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Tracing Trade Structure and Potentialities of Bangladesh with Some Selected Economies: A Gravity Model Analysis

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ABSTRACT

International trade plays a crucial role in Bangladesh's economy, influencing key macroeconomic indicators such as employment and the balance of payments. This study uses an augmented gravity model of international trade to examine the factors influencing Bangladesh's trade performance with 29 trading partners from 1999 to 2019. The results show that Bangladesh's national income, the partner's national income, and the relative price of its currency have a positive and statistically significant impact on trade. Additionally, two new variables: "economic remoteness," which measures each country's geographic distance from global economic activity, and "per capita gross domestic product difference," which measures economic disparity between the two countries, both of which have an inverse influence on the country's foreign trade. Furthermore, affiliations to religion and regional alliances have no meaningful influence on Bangladesh's foreign trade. The study recommends that policymakers focus on boosting national income, stabilizing the relative price of Bangladesh's currency, and fostering stronger economic relationships with key trading partners. Moreover, efforts to reduce economic remoteness and bridge the per capita GDP disparity with trading partners could further enhance trade flows. These policy actions could significantly optimize Bangladesh's trade performance and contribute to broader economic growth. Despite its geographical challenges, Bangladesh's trade performance has slightly exceeded gravity model predictions, suggesting untapped potential for further growth.

1. Introduction

Bangladesh is a middle-income, well-functioning market economy. This economy exhibits moderate economic growth, conspicuous poverty, elevated income inequality, rising unemployment, reduced import substitution in fuel and capital equipment, diminished national savings, reliance on foreign aid, and a continuous expansion in the service and industrial sectors. Bangladesh's economy has grown dramatically since the country became independent in 1971. As a developing nation, Bangladesh is one of the Next Eleven emerging markets . The IMF estimates that its per-capita GDP will be US$2,122 in 2021, with a total GDP of $352.91 billion. In South Asia, Bangladesh has maintained lower foreign currency reserves at US$28 billion. The apparel sector in Bangladesh has evolved into one of the world's largest ready-made clothing industries. Bangladesh's economy is presently the 37th biggest in terms of nominal GDP and the 31st largest in purchasing power parity, ranking second in South Asia in 2021. In 2019, Bangladesh was the world's 57th-highest exporter and the 46th-largest importer.

International trade accounted for 60.29 percent of global GDP in 2019, according to the World Bank. When we divide this share between developed and developing countries, we can observe that industrialized countries have a larger proportion of commerce than emerging countries. Bangladesh's share of international trade, for example, was only around 36.76 percent in 2019. Improving a country's international trade is not an inherent process, but proper policy can facilitate it. As a result, research is crucial to a country's economic success. Empirical research on international trade employs various approaches. Adam Smith proposed the first theory of international commerce, claiming that trade occurs because certain nations have a complete advantage in manufacturing specific items over others. The Ricardian model, based on differences in technology or natural resources, is another popular theory proposed by David Ricardo. Another idea posits that commerce is contingent on the proportional abundance of resources. Staffan Linder initially introduced an alternative proposition, anticipating that the aggregated preferences for goods

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within countries will dictate trade patterns.

Nevertheless, the currently esteemed model is the Gravity Model of International Commerce. In the most straightforward way, this model predicts trade by considering the distance between countries and the interaction of their economic sizes. The model of gravity has become a mainstay of the literature on fundamental commerce worldwide over the past fifty years. Starting with Tinbergen (1962), a large number of publications and conference papers based on this model have been published, covering an extensive variety of regions, times, and industries. In Bangladesh, Rahman (2003) initially introduced this model for finding the determinants of Bangladesh's international trade. Thereafter, a large number of researchers use this gravity model as their research tool, like Rahman *et al.* (2019), to tests its validity in explaining Bangladesh's trade with Asian sub-regions. Hassan (2017) uses a stochastic frontier gravity model to evaluate the effectiveness of trade integration in Bangladesh's export industry in relation to its greatest potential levels. Akter *et al.* (2017) use this to analyse tourism demand in Bangladesh.

