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Trade Flows of Bangladesh: A Gravity Model Approach

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Abstract

This study gives an overview of different methodologies related to gravity model analysis in Bangladesh trade flow. A pooled cross section and time series data were analyzed to incorporate the country specific heterogeneity in country pair trading partners. The trade flows are justified by the basic gravity model since Bangladesh trade is positively significant by the economy size and inversely related to trade barrier. Accordingly, pooled ordinary least square, fixed effect and random effect methods are implied. This study also explores extended gravity model that depicts trade is determined by the gross domestic product, openness of the economy and exchange rate. In addition, cross section results show that regional trade arrangement which is South Asian Association for Regional Co-operation and border are significant for Bangladesh trade.

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1. Introduction

Trade is an integral part of the total national development and growth of an economy. This is in fact a crucial instrument for industrialization while access to foreign exchange is essential for sustained economic development. Trade policy works by inducing substitution effects in the production and consumption of goods and services through changes in price. Trade liberalization is also seen as expanding economic opportunities by enlarging the market size and enhancing the impact of knowledge spillover. Although the foreign trade sector of Bangladesh constitutes an important part of its economy, the country suffers from a chronic deficit in her balance of payments. The trade relations of Bangladesh with other countries, especially with South Asian Association for Regional Co-operation (SAARC) countries, do not show any hopeful sign for the desirable contribution to country's economic development.

Hossain (2009) analyzed the impact of South Asian Free Trade Area (SAFTA) on Bangladesh in terms of export generation within member countries. From the estimated result, it was observed that Bangladesh has huge export potential to South Asia in general, and India in particular. In terms of imports, Bangladesh has exceeded its potential level. Rahman (2003) applied the generalized gravity model to analyze Bangladesh trade with its major trading partners using the panel data estimation technique. The results showed that Bangladesh trade is positively determined by the size of the economies and openness of the trading countries.

Therefore, this study attempts to provide a synopsis of Bangladesh trade using panel data estimation technique. We have applied extended gravity model for the analysis. As a reminiscence of Isaac New-ton's law of gravity, the trade version of the latter represents a reduced form which comprise supply and demand factors, like Gross Domestic Product (GDP) or Gross National Product (GNP) and population, as well as trade resistance (geographical distance, as a proxy of transport costs and home bias) and trade preference factors (preferential trade agreements, common language, common borders). Because of its appeal as an empirical strategy its application has became enormously popular. Quoting by Eichengreen and Irwin (1997), the gravity model is nowadays '... the workhorse for empirical studies ...' in international trade. Since early 1990s, the large availability of international data, it is necessary to fill the standard specification of the model.

In the basic form of the gravity equation, trade between a pair of countries is modeled as an increasing function of their sizes and a decreasing function of the distance between the two countries. This simple framework explains most of the variations in observed volumes of trade flows.

2. Data

This study covers a total of 14 countries including Bangladesh and other 13 countries those who have the bilateral trade agreement with Bangladesh. The other countries are India, Nepal, Sri Lanka, Indonesia, Malaysia, Singapore, Thailand, Canada, USA, France, Germany, Kuwait, and Saudi Arabia. The data collected for the period of 1991 to 2007 (17 years). We cannot go beyond this period because of data limitation. All observations are annual and a balance panel of 221 observations. Data on the distance (in kilometer) between Dhaka (capital of Bangladesh) and other capital cities of country j has been collected from a distance calculation. GDP is in (based on 2005=100) million US dollars has been obtained from world development indicator (national accounts). Bangladesh trade are measured in million US dollars have been collected from Bangladesh Bank (2010). Data on the exchange rates are converted in national currency per US dollar for all countries, obtained from the Bangladesh Bank (2010).

