PREDICTIVE CAPACITY OF GRAVITY MODEL FOR INDIA'S INTERNATIONAL TRADE

Ashish Bhatt

Parul Institute of Management

Parul University

ashishkumar.bhatt@paruluniversity.ac.in

Abstract

Study attempted to estimate the predictive capacity of India's international trade of India's 170 trade partners for the period of 1991 to 2017. Predictive capacity of traditional and augmented equation measured with respect to pooled, fixed and random effect to measure the accuracy of the model for India. Augmented gravity model used new dummy variable, logistics performance index, with traditional variables. India's trade responds significantly to size of the trading partner and logistics performance index while more than proportionally to distance. Colonial heritage is important factor in India's trade. India's trade is more with better logistics performance index countries.

Keywords: Trade potential, gravity model, International Trade, Logistics performance index

JEL classification: C0, F1

Introduction

World witnessed tremendous change during the last decade. The economic bubbles burst were absorbs by most of the nations quickly but bubbles burst made a major impact. This proves that no country in the globe can keep away itself from the rest of the world. Advancement in telecommunication and transportation compact the globe into single global community. Such changes impact heavily on international trade. The global trading system has been witnessing a creation of regional economic integration scheme or trade blocs or Regional Trade Agreements (RTAs) designed to achieve specific economic and political purposes **(WTO, 2011).** The growth of RTAs has been very rapid, particularly since 1990's. The global economy has been on a subdued growth path since the advent of 'Financial Crisis'

of 2008, and has now started to show signs of global recovery. In October 2017, the IMF projected world GDP growth to pick up from 3.2% in 2016 to 3.6% in 2017 and further to 3.7% in 2018. Economic activity has also picked up in developed market economies such as the US, UK, and Europe. There is a rise in global demand, which is expected to remain buoyant. **(EXIM)**

List of the factors affecting India's trade are quite large in numbers such as absolute and comparative advantage over other countries, economies of scale, digitalisation, diasporas and remittance, government policy related to trade, political and trade agreement(Includes bilateral, regional and multilateral). India opened the economy and begun to reforms the centralised weak economy to planned and developing economy with exception to be developed economy on the comparative advantage in agriculture. The most important reforms been taken during the 90's were opening up doors for private players, growth of financial sector and promotion of international trade with neighbouring and closed(Soviet Union and Japan) countries. As a result the India's trade activities started growing and contributing good to balance of payment. A trade reform was one of the most an integral part of the comprehensive programme of structural reforms initiated in India in 1991-92. These reforms have led to a noticeable change in the economic performance of the external sector in India. **(Batra, India's Global Trade Potential: The Gravity Model Approach, 2004)**. Emergence of India as global trading partner is serious concern for China. With reference to emergence of India as major trader from Asia other than China, China started investing in to African continental through its major project, Forum on China–Africa Cooperation, invested $60 billion investment across Africa **(Christian Shepherd, 2018)**. China's One Belt One Road (OBOR) initiative opens the door for China to enter into African continental and European markets. In answer to such strategic move, India , Russia and Iran come together and started massive International north south transport corridor (INSTC) expecting 30 percent cheaper through the INSTC and shall cut approximately 40 percent of transit time **(Kashyap, 2018).** INSTC also open the doors for India to entre in to Central Asian and CIS countries with great price advantage. India's investment to Chabahar port is considered as strategic answer to china for investing in African sea ports.

India became worlds one of the largest economies and become one of the second largest market for the world. India's trade mainly comprises import rather than export as demand is higher than its production. Literature suggested that gravity model was used to point out that GDP, population, distance and culture have important effect on trade flows between countries

such as the work of blomqvist **(Blomqvist, 2004)** on Singapore and Montanari **(M.Montanari, 2005)** on Balkans.

