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Gravity Estimation Model and Trade Intensity

Pritam Chatterjee

Contractual Full Time Lecturer, Sarojini Naidu College for Women

Abstract: **In terms of economic development, it makes a difference whether export increases at the extensive (new trade flows) or intensive margin (traditional, well-established trade flows)Global Economic Crisis, starting from US, then Europe, really started to showing its effect on 2008.Not only the GDP declines, but also world trade declines rapidly. This paper tries to explain whether simple Gravity Estimation Model can explain factor responsible for Trade Intensity or not. Gravity Estimation analysis is done for two separate periods-pre crisis and post crisis. Time period is 2003-2012,from these,2003-2007 is the pre-crisis period and 2008-2012 is the crisis and post crisis period. The analysis is done for Emerging Market Economies as EMEs are fastest growing economy.**

JEL CLASSIFICATIONS-C1, F1.

Keywords: **Crisis, Bilateral Trade, Emerging Market Economy, Gravity Model.**

1. INTRODUCTION

During economic crises, a fall in international trade can affect new flows as well as traditional ones. Using simple measures of extensive and intensive margins, the analysis in the previous chapter shows that decline in exports from emerging market economies is largely on account of decline in intensive margins with traditional trading partners. Even if new trading partners have emerged during the crisis period, the bilateral intensities of new partners are low. The results imply that such decline in trade margins is largely on account of trade contraction that happened during crises. This paper investigates into the factors determing trade intensities based on gravity model estimation .The analysis is done for 32 Emerging Market Economies.

Table a: List of all Emerging Market Economies

Sl. No.	Name of the countries	Sl. No.	Name of the countries
1	Argentina	17	Nigeria
2	Brazil	18	Oman
3	Bulgaria	19	Pakistan
4	China	20	Peru
5	Colombia	21	Poland
6	Egypt	22	Qatar
7	Hungary	23	Russia
8	Jordan	24	Romania
9	Indonesia	25	South Africa
10	India	26	Turkey
11	Kazakhstan	27	Tunisia
12	Latvia	28	Thailand
13	Lithuania	29	UAE
14	Mauritius	30	Ukraine
15	Malaysia	31	Venezuela
16	Mexico	32	Vietnam

This paper is structured as follows. Apart from the introduction, section 1.2 details out gravity estimation model from the literature. Section 1.3 delineates the method and data used in this chapter. Section 1.4 describes the details of estimation results and finally, section 1.5 provides the summary of findings.

2. GRAVITY ESTIMATION MODEL

The gravity model of trade in international economics, similar to other gravity models in social science, predicts bilateral trade flows based on the economic sizes (often using GDP measurements) and distance between two units. The model was first used by Jan Tinbergen in 1962. The basic model for trade between two countries (i and j) takes the form of

$$F_{ij} = G(M/D)$$

where F is the trade flow, M is the economic mass of each country, D is the distance and G is a constant. The model has also been used in international trade to evaluate the impact of treaties and alliances on trade, and it has been used to test the effectiveness of trade agreements and organizations such as the North American Free Trade Agreement (NAFTA) and the World Trade Organization (WTO).

The traditional gravity equation for trade was later theoretically founded by Anderson (1979) and Anderson and van Wincoop (2003) to include multilateral resistance terms. This model has a long tradition of successfully explaining bilateral trade patterns among countries. Empirically the size of each country (proxied by the GDPs of the two countries) as well as the distance between them (proxy for bilateral trade cost) has successfully explained much of the variation in bilateral exports between countries. The theoretical basis for these findings is grounded on the premise that the most important determinants of bilateral trade are size and trade costs. The above studies have used stochastic version of the canonical gravity equation, which is

$$X_{ij} = \emptyset_0 Y_i \emptyset_1 Y_j \emptyset_2 Z_{ij} \emptyset_3 n_{ij}$$

where φ_0 ,φ_1 ,φ_2 and φ_3 are unknown parameters to be estimated, η_{ij} is an error factor assumed to be statistically independent of the regressors with $E(\eta_{ij}|y_i, y_j, Zi_j)=1$. The traditional equation as stated in *(1)* indicates that trade flow from country *i* to country *j* (i.e. *Xij*) is proportional to the economic mass/size of both the exporting and importing countries (proxied by the product of the two countries GDP, denoted as *Yi* and *Yj*) and inversely proportional to the distance between them, *Zij* (broadly defined to include all factors that pose as resistance to trade and thereby impose trade costs).