However, there are some estimation issues when it comes to incorporating basic gravity models. Rahman (2003) asserts that estimating variables that remain constant over time is not possible directly, as the inherent transformation erases such variables, but "distance among countries" is a time-invariant variable. Second, there are two schools of thought on trade patterns: one adheres to the Linder hypothesis, while the other follows the Heckscher-Ohlin (H-O factor proportions) model. According to Swedish economist Steffan Linder, nations in comparable phases of their growth have identical priorities, which lead to more commerce. This study incorporates innovative methods, particularly time-invariant variables, into the gravity model of international trade. Remoteness is employed as a proxy variable for the geographical distance among the nations and is calculated by multiplying the physical distance by the ratio of the partner countries' GDP to the world GDP. In addition to the suggested Gravity model variable, this study includes additional key factors such as 'GDP distance' and 'Scale'. GDP distance is determined by assessing disparities in per capita national income between the domestic country and its trade partner, reflecting the economic development gap between the two nations. These variables answer the crucial question of which model Bangladesh follows (the Linder hypothesis or the H-O theorem).

If the GDP distance variables exhibit a notably positive impact on the dependent variable, it indicates that Bangladesh adheres to the Heckscher-Ohlin model. Conversely, if there is a substantial negative effect, it indicates that Bangladesh is more likely to do business with comparable nations, supporting the Linder hypothesis. Another crucial variable is 'scale,' which is simply the product of the populations of two trading countries. It is commonly assumed that countries with larger populations engage in more trade with each other compared to those with smaller populations. This study also examines the significance of religious considerations in commerce around the world. To investigate this issue, we introduce the D-8 group of countries, which share similar religious affiliations and have formed this alliance for cooperative purposes.

The study contributes significantly to understanding the factors influencing Bangladesh's trade performance by applying an augmented gravity model of international trade. By examining data from 29 trading partners over a span of two decades (1999-2019), the research recognizes key variables such as Bangladesh's national income, the economic size of trading partners, and the relative price of the currency as significant drivers of trade. Furthermore, the study presents two novel variables—economic remoteness and per capita GDP disparity—that adversely affect trade flows. The findings provide valuable insights for policymakers, suggesting that enhancing national income, stabilizing the currency, and reducing economic remoteness could optimize trade performance. This research not only expands the scope of the gravity model but also highlights Bangladesh's potential for improved trade with specific countries, offering strategic policy recommendations to foster economic growth.

We organize the paper as follows: Section 1 introduces the research, outlining the objectives and significance of the study. Section 2 reviews the existing literature, synthesizing key theories and identifying gaps in current knowledge about international trade and Bangladesh's trade dynamics. Section 3 describes the methodologies used, explaining the research design, data collection, and analytical techniques. Section 4 presents the study's results, analyzing the findings and discussing their practical implications for policymakers and businesses. Finally, Section 6 summarizes the key findings, offering suggestions for future research and practical applications. This study contributes significantly to the literature on international trade, focusing on Bangladesh's trade issues and providing valuable insights for economic development and policy.

2. Literature Review

The gravity model has served as a valuable model in the field of international economics for quite some time now. In economics, the volume of trade between two nations is correlated with their sizes, which are typically determined by their GDPs rather than their actual physical masses. The economic distance or transaction costs associated with trading between the countries are reflected in the trade volume's decline with increasing geographical separation between them. Economists have applied this model to examine various aspects of international trade, migration, and other related areas. The gravity model was first used by Tinbergen (1962) and Poyhonen (1963) in their research on trade between nations. They utilized it to study the patterns that emerged in trade flows among European nations.