3. Methodology and Estimated Results

3.1. The Fixed Effects Estimator

The term fixed effect is due to the fact that each country's intercept does not vary over time, that is, it is time invariant. The basic framework for this discussion is a regression model of the form:

$$y_{it} = x_{it}\beta + \alpha_i + \varepsilon_{it} \;;\; \text{i=1,2,…,n} \quad \text{t=1,2,…,T} \tag{1}$$

If $\alpha_i = \alpha$ contains only a constant term, then ordinary least squares provides consistent and efficient estimates of the common α and the slope vector β . This is the pooled ordinary least square estimator (OLS). If α_i is unobserved, but correlated with x_{it}, then the least squares estimator of β is biased and inconsistent as a consequence of an omitted variable. This fixed effects approach takes α_i to be a group-specific constant term in the regression model. Fixed effects methods completely ignore the between-country variation and focus only on the within-country variation.

Assumptions about unobserved terms are: α_i freely correlated with x_{it} and E ($x_{it}u_{is}$) = 0 for s = 1,2,… ,T (strict exogeneity).

To see how the fixed effect estimator solves the endogeneity problem that would contaminate the OLS estimates, we begin by taking the average over time of equation(1) for each individual - this gives

$$\bar{y}_i = \bar{x}_i\beta + \alpha_i + \bar{\varepsilon}_i \tag{2}$$

Now subtracting equation (2) from (1), we have

$$y_{it} - \bar{y}_i = (x_{it} - \bar{x}_i)\beta + (\varepsilon_{it} - \bar{\varepsilon}_i) \tag{3}$$

This transformation of the original equation, known as the *within transformation*, has eliminated α_i from the equation.

Hence, we can estimate β consistently by using OLS on equation (3). This is called the within estimator or the Fixed Effects estimator.

3.2. The Random Effects Estimator

Individuality of each country or cross sectional unit can be measured by letting the intercept vary for each country and assuming the slope coefficients are constant over time.

$$y_{it} = x_{it}\beta + \alpha_1 + u_i + \varepsilon_{it} \quad \text{i=1, 2,…,n; t=1,…,T.} \tag{4}$$

Where, there are k regressors including a constant term and now the single constant term is mean of the unobserved heterogeneity. The component u_i is the random heterogeneity specific to the ith observation and is constant through time. Assumptions are as follows:

$E[\varepsilon_{it} \mid X] = E[u_i \mid X] = 0\, E[\varepsilon_{it}{}^2 \mid X] = \sigma_{\varepsilon}{}^2, E[u_i{}^2 \mid X] = \sigma_u{}^2, E[\varepsilon_{it} u_j \mid X] = 0,$

$E[\varepsilon_{it}\varepsilon_{js} \mid X] = 0, E[u_i u_j \mid X] = 0,$ for all i, t and j.

3.3. Gravity Model

This model originates from the Newtonian physics notion. Newton's gravity law in mechanics states that two bodies attract each other proportionally to the product of each body's mass (in kilograms) divided by the square of the distance between their respective centers of gravity (in meters).The gravity model for trade is analogous to the law. The analogy is as follows: 'the trade flow between two countries is proportional to the product of each country's economic mass, generally measured by GDP, each to the power of quantities to be determined, divided by the distance between the countries respective economic centers of gravity, generally their capitals, raised to the power of another quantity to be determined. This formulation can be generalized to

$$X_{ij} = KY_iY_jD_{ij} \tag{5}$$

Where X_{ij} is the trade flow of country i to country j , Y_i and Y_j are country i's and country j's GDPs and D_{ij} is the geographical distance between the countries capitals.

The linear form of the model is as follows:

$$\log X_{ij} = \alpha + \beta \log Y_i + \gamma \log Y_j + \delta \log(D_{ij}) \tag{6}$$

Where, α = logk.

Most estimates of gravity models add a certain number of dummy variables to equation (6) that test for specific effects, for example being a member of a trade agreement, sharing a common land border, speaking the same language and so on. For the trade model we have followed, Frankel and Wei (1993), Sharma and Chua (2000) and Hasan (2001). Since the dependent variable in the gravity model in bilateral trade (sum of exports and imports) between the pairs of countries, the product of GDP has been used as independent variables.

