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The Determinants of Bangladesh's Trade: Evidence from the  
Generalized Gravity Model

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## The Determinants of Bangladesh's Trade: Evidence from the Generalized Gravity Model

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### ABSTRACT

The application of the generalized gravity model in analyzing the Bangladesh's trade reveals that Bangladesh's trade is positively determined by the size of the economies, per capita GNP differential of the countries involved and openness of the trading countries. Bangladesh's exports are positively determined by the exchange rate, partner countries' total import demand and openness of the Bangladesh economy. Bangladesh's imports are determined by inflation rates, per capita income differentials, openness of the countries involved in trade and the border between India and Bangladesh. Multilateral resistance factors and transportation costs affect Bangladesh's trade positively and negatively respectively.

**JEL classification:** Gravity Model, Panel Data, Fixed Effect Model, Bangladesh's Trade  
**Key Words:** C21, C23, F10, F11, F12, F14

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## 1. Introduction

Bangladesh economy has been suffering from a chronic deficit in trade and balance of payments for a long time. The trade relations of Bangladesh with other countries, especially with SAARC countries, do not show any hopeful sign for the desirable contribution to country's economic development. Therefore this study is an attempt to find out the major determining factors of Bangladesh's trade using panel data estimation technique. We have applied the generalized gravity model for our analysis.

The gravity model has been applied to a wide variety of goods and factors of production moving across regional and national boundaries under different circumstances since the early 1940s (Oguledo and Macphée 1994). 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 this 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." (Christie 2002:1). This formulation can be generalized to

$$M_{ij} = KY_i^\beta Y_j^\gamma D_{ij}^\delta \quad (1)$$

where  $M_{ij}$  is the flow of imports into country  $i$  from 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.

In this paper, we would make an attempt, firstly, to provide a theoretical justification for using the gravity model in applied research of bilateral trade, and secondly, to apply this model in analyzing the trade pattern and trade relation of Bangladesh with its major partner countries. So the rest of the paper is organised as follows: section 2 presents theoretical justification of the model, section 3 analyses the Bangladesh's trade using panel data and the gravity model, and finally section 4 summarizes and concludes the paper.

## 2. Theoretical Justification of the Gravity Model in Analyzing Trade

The Newtonian physics notion is the first justification of the gravity model. The second justification for the gravity equation can be analyzed in the light of a partial equilibrium model of export supply and import demand by Linneman (1966). Based on some simplifying assumptions the gravity equation turns out to be a reduced form of this model. However, Bergstrand (1985) and others point out that this partial equilibrium model could not explain the multiplicative form of the equation and also left some of its parameters unidentified mainly because of exclusion of price variable. With the simplest form of the equation, of course, Linneman's justification for exclusion of prices is consistent.

Using a trade share expenditure system Anderson (1979) also derives the gravity model which postulates identical Cobb-Douglas or constant elasticity of substitution (CES) preference functions for all countries and weakly separable utility functions between traded and non-traded goods. Here utility maximization with respect to income constraint gives traded goods shares that are functions of traded goods prices only. Prices are constant in cross-sections; so using the share relationships along with trade (im) balance identity, country  $j$ 's imports of country  $i$ 's goods are obtained. Then assuming log linear functions in income and population for shares, the gravity equation for aggregate imports is obtained.

The next approach is based on the Walrasian general equilibrium model, with each country having its own supply and demand functions for all goods. Aggregate income determines the level of demand in the importing country and the level of supply in the exporting country. While Anderson's analysis is at the aggregate level, Bergstrand (1985, 1989) develops a microeconomic foundation to the gravity model. He opines that a gravity model is a reduced form equation of a general equilibrium of demand and supply systems. For each country the model of trade demand is derived by maximizing a constant elasticity of substitution (CES) utility function subject to income constraints in importing countries. On the other hand, the model of trade supply is derived from the firm's profit maximization procedure in the exporting country, with resource allocation determined by the constant elasticity of transformation. The gravity model of trade flows, proxied by value, is then obtained under market equilibrium conditions, where demand for trade flows equals supply of the flows. Bergstrand argues that since the reduced form eliminates all endogenous

variables out of the explanatory part of each equation, income and prices can also be used as explanatory variables of bilateral trade. Thus instead of substituting out all endogenous variables, the author treats income and certain price terms as exogenous and solves the general equilibrium system retaining these variables as explanatory variables. The resulting model is termed as a "generalized" gravity equation. Bergstrand's analysis is based on the assumptions of nationwide product differentiation by monopolistic competition and identical preferences and technology for all countries. With  $N$  countries, one aggregate tradable good, one domestic good and one internationally immobile factor of production in each country, Bergstrand's (1985) model is a general equilibrium model of world trade. Bergstrand's (1989) model is an extension of his earlier work where production is added under monopolistic competition among firms that use labor and capital as factors of production. Firms produce differentiated products under increasing returns to scale.