There have been number of studies using gravity model to analyse the foreign trade activities of India ignoring predictive capacity /fitness of gravity equation for India was carried out by Ranajoy Bhattacharya and Tathagata Benerjee (R Bhattacharya & T Benerjee, 2006) examined the fitness of the gravity model for India and concluded that the core gravity model explains around 43 percent of the fluctuations in India's trade of direction for the year 1950 to 2000. Second major research for India was carried out by Amita Batra estimated trade potential for India using the gravity model approach for the year 2000. Study used augmented model to analyse the trade flows ,coefficients and predict trade potential for India **(Batra, India's global trade potential : The gravity model Approach , 2004).**

India had expanded the trade activities towards to the Central and CIS nation's meanwhile traditional partners such as USA, Europe and Middle East countries ware stabled. Bilateral trade between India and CIS and central Asia had huge potential for growth. Keeping this it required to understand India's trade activities and factors largely affecting for the betterment of trade.

Study used basic gravity model on panel data to evaluate the fitness for the period of 27 years with 170 trade partners. Literature suggested to take the aggregated data for the gravity model (Andrew, 2001). Theory narrow down from the Newtonian law of gravity, states that bilateral trade increase with the Gross Domestic Product of countries and decreases with the distances between countries. In the literature there have been several attempts to derive the strong relationship between GDPs of home and host countries and geographical distance. Studies suggested positive relationship with GDPs and negative relation with distance. Advancement in transportation and logistics technology, do such basic factor distance affects in current era? There has been reduction in the transportation cost observed during the last few years **(Robert de Souza)**. The strong research in the carriage carrier reduced the transportation cost which can now remove the distance barrier or nullify the effect.

Literature

(R Bhattacharya & T Benerjee, 2006) A panel data approach" used the data of 177 trading partner for the year 1950 to 2000 and concluded that the gravity model can explain about 43 to 50 percent of the fluctuations in India's direction of trade. India's trade responds less than

proportionally to size and more proportionally to distance. Colonial heritage is still an important variable for India's direction of trade. Finally he concluded that India's trade is more with developed nations rather than developing trading partners. They used fixed effect model for the regression analysis and considered 0.00001 as trade value for those who have not reported the trade data in case of taking logarithm value of independent variables.

(Batra, India's global trade potential : The gravity model Approach , 2004) Estimated trade potential of India using the augmented gravity model for cross sectional data of the year of 2000 using the pooled OLS. Her estimates indicate that India can potentially attain ten times or more the level of the actual trade with countries like Georgia, Turkmenistan, and Uzbekistan. In fact, most of the countries in the CIS region reveal possibilities of expanding trade with India. Among specific country groupings/trade arrangements India's trade potential is maximum with Pakistan in SAARC, with Philippines and Cambodia in the ASEAN region and with Oman, Qatar and Kuwait in the GCC.

(V.R. Renjinia, January-June 2017) Analysed the competitiveness and potential of agricultural trade between India and ASEAN members for the period 1995-2014. They used Revealed Comparative advantage index and gravity model to assess the India's trade potential with ASEAN countries. The model estimated that partners' income and free trade agreement ware positively influencing the bilateral trade. The border trade has found no significance in the bilateral trade pointing weak infrastructure at Indo-Myanmar border. The study stresses the importance of trade facilitation measures to enhance the trade with the ASEAN.

(Sarin, 2017) Used augmented gravity model for the year 1997 to 2015 with panel data of India and Thailand. They used ordinary least squares model has been used to estimate the dummies that capture specific fixed effects on nations. Results of study showed that the assessed coefficients of variables observed as statistically significant. The adjusted R^2 values ranges from 0.544 (low) to 0.604 (high). The values used for comparison purpose employing in the gravity model to examine trade creation and diversion effect. R-square has a high value implies that coefficients are highly significant.

(Dinh Thi Thanh Binh) Applied gravity model in order to analyze bilateral trade activities between Vietnam and 60 other countries for the period of 2000 to 2010. The estimated results revealed that economic size of Vietnam, economic size and market size of foreign partners,

distance and culture have huge effects on bilateral trade flows between Vietnam and these 60 countries. By applying method of speed of convergence, they found out that Vietnam had trade potential especially with some new markets such as Africa and Western Asia.