To test for p distinct effects, the model then becomes:

$$\log X_{ij} = \alpha + \beta \log Y_i + \gamma \log Y_j + \delta \log(D_{ij}) + \sum_{s=1}^{p} \lambda s G s \tag{7}$$

For the gravity model of Bangladesh's trade, the following model is considered:

$$LTrade_{ijt} = \beta_{0i} + \beta_1 L(GDP_{it} * GDP_{jt}) + \beta_2 LDist_{ij} + \beta_3 LExrate_{ijt} + \beta_4 Tr/GDP_{it} + \beta_5 Tr/GDP_{jt} + \delta_1 D_{1ijt} + \delta_2 D_{2ijt} + U_{ijt} \quad (8)$$

Here, i=Bangladesh ; j=1,2,…,13; t=1,2,…,17.

Where, L=natural log, t=time point, $Trade_{ijt}$ =bilateral trade between Bangladesh(country i) and country j at time t, GDP_{it} =gross domestic product for country Bangladesh(i), GDP_{jt} =GDP for country j, $PCGDP_{it}$ =per capita GDP for country i , $PCGDP_{jt}$ =per capita GDP for country j, $Dist_{ij}$ =distance between two country, $Exrate_{ijt}$ =exchange rate, Tr/GDP_{it} = trade GDP ratio for country i, Tr/GDP_{jt} = trade GDP ratio for country j, D_{1ijt} =dummy variable which is unity if both countries i(Bangladesh) and j belongs to SAARC at time t, and 0 otherwise, D_{2ijt} =dummy variable which is unity if two countries (Bangladesh and j) share the common border and 0 otherwise, U_{ijt} is log normally distributed with E [$\ln u_{ijt}$]=0.

3.4. Estimation Results

The Gravity model of Bangladesh trade in equation (8) has been estimated taking all explanatory variables except distance and dummy variable. Then the model is estimated by OLS and the estimated model represents the elasticity of dependent variable with respect to independent variable due to its log-linear structure.

Table1.Gravity variables only

Variables	coefficients	Robust standard error	p value	t-ratio
Importer's GDP	2.183	0.364	0.000	6.00
Exporter's GDP	0.795	0.054	0.000	14.72
Geographic distance	-0.472	0.111	0.000	-4.25

R-square = 0.623, the result of Akaike information criteria (AIC) = 675.613, Bayesian Information criteria (BIC) = 689.21.

The Breusch-Pagan test is designed to detect any linear form of heteroskedasticity. Breusch-Pagan / Cook-Weisberg test for heteroskedasticity with H_0: Constant variance shows that Chi-square (1) = 7.95 and Prob > chi-square = 0.0048. That is, heteroscedasticity possesses. Thus table 1 depicts the robust standard errors through the remedial of heteroscedasticity by Breusch-Pagan approach (Greene, 1997).

According to trade model, table 1 depicts that all estimated coefficients on the levels of GDPs and the distance show highly significant at 1 percent level with the expected sign. The estimated results of basic gravity model represents Bangladesh trade flow is positively determined by the home and foreign country's GDP and negatively determined by the trade impediment factor, distance.

In this trade model, the intercept term β_{0i} are considered to be country specific and the slope coefficients are considered to be the same for all countries for fixed effect estimation technique. The intercept terms in random effect model are considered to be random variables, instead of treating β_{0i} as fixed country specific variables, and the slope coefficients are considered to be the same for all countries (Rahman, 2003).

The basic gravity model includes only GDP and distance. But in this study, we have used extended gravity model by including more variables rather than GDP and distance. The simplest, and possibly naive, approach is to disregard the space and time dimensions of the pooled data and just estimate the usual OLS regression.