Eaton and Kortum (1997) also derive the gravity equation from a Ricardian framework, while Deardorff (1997) derives it from a H-O perspective. Deardorff proves that, if trade is impeded and each good is produced by only one country, the H-O framework will result in the same bilateral trade pattern as the model with differentiated products. If there are transaction costs of trade, distance should also be included in the gravity equation. Evenett and Keller (1998) demonstrate that the standard gravity equation can be obtained from the H-O model with both perfect and imperfect product specialization. Some assumptions different from increasing returns to scale, of course, are required for the empirical success of the model. They also argue that the increasing returns to scale model rather than the perfect specialization version of the H-O model is more likely candidate to explain the success of the gravity equation. Furthermore, they find that the variations in the volume of trade can be explained better by the models with imperfect product specialization than the models with perfect product specialization (Carrillo and Li 2002).

Haveman and Hummels (2001) note that gravity equation can be generated from a model with complete and incomplete specialization. The works of Anderson (1979), Bergstrand (1985), Deardorff (1997), and Helpman and Krugman (1985) are the example of complete specialization model. Derivation of the gravity equation under complete specialization model implies that each good is produced in only one country; consumers highly value variety and therefore import all goods that are produced. On the other hand, incomplete specialization model implies that importers buy from only a small

fraction of available sources. As a result, trade levels predicted under complete specialization model is much higher than incomplete specialization model.

Therefore, the gravity equation can be derived assuming either perfectly competition or monopolistic market structure. Also neither increasing returns nor monopolistic competition is a necessary condition for its use if certain assumptions hold regarding the structure of both product and factor markets (Jakab et. al 2001).

Trade theories just explain why countries trade in different products but do not explain why some countries' trade links are stronger than others and why the levels of trade between countries tends to increase or decrease over time. This is the limitation of trade theories in explaining the size of trade flows. Therefore, while trade theories cannot explain the extent of trade, the gravity model is successful in this regard. It allows more factors to take into account to explain the extent of trade as an aspect of international trade flows (Paas 2000).

Trade occurs because of differences across countries in technologies (Ricardian theory), in factor endowments (H-O theory), differences across countries in technologies as well as continuous renewal of existing technologies and their transfer to other countries (Posner 1961 and Vernon 1966). Quoting from Dreze (1961) Mathur (1999) says that country size and scale economies are important determinants of trade (Paas 2000).

The production will be located in one country if economies of scale are present. They also induce the producers to differentiate their product. The larger the country is in terms of its GDP/GNP, for instance, the larger the varieties of goods offered. The more similar the countries are in terms of GDP/ GNP, the larger is the volume of this bilateral trade. Thus with economies of scale and differentiated products, the volume of trade depends in an important way on country size in terms of its GDP/GNP (Paas 2000:). This is the concept of new theories of international trade, and it provides a better explanation of empirical facts of international trade in terms of their pattern, direction and rate of growth. As a result, the traditional theories are supplemented, if not replaced, by the new trade theories, in recent years, based on the assumptions of product differentiation and economies of scale. Among the contributors of these new theories, Krugman (1979), Lancaster (1980), Helpman (1981, 1984, 1987 and 1989), Helpman and Krugman (1985, 1989), and Deardorff (1984) warrant special mention in the context of their explaining trade both empirically and theoretically (Mathur 1999). Assumption of similar technologies and factor endowments across countries are implicit in these theories.

While we are taking GNP as a variable, the reasons for taking 'per capita GNP' as a separate independent variable are that it indicates the level of development. If a country develops, the consumers demand more exotic foreign varieties that are considered superior goods. Further, the process of development may be led by the innovation or invention of new products that are then demanded as exports by other countries. Also it is true that more developed countries have more advanced transportation infrastructures which facilitate trade.

Transportation cost is an important factor of trade. Production of the same good in two or more countries in the presence of transport costs is inconsistent with factor price equalization. Moreover, different trade models might behave differently in the presence of transport cost and differences in demand across countries (Paas 2000, quoted from Davis and Weinstein 1996).

Transport costs are proxied by the distance. So distance between a pair of countries naturally determines the volume of trade between them. Three kinds of costs are associated with doing business at a distance: (i) physical shipping costs, (ii) time-related costs and (iii) costs of (cultural) unfamiliarity. Among these costs, shipping costs are obvious (Frankel 1997 quoted from Linnemann 1966).

Trade barriers such as tariff have a statistically significant negative effect on trade flows between countries. On the other hand, preferential arrangements are found to be trade enhancing and statistically significant (Oguledo and Macphee 1994).

### **3. Application of the Gravity Model in Analyzing Bangladesh Trade**

#### ***(i) A Brief Picture of the Bangladesh's Trade***

Trade sector is continuously playing an important role in the Bangladesh economy. In 1999, compared to 1988, Bangladesh's total trade, total exports and total imports increased by 168%, 204% and 153% respectively. In case of trade with our sample countries, this increase is the highest for the SAARC countries 439% (exports + imports). When separated, the increase of imports is the highest for the SAARC countries (602%), followed by ASEAN (276%) and EEC (107%); the increase of exports is the highest for the EEC countries (363%) followed by the NAFTA countries (323%), the Middle East countries (85%) and the SAARC countries (33%).