Bergstrand (1985 and 1989) shows that a gravity model is a direct implication of a model of trade based on monopolistic competition developed by Paul Krugman (1980). In this model, identical countries trade differentiated goods because consumers have a preference for variety. Models with monopolistic competition overcome the undesirable feature of Armington models whereby goods are differentiated by location of production by assumption. Firm location is endogenously determined and countries are specialized in the production of different sets of goods. Deardorff (1998) shows that a gravity model can arise from a traditional factor proportions explanation of trade. Eaton and Kortum (2002) derive a gravity-type equation from a Ricardian type of model, and Helpman et al. (2008) and Chaney,(2008) obtained it from a theoretical model of international trade in differentiated goods with firm heterogeneity. In its general formulation, the gravity equation has the following multiplicative form:

$$X_{ij} = GS_i M_j \emptyset_{ij}$$

where Xij is the monetary value of exports from *i* to *j*, Mj denotes all importer-specific factors that make up the total importer's demand (such as the importing country's GDP) and S_i comprises exporter-specific factors (such as the exporter's GDP) that represent the total amount exporters are willing to supply. G is a variable that does not depend on *i* or *j* such as the level of world liberalization. Finally, φ_{ij} represents the ease of exporter *i* to access of market *j* (that is, the inverse of bilateral trade costs).

As argued by Anderson and van Wincoop (2003), by not taking into account multilateral resistance terms (i.e. relative prices), the traditional gravity equation had not been correctly specified. The motivation behind this argument stemmed from the highly overstated impact of national borders found by McCallum (1995) resulting from estimating the traditional gravity equation for bilateral trade between United States and Canada. McCallum (1995) estimated a version of equation for U.S. states and provinces of Canada with two *z* variables (bilateral distance and a dummy variable that is equal to one if the two regions are located in the same country and equal to zero otherwise). After controlling for distance and size McCallum found trade between provinces to be twenty-two times more than trade between states and provinces, suggesting that there were substantial trade costs incurred in trade across the United States-Canada border. Anderson and van Wincoop's (2003) theory-based gravity equation was therefore a theoretical refinement of the traditional gravity model to include multilateral trade resistance variables. As suggested by Anderson and Van Wincoop (2003), one way of

augmenting the traditional gravity equation with multilateral resistance terms is to include exporter and importer fixed effects leading to the stochastic theory based gravity equation of the form

$$Xij = \emptyset_0 Y_i^{\emptyset_1} Y_j^{\emptyset_2} Z_{ij}^{\emptyset_3} e^{\propto_i d_i + \propto_j d_j}$$

where all φ's are unknown parameters to be estimated, and *di* and *dj* are exporter and importer dummies and $\varphi_1 = \varphi_2 = 1$ (unit-income elastic). Anderson and van Wincoop's (2003) theory-based gravity equation has been widely used by various authors to explain the pattern of bilateral trade amongst countries.

In addition to augmenting the traditional gravity equation with multilateral resistance terms in an attempt to fully explain bilateral trade amongst countries, the traditional specification as well as the theory-based gravity equations has been subjected to further augmentation to include other factors that are deemed significant determinants of trade costs and volumes. Most studies that have made use of the gravity equation have augmented it with various measures of distance and country characteristics, as well as measures of trade facilitation, infrastructure and logistics.