(Rojid, 2006)Study used a panel data analysis to estimate export flows from 147 exporting countries for a period of 21 years (1980–2001). The equation was estimated using a Tobit model. The coefficients on the observable effect in determining bilateral trade, except real effective exchange rate, ware as expected and highly significant. They used an extended gravity model in their analysis.

(Yunus, 2012) They accessed the volume of recent export flows from China, India, Iran, Russia and Turkey to countries in Central Asia. They estimated an augmented gravity model and conduct trade complementarily analysis to compare the factual export volumes with projections generated by the model. They have expanded their exports beyond numbers predicted by the augmented gravity model.

(Pradhan, --) He used an augmented gravity model to analyze India's world export flows and the coefficients thus obtained ware incorporated to predict India's export potentials to the six-member GCC countries. This model has been estimated using the ordinary least square (OLS) technique with panel data. The dependent variable in all his tests was total merchandise exports (constant US dollars), in log-linear form between country-pairs of India with other 150 countries of the world.

Statistical Model and Variables

Literature observed that the researcher just used the augmented gravity model without measuring its predicting capacity of model for India. Literature review found only one research carried out till date where study tried to calculate the predicting capacity of gravity model of India (R Bhattacharya & T Benerjee, 2006). Literature survey is not able to find more studies where researcher tried to measure predictive capacity of the gravity model for India. Current study tried to calculate the predicting capacity of the gravity model for India for the different time with new dummy variables and found huge gap between the results of the studies.

Literature observed that the studies carried out for India are almost common dummy variables such as common language, contingency, colony, agreement and foreign exchange

etc. but very few studies focused on the logistic performance of the India and its impact on the gravity model which this study did and found significant impact on India's trade. Such findings support the policy and strategic decision, such as INSTC and Chabahar Port partnership, made by the Republic of India.

Augmented gravity model:

$$T_{ij=} \alpha + \beta_1 \ln GDP_i + \beta_2 \ln GDP_j + \beta_3 \ln Dist + \beta_4 Dummy\ Variable + \delta$$

i represents India and **j** represents partner country

$\ln GDP_{ij} =$ Natural logarithm of GDP of country i and j

$\ln Dist =$ Natural logarithm of bilateral distance between countries i and j

Dummy Variables

Comlang = Binary variable that takes the value 1 if countries have common official language, and 0 otherwise

Comborder = Binary variable that takes the value 1 if both countries share border, otherwise 0

Colony = Binary variable that takes the value 1 if countries were under the same colonizer, otherwise 0

Landlocked = Binary variable that takes the value 1 if both the country is landlocked, otherwise 0

Agreement = Binary variable that takes the value 1 if countries have trade agreement, otherwise 0

Exchange rate = Annual average of the national currency unit of India per US dollar / Annual average of the national currency unit of country j per US dollar

Logistics performance index: Binary variables that takes the value 1 if partner countries LPI is greater than India (ie3.18), otherwise 0

Data and Estimation

India's export and import data with all its trading partners has been taken from the Direction of Trade Statistics, IMF (**IMF**). The trade data is in US $. To bring it to real terms, divided it with the consumer price index (CPI) of the US. The US CPI (for all urban consumers) data is taken from the US Department of Labour (Bureau of labour statistics). Data for GDP is taken from the PENN world table. Study multiplied CGDP (real per capita GDP in current US $ i.e.

current GDP divided by current price) from PENN by population (taken from the same source) to arrive at the aggregate GDP of each country. The data for distance is taken from Centre D'etudes Prospectives Et D'informations Internationales[1].

There are total 170 countries with which India had trade relation from 1991 to 2017. Therefore total number of potential observation for the study is 4590. As far as is data is concerned, the countries which did not reported the trade values we considered the trade as zero trade and considered the values as 0.00001 for model where we considered log values (R Bhattacharya & T Benerjee, 2006).