Individually 20% of Bangladesh's trade of our sample total occurred with the USA in 1999 followed by India (12%), UK, Singapore, Japan (7%), and China, Germany (6%). In the same year the exports figures of Bangladesh are, of our sample total, 39% to the USA, 12% to Germany, 10% to UK, 7% to France, 5% to The Netherlands and Italy, 2% to Japan, Hong Kong, Spain and Canada and 1% to India and Pakistan. On the other hand, the imports figure of Bangladesh, of our sample total, is the highest from India (18%) followed by Singapore (12%), Japan (10%), China (9%) and USA and Hong Kong 8%. The over all trade balance of Bangladesh, of course, gives us disappointing results. Compared to 1988, the total trade deficit of Bangladesh increases by 115% in 1999. This figure is 987% with the SAARC countries, 1098% with India and 108% with Pakistan (IMF: Direction of Trade Statistics Yearbook-various issues).

### *(ii) Sample Size and Data Issues*

Our study covers a total of 35 countries. The countries are chosen on the basis of importance of trading partnership with Bangladesh and availability of required data. Five countries of *SAARC*, five countries of *ASEAN*, three countries of *NAFTA*, eleven countries of *EEC (EU)* group, six countries from *the Middle East* and Five *other* countries are included in our sample for the analysis of Bangladesh's trade<sup>1</sup>.

The data were collected for the period of 1972 to 1999 (28 years). All observations are annual. Data on GNP, GDP, GNP per capita, GDP per capita, population, inflation rates, total exports, total imports, taxes on international trade (% of current revenue) and CPI are obtained from the *World Development Indicators (WDI)* database of the World Bank. Data on exchange rates, index numbers of export and import prices are obtained from the *International Financial Statistics (IFS)*, CD-ROM database of International Monetary Fund (IMF). Data on Bangladesh's exports of goods and services (country *i*'s exports) to all other countries (country *j*), Bangladesh's imports of goods and services (country *i*'s imports) from all other countries (country *j*) and Bangladesh's total trade of goods and services (exports plus imports) with all other countries included in the sample are obtained from the *Direction of Trade Statistics Yearbook* (various

<sup>1</sup> **SAARC**: Bangladesh, India, Nepal, Pakistan and Sri Lanka; **ASEAN**: Indonesia, Malaysia, the Philippines, Singapore and Thailand; **NAFTA**: Canada, Mexico and USA; **EU**: Belgium, Denmark, France, Germany, Greece, Italy, the Netherlands, Portugal, Spain, Sweden and the United Kingdom; **Middle East**: Egypt, Iran, Kuwait, Saudi Arabia, Syrian Arab Republic and the United Arab Emirates; **Other**: Australia, New Zealand, Japan, China and Hong Kong

issues) of IMF. Data on the distance (in kilometer) between Dhaka (capital of Bangladesh) and other capital cities of country *j* (as the crow flies) are obtained from an Indonesian Website: [www.indo.com/distance](http://www.indo.com/distance).

GNP, GDP, GNP per capita, GDP per capita are in constant 1995 US dollars. GNP, GDP, total exports, total imports, taxes, Bangladesh's exports, Bangladesh's imports and Bangladesh's total trade are measured in million US dollars. Population of all countries are considered in million. GNP and per capita GNP of U.K. and New Zealand are always replaced by GDP and per capita GDP of these two countries respectively as the data on the former are not available for some years of the sample period. Data on the exchange rates are available in national currency per US dollar for all countries. So these rates are converted into the country *j*'s currency in terms of Bangladesh's currency (country *i*'s currency).

### *(iii) Methodology*

Classical gravity model generally uses cross-section data to estimate trade effects and trade relationships for a particular time period, for example one year. In reality, however, cross-section data observed over several time periods (panel data methodology) result in more useful information than cross-section data alone. The advantages of this method are: first, panels can capture the relevant relationships among variables over time; second, panels can monitor unobservable trading-partner-pairs' individual effects. If individual effects are correlated with the regressors, OLS estimates omitting individual effects will be biased. Therefore, we have used panel data methodology for our empirical gravity model of trade.

The generalized gravity model of trade states that the volume of trade / exports / imports between pairs of countries,  $X_{ij}$ , is a function of their incomes (GNPs or GDPs), their populations or per capita income, their distance (proxy of transportation costs) and a set of dummy variables either facilitating or restricting trade between pairs of countries. That is,

$$X_{ij} = \beta_0 Y_i^{\beta_1} Y_j^{\beta_2} y_i^{\beta_3} y_j^{\beta_4} D_{ij}^{\beta_5} A_{ij}^{\beta_6} U_{ij} \quad (2)$$

where  $Y_i$  ( $Y_j$ ) indicates the GDP or GNP of the country  $i$  ( $j$ ),  $y_i$  ( $y_j$ ) are per capita income of country  $i$  ( $j$ ),  $D_{ij}$  measures the distance between the two countries' capitals (or economic centers),  $A_{ij}$  represents dummy variables,  $U_{ij}$  is the error term and  $\beta_s$  are parameters of the model.