The following is a list of other notable studies that have used this model in the past ten years, particularly for Bangladesh and other comparable countries: Dhami *et al.* (2020) estimated the trade-related gravity model for India's trading partner. According to their research, there is a statistically significant and adverse effect of per capita GDP differences on bilateral trade flows. This finding supports the Linder hypothesis that nations with similar traits trade more than those that don't. The well-known Heckscher-Ohlin doctrine, which contends that increased trade between two nations results from their disparate economies, stands in stark contrast to this. According to their findings, bilateral trade flows are negatively and statistically significantly impacted by disparities in per capita GDP. This bolsters the Linder hypothesis, which postulates that nations with comparable traits typically engage in more commerce with one another than with those with distinctive traits. This stands in stark contrast to the well-known Heckscher-Ohlin doctrine, which argues that more trade between two countries results from their disparate economies. Rahman *et al.* (2019) calculated and analyzed Bangladeshi textile and clothing (T&C) exports using the panel gravity model. Their analysis shows that, although geographic distance has little bearing on Bangladesh's textile exports, the importers' gross domestic product (GDP), real exchange rate, and per capita GDP all have a substantial impact. The analysis suggests that aligning worker pay with Bangladesh's GDP development could potentially reduce the textile industry's competitive advantage.

Allayarov *et al.* (2018) used a panel data augmented gravity model to examine trade between Kyrgyzstan and its 35 main trading partners between 2000 and 2016. According to their model, there is a negative relationship between commerce and the partner nation's population. The results of this study defy theoretical predictions, which state that trade should normally rise as the population grows. Mdanat *et al.* (2018) attempted to determine the major variables affecting exports in small open economies such as Jordan. To identify these elements in such an economy, they used a gravity model and panel data from 2001 to 2014. According to their findings, exports rise by 0.48 percent for every 1% increase in trading partners' relative income and by 0.25 percent for Jordanian exports when trade expenses reduce by 1%, indicating closer trading partners. Mukherjee *et al.* (2018) determined, with an emphasis on South Africa, the main variables impacting bilateral trade between the G-20 and the top ten African nations. According to their findings, distance has a detrimental effect on bilateral trade flows between South Africa and its partner nations, although GDP and market size (population) have a favorable effect.

To evaluate the effectiveness of trade integration with respect to Bangladesh's export industry's maximum potential levels, Hassan (2017) used a stochastic frontier gravity model. Remarkably, the model indicates that the population size of Bangladesh or its partner nations has no substantial effect on Bangladesh's exports, despite suggesting that the GDP and geographic distance of Bangladesh and its partner countries considerably affect Bangladesh's exports. This outcome is a stark contrast to what previous research has found. To investigate the factors influencing Bangladesh's tourism demand, Akter *et al.* (2017) used GLS regression analysis using Rodrigue's modified Gravity model. They used visitor arrivals as a proxy for tourism demand, controlling for important economic variables including population, per capita GDP, distance, and Bangladesh's CPI. The population and GDP per capita were shown to positively correlate with tourist arrivals, according to the study. Conversely, the Consumer Price Index, the foreign exchange rate, and distance all showed negative correlations. Narayan and Nguyen (2016) studied Vietnam's bilateral trade connections with its top 54 trading partners from 1986 to 2010. The results indicated that Vietnam's trade practices with more affluent trading partners are consistent with the Heckscher-Ohlin (H-O) theory, which suggests that trade increases as factor endowments vary. Husain and Yasmin (2015) used the trade gravity model to examine Bangladesh's trade with its fifty-two principal trading partners. The study found that membership in the OECD and GSP significantly impacted trade.

In order to assess the export potential of environmental commodities in India, Jomit (2014) used a gravity model analysis. The findings suggest that the magnitude of trading partners has a somewhat smaller effect on India's exports than does distance. Furthermore, being a part of bilateral trade agreements and sharing a shared colonizer have a favorable and significant impact on India's exports. Abidin *et al.* (2013) aimed to investigate Malaysia's exports to OIC member countries. They found that Malaysia's international trade is positively associated with GDP and distance, which contradicts the gravity model's expectation that trade should decrease as distance increases. (Oh & Rahman Sardar, 2013) uses a gravity approach to explore Bangladesh's trade pattern. According to their model, Bangladesh's foreign trade follows the traditional gravity model, but Bangladesh has less trade with other SAARC countries. Using a generalized gravity model, Rahman & Dutta (2012) examine Bangladesh's trade patterns. They discover that the standard gravity model applies to Bangladesh's international trade. Their concept asserts that Bangladesh's trade adheres to the H-O model of international commerce. The gravity model was utilized by Ullah & Inaba (2012) to determine if favorable and open trade arrangements have had a major positive impact on Bangladesh's export flows. In comparison to the country's total export growth, the nation's exports to the bloc's member countries have had a significantly slower rate of growth. A trade gravity model was used by Jafari *et al.* (2011) to study the determinants influencing export flows among the D-8 countries. They found that when the exporter's GDP rises by 1%, export volume rises by 1.3%, and when the partners' GDP rises, export volume increases by 0.41 percent. The export flow between them declines by 0.53 percent for every 1% increase in distance, according to the distance variable's coefficient.