Table2. Pooled OLS without dummy

Variables	coefficients	standard error	p value	t-ratio
GDPi*GDPj	0.757	0.042	0.000	18.02
Trade/ GDPi	0.205	0.086	0.019	2.38
Trade/GDPj	3.652	0.301	0.000	12.13
Exchange rate	0.100	0.024	0.000	4.17

R-square = 0.794, AIC = 38.03 and BIC=40.29.

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity Ho: Constant variance shows that Chi-square (1) =0.61 Prob > chi-square = 0.4348. So homoscedasticity of error variances remains in table 2.

The result of table 2 represents the extended gravity model with pooled ordinary least square (OLS). Although we have found all variables significant here but as the intercept is constant across time and country, it does not represent a good estimation.

Table 3. Fixed effect within group

Variables	coefficients	Robust standard error	p value	t-ratio
GDPi*GDPj	0.806	0 .264	0.010	3.05
Trade/ GDPi	0.063	0.182	0.071	0.35
Trade/GDPj	2.925	0.513	0.000	5.70
Exchange rate	1.088	0.554	0.073	1.96

F test that all u_i =0, F (12, 205) = 7.60, Prob > F = 0.000, AIC=460.8034, BIC=474.3961, R-square within=0.5616 between=.0747.

Modified Wald test for group-wise heteroskedasticity in fixed effect regression model with H_0: $\sigma_i^2 = \sigma^2$ for all i shows that chi-square (13) = 15841.03 and Prob>chi-square = 0.00. That is why robust standard errors are included due to removal of heteroscedasticity.

From the table 3, the coefficient of product of GDP is positive and highly significant as expected. This implies that Bangladesh tends to trade more with larger economies. Bangladesh bilateral trade with country j (any other country) increases by 0.80% (almost proportional) as the product of Bangladesh's GDP and country j's GDP increases by 1%. The trade-GDP ratio is the proxy of openness. The coefficient of this variable for country j is found large, significant at 10% level and expected positive sign. This implies that Bangladesh trade with all other countries under consideration is likely to improve very significantly with the liberalization of trade barriers in these countries. Our estimate suggests that a 1% increase in the openness of trade in j countries could increase Bangladesh trade by 18.54% [exp(2.92)=18.54] . The coefficient of this variable for country i is also found to be significant at 1% level and is very large. 1% increase in the openness of economy could increase Bangladesh trade by 1.06% [exp(0.06)=1.06], when other things held constant. The estimated coefficient of exchange rate is found significant and positive, states that 1% depreciation of Bangladesh currency increases trade by 1.08%. In table 3, we have used the model in log-linear form. The variables are interpreted in terms of percentage change. Trade-GDP ratio implies the openness of economy and by taking log it exhibits the negative value, and the exponent form is used in interpretation.

A simple Chow test with the restricted residual sums of squares (RRSS) being that of OLS on the pooled model and the unrestricted residual sums of squares (URSS) being that of the least square dummy variable (LSDV) regression, where LSDV is equivalent to the within group fixed effects. Since, LSDV suffers from an incidental parameter problem we have performed the Within transformation and use that residual sum of squares as the URSS. So fixed effect model is significant. The rejection of null hypothesis prefer fixed effect model over pooled OLS model that implies there is a correlation between unobserved effects and regressors (Baltagi, 2001)

To compare a fixed effect model and its similitude random effect model, we have used Hausman specification test that examines correlation between individual effects with the explanatory variables in the model. Chi-square (4) = 50.53, Prob>chi-square = 0.00. Rejection of null hypothesis conclude that, individual effects are correlated with the explanatory variable depicts fixed group effect model is fitted for this study.

A particular attention is given to the fact that gravity model not only contains time varying variables such as GDPs, exchange rate; but also includes time invariant variables namely distance and border. It is worth noting that fixed effect model does not allow for estimating time invariant variables because successful transformation wipes out such variables. However, the random effects treatment does allow the model to contain observed time invariant characteristics.