As the gravity model is originally formulated in multiplicative form, we can linearize the model by taking the natural logarithm of all variables. So for estimation purpose, model (2) in log-linear form in year  $t$ , is expressed as,

$$\ln X_{ijt} = \beta_0 + \beta_1 \ln Y_{it} + \beta_2 \ln Y_{jt} + \beta_3 \ln y_{it} + \beta_4 \ln y_{jt} + \beta_5 \ln D_{ijt} + \sum_b \delta_b P_{ijbt} + U_{ijt} \quad (3)$$

where  $l$  denotes variables in natural logs.  $P_{ijb}$  is a sum of preferential trade dummy variables. Dummy variable takes the value one when a certain condition is satisfied, zero otherwise.

Using our data set, we estimate three gravity models of Bangladesh trade: (a) the gravity model of Bangladesh's trade (exports + imports), (b) the gravity model of Bangladesh's exports, and (c) the gravity model of Bangladesh's imports. For the model (a), we have followed Frankel (1997), Sharma and Chua (2000) and Hassan (2000, 2001). Since the dependent variable in the gravity model is bilateral trade (sum of exports and imports) between the pairs of countries, the product of GNP/GDP and the product of per capita GNP/ GDP have been used as independent variables. We have added some additional independent variables in our model. Thus the gravity model of trade in this study is:

$$\begin{aligned} \log(X_{ijt}) = & \alpha_0 + \alpha_1 \log(\text{GNP}_{it} * \text{GNP}_{jt}) + \alpha_2 \log(\text{PCGNP}_{it} * \text{PCGNP}_{jt}) + \alpha_3 \log \\ & (\text{Tax}_{it} * \text{Tax}_{jt}) + \alpha_4 \log(\text{Distance}_{ij}) + \alpha_5 \log(\text{PCGNPD}_{ijt}) + \alpha_6 \\ & (\text{TR}/\text{GDP}_{it}) \\ & + \alpha_7 (\text{TR}/\text{GDP}_{jt}) + \alpha_8 (\text{Border}_{ij}) + \alpha_9 (\text{j-SAARC}) + U_{ijt} \end{aligned} \quad (4)$$

where,  $X_{ij}$  = Total trade between Bangladesh (country  $i$ ) and country  $j$ ,  $\text{GNP}_i$  ( $\text{GNP}_j$ ) = Gross National Product of country  $i$  ( $j$ ),  $\text{PCGNP}_i$  ( $\text{PCGNP}_j$ ) = Per capita GNP of Country  $i$  ( $j$ ),  $\text{Tax}_i$  ( $\text{Tax}_j$ ) = Trade tax as % of revenue of country  $i$  ( $j$ ),  $\text{Distance}_{ij}$  = Distance between country  $i$  and country  $j$ ,  $\text{PCGNPD}_{ij}$  = Per capita GNP differential between country  $i$  and  $j$ ,  $\text{TR}/\text{GDP}_{i(t)}$  = Trade- GDP ratio of country  $i$  ( $j$ ),  $\text{Border}_{ij}$  = Land border between country  $i$  and  $j$  (dummy variable),  $\text{j-SAARC}$  =

Country  $j$  is member of SAARC (dummy variable),  $U_{ij}$  = error term;  $t$  = time period,  $\alpha_s$  = parameters.

With regard to the gravity model of Bangladesh's export, we consider the following model:

$$\begin{aligned} \ln X_{ijt} = & \beta_0 + \beta_1 \ln Y_{it} + \beta_2 \ln Y_{jt} + \beta_3 \ln y_{it} + \beta_4 \ln y_{jt} + \beta_5 \ln D_{ijt} + \beta_6 \ln y_{dijt} + \beta_7 \ln ER_{ijt} + \beta_8 \ln n_{it} + \\ & \beta_9 \ln n_{jt} + \beta_{10} \ln TE_{it} + \\ & \beta_{11} \ln TI_{jt} + \beta_{12} \ln (IM/Y)_{jt} + \beta_{13} \ln (TR/Y)_{it} + \beta_{14} \ln (TR/Y)_{jt} + \sum_b \delta_b P_{ijbt} + U_{ijt} \end{aligned} \quad (5)$$

where,  $X$ = exports,  $Y$ =GDP,  $y$  = per capita GDP,  $D$ = distance,  $y_d$ = per capita GDP differential,  $ER$  = exchange rate,  $\ln$  = inflation rate,  $TE$  = total export,  $TI$  =total import,  $IM/Y$  = Import-GDP ratio,  $TR/ Y$ = trade-GDP ratio,  $P$  =preferential dummies. Dummies are:  $D1$ = j-SAARC,  $D2$ =j-ASEAN,  $D3$ = j-EEC,  $D4$  = j-NAFTA,  $D5$ = j-Middle East,  $D6$  = j- others and  $D7$ = border $_{ij}$ ,  $l$ = natural log.

