasticity-robust standard errors in parentheses.

Variable	2011 Coef.	2011 Robust SE	2017 Coef.	2017 Robust SE
ln(GDP, partner)	0.974***	-0.047	0.930***	-0.036
ln(Distance, harmonic)	-1.097***	-0.172	-0.908***	-0.136

Common language (=1)	0.342	-0.22	0.059	-0.181
WTO member (=1)	0.988***	-0.309	1.135***	-0.257
Constant	4.577**	-1.773	3.640**	-1.435
Observations	191		198	
R-squared	0.803		0.826	
Adjusted R-squared	0.799		0.822	

*Table 2. Gravity model estimates of India's bilateral trade, 2011 and 2017. Robust (HC1) standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: ln(bilateral trade).*

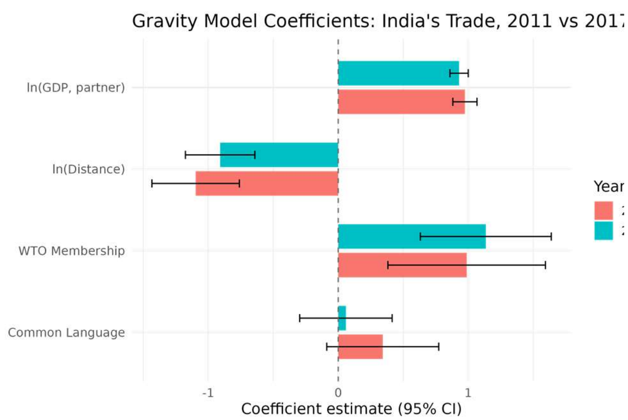

Figure 1: Comparison of gravity model coefficients, 2011 vs. 2017 (95% confidence intervals).

4.2 Interpretation

The gravity model results are consistent with theoretical expectations, showing that partner-country GDP has a strong positive effect on India's bilateral trade, while distance significantly reduces trade in both 2011 and 2017. WTO membership is associated with substantially higher trade flows, whereas a common ethnic or diaspora language does not have a statistically significant independent effect. The model explains around 80% of the variation in trade, with a slightly better fit in 2017. Diagnostic tests indicate no serious multicollinearity, justify the use of heteroskedasticity-robust standard errors due to heteroskedasticity, and show only mild non-normality of residuals in the 2011 model, suggesting that the estimated coefficients remain reliable while exact finite-sample inference should be interpreted with some caution.

4.3 Association Between Common Language and WTO Membership

Since the regression includes two categorical covariates, common ethnic/diaspora language and partner WTO membership, it is useful to check directly whether these two partner-country characteristics are themselves associated, independent of their joint role in the gravity equation. Table 3 cross-tabulates the two indicators for each year, and Pearson's chi-squared test (with Yates' continuity correction) and Fisher's exact test are used to test the null hypothesis of independence.

Variable	2011: WTO=0	2011: WTO=1	2011 Row Total
Common language = 0	27	104	131
Common language = 1	14	46	60
Column Total	41	150	191
Variable	**2017: WTO=0**	**2017: WTO=1**	**2017 Row Total**
Common language = 0	26	110	136
Common language = 1	12	50	62
Column Total	38	160	198

Table 3. Cross-tabulation of common language and WTO membership, 2011 and 2017 (estimation sample).

The chi-squared and Fisher's exact tests show that there is no significant association between common language and WTO membership in both years 2011 and 2017. There is also a very low phi coefficient confirms that these two variables are substantially independent, suggesting that they capture different aspects of India's trade relationship rather than overlapping characteristics. These findings are consistent with the low variance inflation factors and support the interpretation of their estimated effects on trade independently.

5. Discussion

5.1 India's Trade Patterns

India's trade in both 2011 and 2017 was concentrated among large economies such as the UAE, China, the United States, and other major trading hubs, consistent with the strong positive effect of partner-country GDP on bilateral trade. Between 2011 and 2017, the negative impact of distance weakened and the positive association with WTO membership strengthened, reflecting India's deeper integration into the global trading system. These changes are expected to coincide with developments like WTO Trade Facilitation Agreement, the Make in India drive, GST implementation and post-financial-crisis recovery. However, the cross-sectional design does not support causal attribution. The influence of these policy changes and structural transformations could be officially tested in future research utilizing panel data and fixed-effects gravity models.