Table 4.Random effect model for time invariant variable

Variables	coefficients	Robust standard error	p value	z-ratio*
GDPi*GDPj	0.730	0.174	0.000	4.20
Trade/ GDPi	0.149	0.155	0.337	0.96
Trade/GDPj	3.257	0.364	0.000	8.95
Exchange rate	0.128	0.055	0.020	2.33
Geographic Distance	0.078	0.369	0.832	0.21
Border	0.774	0.350	0.027	2.21

R-square: Within country 0.516, Between country 0.9338, Overall 0.798. z-ratio*=The random effect model uses generalized least square estimation technique and hence gives the z-ratio results instead of t-ratio.

From table 4, random effect model are analyzed to explore the impact of geographic distance and border on trade flows of Bangladesh. Here it is seen that, though border dummy is positively significant but geographic distance is not significant and the sign is positive.

The Breusch-Pagan Lagrange Multiplier (LM) test is designed to test random effects. The null hypothesis of the random group effect model is that individual-specific error variances are zero. Chi-square (1) = 49.51 and Prob > chi-square = 0.00. So, we can reject the null hypothesis in favor of the random group effect model.

Table 5.Cross section results with country dummy and distance

Variables	coefficients	standard error	p value	t-ratio
SAARC	-3.483	0.795	0.002	-4.38
Border	4.482	1.130	0.003	3.97
Distance	-0.00009	0.00007	0.238	-1.29

R-square =0.7258, AIC=38.03, BIC= 40.290.

Table 5 summarizes that distance variable is not significantly contributing on Bangladesh trade,which does not support the theory of gravity model. The border dummy is found significant and has positive sign which indicates Bangladesh tends to trade more with the adjacent country India.

Breusch-Pagan test for heteroskedasticity with H_0: Constant variance shows that chi-square(1) = 0.34, Prob > chi-square = 0.56. So, homoscedasticity of error variances remains in table 5. To see if time fixed effects are needed when running a fixed effect model. It is a joint test to see if the dummies for all years are equal to zero. Here, F(16, 201) = 0.18 and Prob > F = 0.99, so we failed to reject the null hypothesis that all years coefficients are jointly equal to zero, therefore no time fixed-effects are required.

4. Conclusion

The main goal of this study is to focus on contributing factors of trade flows in Bangladesh through gravity model panel data approach. An assessment of the empirical evidence has been acquired through pooled OLS model and fixed effect model within group estimator. Further, the study explores the impact of time invariant variable under random effect model and cross section country effects.

It is found that trade model coincide with the gravity equation as GDP is positive and distance negative (ceteris paribus). On the other hand, to focus the impact of regional dummy SAARC and contiguity factor border, it was found significant influence on bilateral trade, this result is contradict with the findings of Rahman (2003). Hossain (2009) found the regional trade dummy is insignificant in trade flows. But in this study, it is explored that the SAARC dummy is significant and negative in cross-sectional analysis.

A comparison among the three estimation leads to the following conclusions. The magnitude of the coefficients in pooled and random effect estimation is notably different from those in fixed effect method. That we have encountered the problem of biased results due to ignoring country specific effects in pooled OLS and uncorrelated relationship between country specific unobserved effects and observed regressors. Country specific unobserved effects are relevant when export or import effects (like tariff and non-tariff barriers imposed by national policy) or environmental determinants that could accelerate or hinder trade flows (geographical, political or historical determinants) are present. These factors are deterministically linked to the country specific effects and cannot be considered as random or stochastic.

Moreover, the Hausman test confirms the presence of a correlation and rejects the null assumption of absence of a correlation between the individual effects and explanatory variables. On the other hand, Chow test prefers the fixed effects over pooled OLS and langrange multiplier tests suggests the random effects model instead of pooled OLS model.

In this study we have established both basic and extended gravity model which implies Bangladesh's trade flows are significantly determined by the size of the economy, openness of the economy and exchange rate, whereas random effect model and cross-sectional effects do not show any significant impact of trade impediment factor in Bangladesh trade.

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