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

$$\begin{aligned} \ln M_{ijt} = & \beta_0 + \beta_1 \ln Y_{it} + \beta_2 \ln Y_{jt} + \beta_3 \ln y_{it} + \beta_4 \ln y_{jt} + \beta_5 \ln D_{ijt} + \beta_6 \ln y_{dijt} + \beta_7 \ln ER_{ijt} + \beta_8 \ln n_{it} + \\ & \beta_9 \ln n_{jt} + \beta_{10} \ln (EX/Y)_{jt} + \\ & \beta_{11} \ln (TR/Y)_{it} + \beta_{12} \ln (TR/Y)_{jt} + \sum_b \delta_b P_{ijbt} + U_{ijt} \end{aligned} \quad (6)$$

where,  $M$ = imports,  $EX/Y$ = export-GDP ratio, and other variables are the same as defined in the export model.

In our estimation, we have used unbalanced panel data, and individual effects are included in the regressions. So we have to decide whether they are treated as fixed or as random. From the regression results of the panel estimation, we get the results of LM test and Hausman test [in the REM of Panel estimation]. These results<sup>2</sup> suggest that FEM of panel estimation is the appropriate model for our study.

There is, of course, a problem with FEM. We cannot directly estimate variables that do not change over time because inherent transformation wipes out such variables. Distance and dummy variables in

<sup>2</sup> Results are not shown. However, these can be provided upon request.

our aforesaid models are such variables. However, this problem can easily be solved by estimating these variables in a second step, running another regression with the individual effects as the dependent variable and distance and dummies as independent variables,

$$IE_{ij} = \beta_0 + \beta_1 \text{Distance}_{ij} + \sum_h \delta_h P_{ijh} + V_{ij} \quad (7)$$

where  $IE_{ij}$  is the individual effects.

(iv) *Estimates of Gravity Equations, Model Selection and Discussion of results*

*Estimation and Model selection*

Equation (4) above is estimated taking all variables except distance and dummy variables for 463 observations. The variables- per capita GNP, and tax- are found to be insignificant. The variable trade-GDP ratio is also not so robust. Another estimate has been taken substituting population variable instead of per capita GNP. Tax variable has also been dropped from the estimation. Trade variable has been regressed on GNP, population, trade-GDP ratio and per capita GNP differential. Covering all countries the number of observations is 910. All variables except the population are found to be significant. So dropping the population variable from the model, another estimate has been taken. This time all explanatory variables-GNP, trade-GDP ratio and per capita GNP differential- are found to be significant with expected signs. So our selected estimated gravity model for Bangladesh trade is:

$$\text{Log}(X_{ijt}) = \alpha_0 + \alpha_1 \log(\text{GNP}_{it} * \text{GNP}_{jt}) + \alpha_5 \log(\text{PCGNPD}_{ijt}) + \alpha_6(\text{TR}/\text{GDP}_{it}) + \alpha_7(\text{TR}/\text{GDP}_{jt})$$

(4')

To test the heteroscedasticity in the model we have run a separate regression considering the heteroscedasticity for every observation and all observations within groups. Hetero corrected regression results are shown in Table 1. Regression results are very similar with significance levels and expected signs. Our FEM has also been estimated with an autocorrelated error structure. All coefficients are still significant with the correct signs though the robustness is slightly lower for variables. All variables are tested for multicollinearity. The model does not have any multicollinearity problem.

The gravity model of Bangladesh's exports-equation (5) above- has been estimated taking all explanatory variables except the distance and dummy variables for 785 observations of 31 countries. Many variables are found to be either insignificant or possessed wrong signs. In the process of model selection, we have found only  $\text{GDP}_i$ , exchange rate $_{ij}$ , total import $_i$ , import/ $\text{GDP}_i$ , trade/ $\text{GDP}_i$  are found to be significant. When tested for the multicollinearity of the variables,  $\text{GDP}_i$  is found to have multicollinearity problem. Dropping this variable if we re-estimate the model on the remaining four variables, it is found that the variable import /  $\text{GDP}_i$  is insignificant. So our estimated desired model is now:

$$\text{Log} X_{ijt} = \beta_0 + \beta_7 \text{ER}_{ijt} + \beta_{11} \text{TI}_{jt} + \beta_{13} (\text{TR}/Y)_{it} \quad (5')$$

Now all explanatory variables are found to be significant with expected signs. The results of the heteroscedasticity corrected model are shown in Table 1. The autocorrelated error structured model also gives almost similar results. All variables are tested for multicollinearity; the model does not have any multicollinearity problem.