Turkson(2011) presented a paper on bilateral trade and augmented gravity model. The approach to estimate the impact of logistics, trade facilitation and infrastructure on bilateral trade has been to include variables that seek to measure physical infrastructure, trade facilitation and logistics in the gravity equation. In an attempt to investigate the relationship between logistics and bilateral trade using the new index of logistics developed by the World Bank, Behar and Manners (2008) estimated by least squares alogarithm-transformed logistics augmented gravity equation of the form;

$$X_{ij} = \beta_0 + \beta_1 Y_i + \beta_2 Y_j + \beta_3 d_{ij} + \beta_4 l_i + \beta_5 l_j + \gamma W + e_{ij}$$

As indicated in the equation the authors linked bilateral exports (X_{ij}) to the GDPs of the exporting and importing countries (y_i and y_j respectively), the distance between them (d_{ij}), logistics indicators for the exporter and importer (l_i and l_j respectively), and a vector *W* of controls that measure aspects of distance and other country characteristics. In addition, Behar and Manners included terms for neighbouring countries infrastructure and interactions between logistics and whether a country was landlocked.

Helpman et al. (2008) extends Heckman's estimation method to also take into account the bias associated with the heterogeneity of firms. The authors develop a complete theoretical framework from which they obtain an empirical specification of the gravity equation. Their model accounts for firm heterogeneity, trade asymmetries and fixed trade costs, suggesting that the decision to export (extensive margin) and the volume of exports (intensive margin) are not independent variables. The model allows both 7 positive and zero trade flows between countries to be predicted and it also allows exports to vary according to the destination country. Helpman et al. (2008) describe a varying distribution of firms where each firm is bounded by a marginal exporter who breaks even by exporting to another country. The underlying idea is that if at least one firm in the country is productive enough to export, country-level exports in that case will be positive. Hence, zero exports are originated by countries where firms are not productive enough to export profitably. In this manner, information that would normally require firm-level data is extracted from country-level data.

There is a huge number of empirical applications in the literature of international trade, which have contributed to the improvement of performance of the gravity equation. Some of them are closer related to our work. First, in recent papers, Chen and Wall (1999), Breuss and Egger (1999) and Egger (2000) improved the econometric specification of the gravity equation. Second, Berstrand (1985), Helpman (1987), Wei, (1996), Soloaga and Winters (1999), Limao and Venables (1999), and Bougheas et al, (1999) among others, contributed to the refinement of the explanatory variables considered in the analysis and to the addition of new variables.

In this chapter, gravity model is used in its simplest form. Here bilateral export is made to depend on GDP of both the trading countries and bilateral distance. The model is improved by including per capital GDP of the trade partners. While estimating the gravity model, estimations are done separately for the pre crises and post crises periods. The basic equations of this used can be written as-

$$logBE = \alpha_0 + \alpha_1 logGDP_i + \alpha_2 logGDP_j + \alpha_3 logBTD + \mu_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\log BE = \alpha_0 + \alpha_1 logPCGDP_i + \alpha_2 logPCGDP_j + \alpha_3 logBTD + \mu_{it} \ldots\ldots\ldots\ldots\ldots (2)$$

where

BE=Bilateral Export

GDP_i=GDP of Export Country

GDP_j=Partner countries GDP

$PCGDP_i$=Per Capita GDP of Export Country

$PCGDP_j$=Partner countries Per Capita GDP

BTD=Bilateral Trade Distance

μ_{it} =Error term

The above two equations will be used for estimation.

3. THE METHOD AND THE DATA

While estimating, only the Pooled OLS estimator is used. The two other most frequently used panel estimators for continuous dependent variables, the random effects estimator and the fixed effects estimator, can be used and hence, are outlined. Followingly, the Hausman-test is performed. which can be considered to be an estimator in between the fixed andrandom effects approach. The presentation of the estimators is followed by the outline of two statistical tests that can be used to decide on which estimator is the appropriate one to base the findings upon. In particular, both the Breusch-Pagan test tests for random effects and the Hausman test are presented, the latter being useful for the choice of either the random effects model, the fixed effects model .