5.2 Limitations

This study has its limitations. The log-linear OLS model excludes zero-trade observations and missing data, which can lead to sample selection bias that can be corrected via PPML estimation. The cross-sectional design does not control for multilateral resistance terms and does not allow for formal comparisons between years with fixed effects. Also, the positive relationship between commerce and WTO membership should not be understood causally because of probable endogeneity. Finally, the residuals are not normally distributed in the 2011 model; nonetheless, the use of heteroskedasticity-robust standard errors supports the validity of the results. The use of bootstrap or quantile regression could give further robustness tests.

6. Conclusion

This paper has estimated a log-linear gravity model of India's bilateral trade with 234 partner countries in 2011 and 2017. Consistent with the predictions of gravity model theory, partner-country GDP and distance are both strong and statistically significant determinants of trade in both years, with GDP elasticities close to unity and distance elasticities exceeding one in absolute value.

We find that WTO membership is significantly related to higher bilateral trade across this period. Also, a common ethnic or diaspora language is not statistically connected with trade after market size and distance are controlled for.

These findings are broadly consistent with India's trajectory of deepening engagement with the multilateral trading system between 2011 and 2017, and point to several avenues for further research, including panel estimation with exporter/importer fixed effects and PPML estimation to address the exclusion of zero-trade observations.

Appendix

Figures 2 and 3 present standard OLS diagnostic plots (residuals vs. fitted, Q-Q, scale-location, and residuals vs. leverage) for the 2011 and 2017 models, respectively.

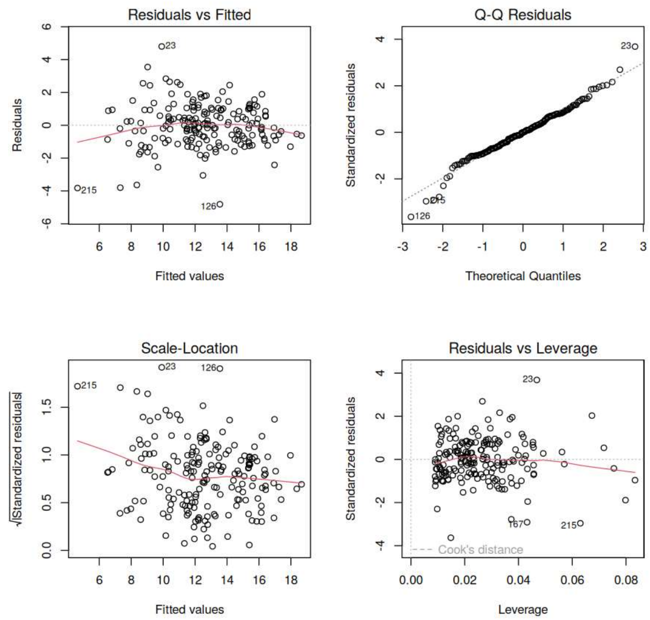

Figure 2: Diagnostic plots, 2011 model.

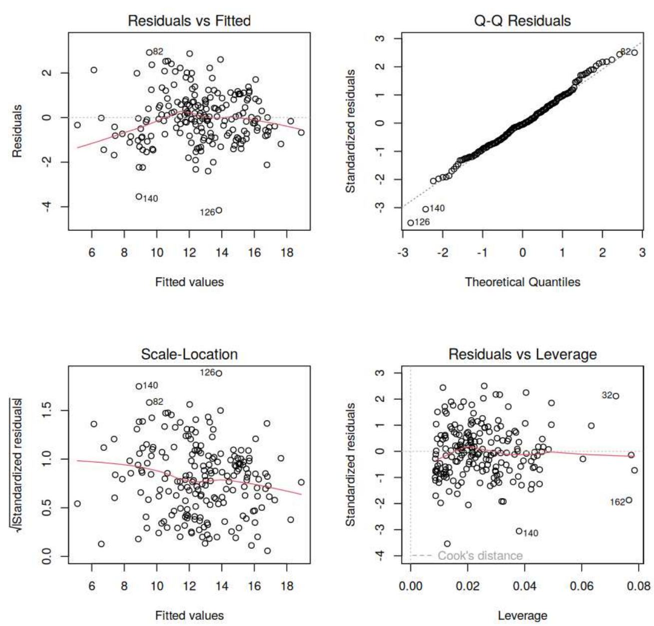

Figure 3: Diagnostic plots, 2017 model.

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