The gravity model of Bangladesh's imports, the equation (6) above, has been estimated taking all variables except distance and dummy variables. The model covers all countries of our sample constituting 899 observations. In the estimation process only  $\text{GDP}_j$ , per capita GDP differential $_{ij}$ , inflation $_i$ , inflation $_j$ , trade/ $\text{GDP}_i$ , trade/ $\text{GDP}_j$  are found to be significant. All other variables are found either insignificant or have wrong signs. While multicollinearity of these variables is being tested,  $\text{GDP}_j$  variable is found to have problem. So omitting this variable from the model we are left with the five explanatory variables, where all variables are found to be significant with the correct signs. Therefore, our preferred estimated gravity model of imports is:

$$\text{Log} M_{ijt} = \beta_0 + \beta_6 \text{lyd}_{ijt} + \beta_8 \text{In}_{it} + \beta_9 \text{In}_{jt} + \beta_{11} (\text{TR}/Y)_{it} + \beta_{12} (\text{TR}/Y)_{jt} \quad (6')$$

The detail results of the heteroscedasticity corrected model are shown in Table 1. The autocorrelated error structured model also gives more or less similar results. The model does not have any multicollinearity problem. The

estimation results of unchanged variables of equation (4), (5) and (6) above -that is equation (7)- are noted in Table 2<sup>3</sup>.

## Discussion of Results

As mentioned earlier, our all three gravity models suggest that, based on the LM and Hausman tests, FEM of Panel estimation is the appropriate strategy to be adopted. So the results of FEM would be discussed here for the said three models. The estimation uses White's heteroskedasticity-corrected covariance matrix estimator. In these models, the intercept terms  $\alpha_{0i}$  and  $\beta_{0i}$  are considered to be country specific, and the slope coefficients are considered to be the same for all countries.

In our trade model (Table 1), the coefficient of product of GNP is positive and highly significant as expected. This implies that Bangladesh tends to trade more with larger economies. Bangladesh's bilateral trade with country j increases by 0.88% (almost proportional) as the product of Bangladesh's GNP and country j's GNP increases by 1%.

The coefficient of per capita GNP differential between Bangladesh and country j is also significant at 1% level and has positive sign. The coefficient value is 0.23, which implies that bilateral trade with country j increases as the per capita GNP differential<sub>ij</sub> increases but less than proportionately. From the positive sign of this coefficient we can have an indication that the H - O effect (differences in factor endowments) dominates the Linder effect in case of Bangladesh trade.

The trade-GDP ratio is the proxy of openness of countries. The coefficient of this variable for country j is found large, significant at 1% level and have expected positive sign. This implies that Bangladesh's 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's trade with these countries by as much as 1.30% [ $\exp(0.27)=1.30$ ]. The coefficient of this variable for country i is also found to be significant at 5 % level and is very large. A 1% increase in the openness of trade of Bangladesh could increase Bangladesh's trade with these countries by as much as 2.03% [ $\exp(0.71)=2.03$ ].

With regard to the country specific effects, we observe that these effects are strongly significant for all countries. Of these effects Mexico followed by Spain, Greece, Portugal, France, etc. appear to have the lowest propensity to trade with Bangladesh, and Nepal then followed by India, Pakistan and Sri Lanka have the highest.

The distance variable (see Table 2) is significant even at 1 % level and has anticipated negative sign which indicates that Bangladesh tends to trade more with its immediate neighboring countries. The coefficient value is -1.23, which indicates that when distance between Bangladesh and country j increases by 1%, the bilateral trade between the two countries decreases by 1.23%. Border dummy (D1) is found to be insignificant with a negative sign, and SAARC dummy (D2) is also insignificant but with positive sign.

For our export model (Table 1), as mentioned earlier, only the variables exchange rate, total import of country j and the trade- GDP ratio of Bangladesh are found to be highly significant (even at 1% level). The positive coefficient of exchange rate implies that Bangladesh's exports depend on its currency devaluation. From the estimated results it is evident that 1% currency devaluation leads to, other things being equal, 0.34% exports to j countries.

Total imports of country j may be considered as target country effect. The coefficient value of this variable is found large and carries an anticipated positive sign. The estimated results show that the exports of Bangladesh increase slightly higher than proportionately with the increase of total imports demand of country j. (The coefficient is: 1.01).

The trade-GDP ratio of Bangladesh, the openness variable, has an expected positive sign. The coefficient of this variable is very large and indicates that Bangladesh has to liberalize its trade barriers to a great extent for increasing its exports. The estimated coefficient is 2.27, which implies that Bangladesh's exports increase 9.68% [ $\exp(2.27) = 9.68$ ] with 1% increase in its trade-GDP ratio, other things being equal.

As per as country specific effects are concerned, all effects are found highly significant. Our results show that Mexico followed by Sweden, Canada, New Zealand, France, the Netherlands, etc., have the lowest propensity to Bangladesh's exports, and Nepal followed by Pakistan, Iran, Syrian, A.R., Italy, Sri Lanka, India, etc., have the highest propensity to Bangladesh's exports. Interestingly the distance variable is found to be insignificant but has expected negative sign (see Table 2). All dummy variables are found to be insignificant.