A panel data of 170 trade partners of India for the year 1991 to 2017 was prepared for analysis. Heteroscedasticity and multicollinearity are the three major problems occur in the panel data. Therefore study first checked the stability of the dependent variable which was trade data by applying cumulative sum of recursive residuals and found that the dependent variable is stable. Study did some diagnostic test to check the expected assumptions of Multicoliniearity and Hetroscedesticity. (Refer Appendix). Multicoliniarity can be explained by high correlation of two variables. This is common statistical nature of the gravity model of estimation. Study used large data set so the impact of the multicoliniarity can be controlled. Problem such as hetroscedisticity , study used Feasible Generalised Least Square(FGLS) regression method for hetroscedisticity panel to solve the problem.

There are three main models which can be used to estimate in panel data: pooled model, random effects model (REM) and fixed effects model (FEM). If individual effects do not exist, the pooled model will be the best choice. But if it exists than it must be reflected in the model estimated values and preferred to use the FEM and REM. FEM will be selected if there is a correlation between individual effects and explanatory variables. Meanwhile, the regression model will be able to control over and separate the impact of individual effects from explanatory variables so that we can estimate the net effects of explanatory variables on dependent variable. But if individual effects of the entities are random and not correlated with explanatory variables, REM will be more effective. REM considers the residual of each entity (which is not correlated with explanatory variables) as a new explanatory variable and can estimate the invariant factors such as distance. **(Gujarati, 2003)**

[1] http://www.cepii.fr/anglaisgraph/bdd/distances.htm, under file name dist_cepii.xls

The main problem of FEM is that the variables which do not change over time cannot be estimated directly in this model. So variables such as distance in equation will not be supported in FEM. This study used pooled model and random effects model for estimation. **(Gujarati, 2003)**

Estimation of Result

As Study had noted that, most gravity models estimated over pairs of countries often for major portions of the world have an R^2 of .60 or above. Most of these models use a large number of dummy variables to capture effects far beyond these basic factors. Though it is hard to guess what the R^2 would be without them, the fit of the model to Indian data does not seem to be far from the benchmarks set by the literature. Overall therefore the gravity model performs well for India and both size and distance play important roles in shaping India's direction of trade.

Let us first look at the estimates by using OLS. The first point to note is that the core gravity model can explain about 65 percent of India's direction of trade. Secondly, since all coefficients are significant.

Coefficients:

	Estimate	**Std. Error**	**t value**	**Pr(>|t|)**
(Intercept)	-30.690560	0.823525	-37.27	<2e-16 ***
GDP_I	1.307004	0.034361	38.04	<2e-16 ***
GDP_J	0.495824	0.006764	73.30	<2e-16 ***
DIST	-0.590906	0.039881	-14.82	<2e-16 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.699 on 4586 degrees of freedom

Multiple R-squared: 0.6506, Adjusted R-squared: 0.6504

F-statistic: 2847 on 3 and 4586 DF, p-value: < 2.2e-16

Gravity Model with Dummy variables

As Study had noted that the value of R^2 is 0.72 which increased from 0.65. Dummy variables included in the study have significant impact on India's trade except foreign exchange as FX is insignificant.

Coefficients:

	Estimate	**Std. Error**	**t value**	**Pr(>|t|)**	
(Intercept)	-2.928e+01	7.620e-01	-38.431	< 2e-16	***
GD	1.338e+00	3.068e-02	43.602	< 2e-16	***
GDP	4.471e-01	7.115e-03	62.847	< 2e-16	***
DIST	-8.024e-01	4.226e-02	-18.987	< 2e-16	***
LNG	-2.320e-01	7.233e-02	-3.207	0.00135	**
CONT	-7.128e-01	1.388e-01	-5.135	2.94e-07	***
COL	1.028e+00	6.437e-02	15.974	< 2e-16	***
LL	-9.910e-01	5.867e-02	-16.893	< 2e-16	***
AGR	2.174e-01	5.355e-02	4.059	5.01e-05	***
FX	-4.638e-10	2.478e-09	-0.187	0.85152	
LPI	1.149e+00	5.717e-02	20.094	< 2e-16	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.511 on 4579 degrees of freedom