The equation for the fixed effects model becomes: $Yit = \beta_1 X_{it} + \alpha_i + u_{it}$

where α_i (i=1….n) is the unknown intercept for each entity (n entity-specific intercepts) and

Y_{it} is the dependent variable (DV) with i = entity and t = time,

X_{it} represents one independent variable,

u**it** is the error term

The random effects model is: $Y_{it} = \beta X_{it} + \alpha + u_{it} + \varepsilon_{it}$

Random effects assume that the entity's error term is not correlated with the predictors which allows for time-invariant variables to play a role as explanatory variables. In random-effects you need to specify those individual characteristics that may or may not influence the predictor variables. The problem with this is that some variables may not be available therefore leading to omitted variable bias in the model.

To decide between fixed or random effects, run a Hausman test where the null hypothesis is that the preferred model is random effects vs. the alternative the fixed effects It basically tests whether the unique errors (u_i) are correlated with the regressors, the null hypothesis is they are not. The Breusch-Pagan test helps to decide between a random effects regression and a simple OLS regression.

The data that are being used in the estimation exercise and their source are as follows:

BILATERAL EXPORT – WITS Database.

GDP_i and GDP_j ($PCGDP_I$ and $PCGDP_j$) – WITS Database.

DISTANCE – CEPII Database. As observed in Chapter 1, this database is used to measure geographical distance between two countries (www.**cepi**i.fr/**cepi**i/en/bdd_modele/bdd.asp).

4. THE RESULTS

The estimations give very confusing results both for the pre- and post crises periods (see Tables 4.1 to 4.2). The Tables 1a and b and Tables 2 a and b are different, the differences being based on Equations 1 and 2. The model does not explain the variations in the data well where pooled OLS method or panel data estimation methods are used. The results do not seem to improve significantly different in the post crises period. It can be said from the tables that Random effects model in all cases are rejected. In all cases, fixed effects model is found to be appropriate. The coefficients of the independent variables vary from one model to the other and also between alternate methods of estimation. The results hint at the inappropriateness of the simple gravity model in explaining differences in bilateral trade across countries between the pre and post crises periods.

5. SUMMARY OF FINDINGS

The above results based gravity model estimation does not prove anything conclusive in explaining the differences in bilateral exports between the pre- and post-crises periods. The simple gravity model is thus inappropriate in explaining differences in bilateral trade across countries. The inappropriateness of the results across specifications is largely on account large number of omitted variables that are present in augmented gravity specification. The other source of inappropriateness of the results could be the short period covered in each regression.

Table 1a: Estimation Results for Pre Crisis Period(2003-2007)

	Dependent Variable-Bilateral Export		
Variables/Methods	POOLED OLS	FIXED EFFECTS	RANDOM EFFECTS
Log of Trade Distance	-0.031 (0.029)	0.01 (0)	-0.020 (0.049)
Log of GDP	0.822 (0.017)	0.134 (0.133)	0.787 (0.028)
Log of GDP of partner countries	0.007 (0.010)	0.533 (0.089)	0.034 (0.016)
Constant Included	YES	YES	YES
Hausman Test	P (chi square)=0.002		
Breusch-Pagan Test	P(chi square)=0		
Observations	21983	21983	21983
R^2	0.0936	0.0022	0.0933

Note: The figure listed here are the coefficient value.Figures in the parentheses indicates standard errors

Table 1b: Estimation Results for Pre Crisis Period(2003-2007)

	Dependent Variable-Bilateral Export		
Variables/Methods	POOLED OLS	FIXED EFFECTS	RANDOM EFFECTS
Log of Trade Distance	0.149 (0.030)	0.01 (0)	0.138 (0.052)
Log of Per Capita GDP	-0.055 (0.021)	0.044 (0.11)	-0.088 (0.033)
Log of Per Capita GDP of partner countries	0.628 (0.0008)	0.491 (0.0004)	0.039 (0.013)
Constant Included	YES	YES	YES
Hausman Test	P(chi square)=0.001		
Brusch-Pagan Test	P(chi square)=0.001		
Observations	21983	21983	21983
R^2	0.0019	0.0006	0.0019