In the import model (see Table 1), per capita GDP differential has positive sign, which again supports the H - O hypothesis. With 1% increase of

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<sup>3</sup> The results of autocorrelated error structured models, multicollinearity tests and the country specific effects are not shown. However, these can be provided upon request.



this variable, imports of Bangladesh increase by 0.69%. Imports of Bangladesh are also positively responsive with the inflation of Bangladesh and negatively responsive with the inflation of country j. The inflation elasticities of imports are 0.08 and -0.15 respectively for Bangladesh and country j. The openness variables of Bangladesh and country j are also major determining factors of Bangladesh's imports. Both variables are highly significant and have positive influences on Bangladesh's imports. The estimated results show that with 1% increase of trade-GDP ratio of Bangladesh, other things being equal, has an effect of 29.37% increase of its imports [ $\exp(3.38)=29.37$ ]. An increase of 1% trade-GDP ratio of country j leads to increase of 1.79% imports of Bangladesh [ $\exp(.58) = 1.79$ ]. So liberalization of trade barriers from both sides is essential.

In terms of country specific effects, all effects except China are found significant. From the estimated results it is observed that Bangladesh's import propensity is the lowest from Portugal followed by Greece, Singapore, Belgium, Spain, etc., and it is the highest from India followed by China (not significant), Nepal, Pakistan, USA, Indonesia, etc.

Table 2 refers to the effects of distance and dummy variables on the Bangladesh's imports. Only border dummy is found to be significant at 5% level. The coefficient value is 1.68 which indicates that Bangladesh's import trade with India is 5.37 times higher just because of common border [ $\exp(1.68) = 5.37$ ].

#### (v) Multilateral Resistance Factors

Bilateral trade may be affected by the multilateral resistance factors. Anderson and Wincoop (2003), Baier and Bergstrand (2003), and Feenstra (2003) have recently considered these factors in their works. Assuming identical, homothetic preferences of trading partners and a constant elasticity of substitution utility function Anderson and Wincoop (2003) define the multilateral trade resistance as follows:

$$P_j = \left[ \sum_i (\beta_i p_i t_{ij})^{1-\sigma} \right]^{1/(1-\sigma)} \quad (8)$$

where  $P_j$  is the consumer price index of j.  $\beta_i$  is a positive distribution parameter,  $p_i$  is country i's (exporter's) supply price, net of trade costs,  $t_{ij}$  is trade cost factor between country i and country j,  $\sigma$  is the elasticity of substitution between all goods. For simplification they assume that the trade barriers are symmetric, that is,  $t_{ij}=t_{ji}$ . They refer to the price index ( $P_i$  or  $P_j$ ) as multilateral trade resistance as it depends positively on trade barriers with all trading partners.

Baier and Bergstrand (2003) note that nonlinear estimation technique for multilateral resistance factor in Anderson and van Wincoop (2003) is complex. However, GDP weighted average of distance from trading partners can be used as a proxy for multilateral resistance term.

#### (vi) Application of Multilateral Resistance in the Bangladesh's Trade

We have tried to see the effects of multilateral resistance on the Bangladesh's trade. We have considered Consumer Price Indices (CPI) of trading partners as multilateral resistance variables (data on commodity prices or commodity price indexes for Bangladesh are not available). Adding CPI as multilateral resistance when we re-estimate the gravity model for Bangladesh trade [equation (4')] we see that  $GNP_{ij}$  variable and  $(Trade / GDP)_j$  are insignificant but  $CPI_{ij}$  is found to be significant. The insignificant results for the  $GNP_{ij}$  and  $(Trade / GDP)_j$ , which were significant in equation (4'), may be due to small sample in this case [Here number of observations is 448 only compared to 910 in equation (4'). Data on CPI of Bangladesh are not available for many years].

We have also re-estimated the gravity model for Bangladesh's export [equation (5')] adding CPI of trading partners as multilateral resistance variable. Here total observations are only 408 [Earlier the number of observations was 785]. Here also multilateral resistance variables are found to be significant though two other variables- total import of country j and trade-GDP ratio of country i-are found to be insignificant. The reason for these two variables to be insignificant may be due to small sample as stated above. The CPI variable has positive effect on Bangladesh's export and Bangladesh's trade (see Table 3). This is expected, as the more is multilateral resistance, the more will be the bilateral trade.

## 4. Summary and Conclusion

The application of the gravity model in applied research of bilateral trade is theoretically justified. There are wide ranges of applied research where the gravity model is used to examine the bilateral trade patterns and trade relationships [see Bergstrand (1985, 1989), Koo and Karemera (1991), Oguledo and Macphee (1994), Zhang and Kristensen (1995), Le et. al (1996), Frankel (1997), Rajapakse and Arunatilake (1997), Karemera et. al (1999), Mathur (1999), Sharma and Chua (2000), Paas (2000), Hassan (2000, 2001), Jakab et. al (2001),

Soloaga and Winters (2001), Christie (2002), Carrillo and Li (2002) and Mátyás et. al (2000)].