Multiple R-squared: 0.7241, Adjusted R-squared: 0.7235

F-statistic: 1202 on 10 and 4579 DF, p-value: < 2.2e-16

Fixed Effect

Use fixed-effects (FE) whenever you are only interested in analyzing the impact of variables that vary over time. FE explores the relationship between predictor and outcome variables within an entity. Each entity has its own individual characteristics that may or may not influence the predictor variables.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-35.25831	5.234047	-6.736339	0.0000
GD	1.234117	0.037181	33.19246	0.0000
GDP	0.607228	0.045750	13.27277	0.0000
DIST	-0.046475	0.598692	-0.077628	0.9381

Effects Specification			
Cross-section fixed (dummy variables)			
R-squared	0.858438	Mean dependent var	-0.874339
Adjusted R-squared	0.852558	S.D. dependent var	2.872965
S.E. of regression	1.103165	Akaike info criterion	3.073506
Sum squared resid	5361.986	Schwarz criterion	3.331332
Log likelihood	-6869.696	Hannan-Quinn criter.	3.164262
F-statistic	146.0009	Durbin-Watson stat	0.832333
Prob(F-statistic)	0.000000		

Gravity Model with FGLS

Coefficients:

	Estimate	**Std. Error**	**t value**	**Pr(>|t|)**
(Intercept)	-31.564703	0.773408	-40.81	<2e-16 ***
GD	1.343612	0.031670	42.43	<2e-16 ***
GDP	0.513591	0.006317	81.30	<2e-16 ***
DIST	-0.609916	0.038723	-15.75	<2e-16 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.738 on 4586 degrees of freedom

Multiple R-squared: 0.6896, Adjusted R-squared: 0.6894

F-statistic: 3396 on 3 and 4586 DF, p-value: < 2.2e-16

Selection of Model

Table 3 presents the result of Hausman test for random effects model. Test result indicates the hypothesis "Random effect model is appropriate" has been accepted. Thus, we decide to select random effects model and focus the interpretation on estimation results obtained from this model.

Table 1 Hausman Test

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	4.909089	3	0.1786

If the p-value is < 0.05 then the fixed effects model is a better choice.

Random Effect

One-way (individual) effect Random Effect Model
(Swamy-Arora's transformation)

Coefficients:

	Estimate	Std. Error	z-value	Pr(>|z|)	
(Intercept)	-33.631605	1.377136	-24.4214	< 2e-16	***
GD	1.329034	0.024028	55.3118	< 2e-16	***
GDP	0.532867	0.021199	25.1360	< 2e-16	***
DIST	-0.366065	0.147326	-2.4847	0.01297	*

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Total Sum of Squares: 12852

Residual Sum of Squares: 5587

R-Squared: 0.56626

Adj. R-Squared: 0.56597

Chisq: 5963.58 on 3 DF, p-value: < 2.22e-16

Conclusion

The major conclusions that emerged from the study are as follows:

1. Best fitted model to measure India's trade direction after LPG policy (after1990) would be Random effect model rather than Fixed or pooled effect model as the India's trade data shown multicoliniarity and hetroscedisticity problem. Hausman test suggested to uses Random Effect model for India's DOT.

2. Market size of the trading partner responds significantly in India's trade.

3. Logistics performance Index plays significant role in India's trade direction with respect to that that LPI of trading partner must have high LPI than India had.

4. Colonial heritage is still an important factor in determining India's trade direction.

	Coefficient	GDP India	GDP Partner	Dist.	R2	Adjusted R2
Basic Model-OLS	-30.69056	1.307004	0.495824	-0.590906	0.6506	0.6504
Augmented - OLS	-2.93E+01	1.34E+00	4.47E-01	-8.02E-01	0.7241	0.7235
Fixed Effect Model	-35.25831	1.234117	0.607228	-0.046475	0.858438	0.852558
FGLS	-31.564703	1.343612	0.513591	-0.609916	0.6896	0.6894
Random Effect Model	-33.631605	1.329034	0.532867	-0.366065	0.56626	0.566