Note: The figure listed here are the coefficient value.Figures in the parentheses indicates standard errors

Table 2a: Estimation Results for Post Crisis Period (2008-2012)

	Dependent Variable-Bilateral Export		
Variables/Methods	POOLED OLS	FIXED EFFECTS	RANDOM EFFECTS
Log of Trade Distance	-0.084 (0.030)	0.038 (0.068)	-0.028 (0.042)
Log of GDP	0.825 (0.018)	-0.333 (0.073)	0.621 (0.028)
Log of GDP of partner countries	-0.007 (0.010)	0.083 (0.145)	0.023 (0.017)
Constant Included	YES	YES	YES
Hausman Test	P(chi square)=0.0021		
Breusch-Pagan Test	P(chi square)=0.002		
Observations	21763	21763	21763
Value of R^2	0.0872	0.0738	0.0865

Note: The figure listed here are the coefficient value.Figures in the parentheses indicates standard errors

Table 2b: Estimation Results for Post Crisis Period (2008-2012)

	Dependent Variable-Bilateral Export		
Variables/Methods	POOLED OLS	FIXED EFFECTS	RANDOM EFFECTS
Log of Trade Distance	0.063 (0.031)	0.038 (0.068)	0.039 (0.043)
Log of Per Capita GDP	-0.121 (0.031)	-0.346 (0.057)	-0.165 (0.031)
Log of Per Capita GDP of partner countries	0.006 (0.008)	0.006 (0.011)	0.0095 (0.0093)
Constant Included	YES	YES	YES
Observations	21763	21763	21763
Hausman Test	P(chi square)=0.0021		
Breusch-Pagan Test	P(chi square)=0		
R^2	0.0020	0.0018	0.0019

Note: The figure listed here are the coefficient value. Figures in the parentheses indicates standard errors

6. CONCLUSIONS AND POLICY IMPLICATIONS

The world economy started slowing down since the third quarter of 2008 leading to an economic crisis worldwide. GDP declined from an average growth of 3 per cent during 2003-2007 to 1.5 per cent during 2008-2012. The decline of world GDP growth was the sharpest at 42 per cent during the third quarter of 2008 to the second quarter of 2009. Not only capital inflows to developing and emerging market economies declined during this period, there has been significant shrinking of markets for developing country exports. World trade declined rapidly beginning in the third quarter of 2008 through the second quarter of 2009. World trade declined in real terms by 12.2 per cent during 2008-2010, with a larger decline of 30 per cent in world trade between the third quarter of 2008 and the last quarter of 2009 (UNCTAD, 2009). This recent global economic slowdown originated in the financial sector of the United States, where the housing market sold sub-prime mortgages to large number of consumers with inadequate income. The financial crisis very rapidly spreaded to real sector in the US economy. The economic crises spreaded to Europe and then to rest of the world. There was a short-lived recovery in 2010, but the global economy slipped into deep recession in the latter half of 2011.

The aim of this study was to find whether the recent economic crisis has adversely affected trade in emerging market economies. In specific, the study investigates into whether economic slowdown consequent upon recent global economic crises has impacted trade performance of these economies at the intensive and extensive margins. Further, it is important to gauge the factors that explain bilateral trade intensities during crises.

On the whole, with economic crises since 2008 and deepening of recession, GDP growth declined worldwide, with larger fall in emerging market and developing countries. The current position worsened across emerging market and developing economies, except China and some ASEAN countries. Further evidence points to declining growth of export of goods and services, merchandise exports in particular. This evidence leads to a further probe of what accounts for such declining export growth during crises.

The results based gravity model estimation does not prove anything conclusive in explaining the differences in bilateral exports between the pre- and post crises periods. The simple gravity model is thus inappropriate in explaining differences in bilateral trade across countries. The inappropriateness of the results across specifications is largely on account large number of omitted variables that are present in augmented gravity specification. The other source of inappropriateness of the results could be the short period covered in each regression.

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