We have estimated the generalized gravity models of trade, export and import. Our results show that Bangladesh's trade (sum of exports and imports) is positively determined by the size of the economies, per capita GNP differential of the countries involved and openness of the trading countries. The major determinants of Bangladesh's exports are: the exchange rate, partner countries' total import demand and openness of the Bangladesh economy. All three factors affect the Bangladesh's exports positively. The exchange rate, on the other hand, has no effect on the Bangladesh's import; rather imports are determined by the inflation rates, per capita income differentials and openness of the countries involved in trade. Transportation cost is found a significant factor in influencing the Bangladesh's trade negatively. This implies Bangladesh would do better if the country trades more with its neighbors. This is also evident from the country specific effects. Also Bangladesh's import is found to be influenced to a great extent by the border between India and Bangladesh. However, per capita income differential, both in the trade and the import models, supports the H-O hypothesis over the Linder hypothesis though this variable was found insignificant in the export model. This is somewhat contradictory result obtained from the distance and country specific effects. It may be the case that per capita income differential is not the proper representation of the factor endowment differential. Also the H-O hypothesis assumes zero transportation cost and perfect competition, which are unrealistic. Bangladesh's bilateral trade and exports are also positively related to multilateral resistance factors.

The policy implications of the results obtained are that all kinds of trade barriers in countries involved, especially in Bangladesh, must be liberalized to a great extent in order to enhance the Bangladesh's trade. It seems that Bangladesh's currency is overvalued. Necessary devaluation of the currency is required to promote the country's exports taking other adverse effects, such as domestic inflation, of devaluation into account. Proper quality of the goods and services must be maintained as well as the varieties of goods and service must be increased as the Bangladesh's exports largely depend on the foreign demand. All partner countries' propensities to export and import must be taken into account sufficiently and adequately when trade policy is set as the Bangladesh's trade is not independent of country specific effects.

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Table 1: Hetero Corrected Fixed Effects Models

Variables	Tr. Model	Exp. Model	Imp. Model
Log(GNP <sub>i</sub> *GNP <sub>i</sub> )	0.88 (11.18)		
Log(PCGNPD <sub>ij</sub> )	0.23 (2.73)		
(TR/GDP) <sub>i</sub>	0.71 (2.02)	2.27 (6.65)	3.38 (9.40)
(TR/GDP) <sub>j</sub>	0.27 (3.99)		0.58 (6.97)
Log (Exc.Rate) <sub>ij</sub>		0.34 (6.78)	
Log (To.Imp) <sub>i</sub>		1.01 (11.41)	
Log (PCGDPD <sub>ij</sub> )			0.69 (6.87)
Log (Infl <sub>i</sub> )			0.08 (2.46)
Log (Infl <sub>j</sub> )			-0.15 (-3.24)
R <sup>2</sup>	0.84	0.79	0.79
F	120.53 [37, 872]	88.78 [32, 752]	87.37 [38, 860]
Observations	910	785	899

*t-ratios are noted in parentheses.*

Table 2: Cross-Section Results of the Distance and Dummy Variables. Dependent Variable is Country Specific Effect.

Variables	Tr. Model	Exp. Model	Imp. Model
Distance	-1.23 (-3.42)	-0.44 (-0.80)	-0.56 (-0.71)
ijBorder	-0.077 (-0.14)	-0.62 (-1.25)	1.68 (1.89)
J-SAARC	0.57 (1.57)	-1.98 (-1.14)	0.75 (0.30)
J-ASEAN		-3.05 (-1.62)	0.47 (0.02)
J-EEC		-2.68 (-1.26)	-0.27 (-0.09)
J-NAFTA		-3.21 (-1.42)	0.48 (0.15)
<b>J-Middle East</b>		<b>-1.92 (-0.94)</b>	<b>-0.84 (-0.03)</b>
J- others		-2.84 (-1.39)	0.53 (0.18)
R <sup>2</sup>	0.58	0.62	0.47
F	13.62 [3, 30]	5.09 [7, 22]	3.24 [7, 26]
Observations	34	30	34

*t-ratios are shown in the parentheses.*

Table 3: Fixed Effects Models with Multilateral Resistance Variables.

Variables	Tr. Model	Exp. Model
Log(GNP <sub>i</sub> *GNP <sub>i</sub> )	0.17 (0.72)	
Log(PCGNPD <sub>ij</sub> )	0.45 (2.43)	
(TR/GDP) <sub>i</sub>	1.35 (2.83)	-0.49(-0.65)
(TR/GDP) <sub>j</sub>	0.61 (0.06)	
Log (Exc.Rate) <sub>ij</sub>		0.46 (2.79)
Log (To.Imp) <sub>i</sub>		0.16 (0.76)
Log(CPI <sub>i</sub> )		1.53(2.90)
Log(CPI <sub>j</sub> )		0.46 (1.90)
Log(CPI <sub>ij</sub> )	0.25 (2.46)	
R <sup>2</sup>	0.92	0.86
F	129.93 [37, 410]	65.77[34, 373]
Observations	448	408

*t-ratios are noted in parentheses.*