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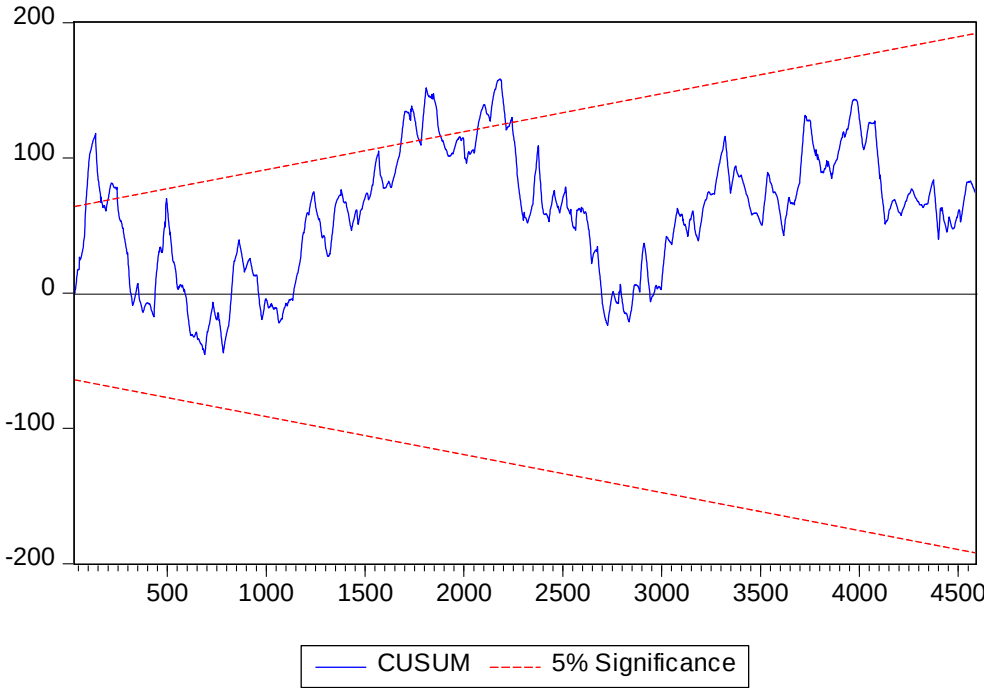
Stability of Dependent variable



Correlation

	TR	*GD*	*GDP*	*DIST*	*LNG*	*CONT*	*COL*	*LL*	*AGR*	*FX*	*LPI*
TR	1.00										
GD	0.42	1.00									
GDP	0.73	0.13	1.00								
DIST	-0.26	0.00	-0.19	1.00							
LNG	-0.10	0.00	-0.22	0.30	1.00						
CONT	0.13	0.00	0.15	-0.43	-0.11	1.00					
COL	0.02	0.00	-0.21	0.02	0.61	0.08	1.00				
LL	-0.19	0.00	-0.08	-0.22	-0.08	0.06	-0.11	1.00			
AGR	0.20	0.00	0.26	-0.06	0.15	0.23	0.10	0.03	1.00		
FX	-0.02	-0.04	0.00	0.01	-0.01	0.00	-0.02	-0.01	0.01	1.00	
LPI	0.42	0.00	0.39	-0.04	-0.04	-0.04	-0.08	-0.11	0.02	-0.01	1.00

VIF

TR	*VIF*
GD	1.025000
GDP	1.477129
DIST	1.475486
LNG	1.925623
CONT	1.319274
COL	1.768970
LL	1.107426
AGR	1.197308
FX	1.002595
LPI	1.222756

Heteroskedasticity test:

studentized Breusch-Pagan test

data: AB01

BP = 365.52, df = 10, p-value < 2.2e-16

Results shown there is hiteroscedisticiy in the data. If the p-value is less than the level of significance (in this case if the p-value is less than α=0.05), then you reject the null hypothesis. Since 2.2e-16< 0.05, we can reject the null hypothesis.