In addition, the two bordering nations trade 1.3% more than one another.

However, to the extent of our knowledge, no empirical study has investigated the trade structure and potentialities of some selected economies. The existing research on trade in Bangladesh has either focused on the exchange rate, trade balance, money supply, non-farm GDP, informal economy, credit and land rentals, foreign aid, public debt, and remittances (Dey *et al.*, 2019 ; Ahmed *et al.*, 2015; Saha *et al.*, 2025; Hasan Maruf *et al.*, 2020; Saha & Saha, 2023; Dey *et al.*, 2020; Saha *et al.*, 2025; Alam *et al.*, 2025; Rabiul Islam Liton *et al.*, 2016). This research aims to address the critical gaps in understanding the structure of trade in Bangladesh, with a particular focus on selected economies. Our study presents significant contributions to the domain of international trade in Bangladesh.

3. Methodology

3.1. Description of variables

For the econometric estimate of the gravity model, the majority of earlier empirical studies employed panel data in addition to cross-section data. Panel data are used in this study to estimate the gravity model. One of the most common problems with gravity model estimate is the estimation of the time-invariant geographical distance variable. Given that the geographical distance between trading nations remains constant over time, posing a challenge for econometric estimation, we employ a clever method to address this issue. This problem can be solved by introducing a more reliable variable known as 'remoteness.' Not only does the geographical distance matter in this variable, but so does the relative importance of the trade partners. So, in comparison to a small economy, larger economies have a competitive advantage in terms of infrastructure and access. This variable is calculated as the product of geographical distance and the GDP ratio of partner countries to global GDP at the time. This will result in a variable that is not a time-invariant variable as previously discussed. Another important feature of the empirical estimation in this study is that it involves individual as well as sub-alliance countries given our interest in investigating Bangladesh's trade. For this, data of three different trade alliances with which Bangladesh trades has been used. We, therefore, need to define this sub-alliance used in this study is i) The governors of central banks and finance ministers representing 19 of the biggest economies in the world make up the G-20, sometimes referred to as the Group of 20. ii) The Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) is an intergovernmental organization in the Bay of Bengal region. iii) The Organization for Economic Cooperation, also known as the Developing-8, is made up of eight developing countries with a majority of Muslims (countries that share religious similarities with Bangladesh). The combination of these three sub-alliance countries is the most important trading partner of Bangladesh in Asia as well as the rest of the world.

Table 1: List of Variables.

Variable Name	Abbreviations	Units/ Calculation	Description
T	Total trade (Export-import)	Million US$	Total trade is the summation of export and import with individual partner countries of Bangladesh.
GDPi	Bangladesh's Gross GDP	Million US$	GDPi is a measure of the total monetary worth of all final products and services produced within the borders of Bangladesh in a given year.
GDPj	Partner Country's Gross GDP	Million US$	GDPj is a measure of the overall monetary value of all completed products and services produced in the partner nation in a given year.
Rem	Remoteness	$\frac{\text{Distance x GDPj}}{\text{WorldGDP}}$	The geographic distance between two countries is represented by the proxy variable of remoteness. The calculation of remoteness involves multiplying the distance between partners by the ratio of the income of each partner to the global gross domestic product.
GDP_D	Per capita GDP difference	US$	The disparity in per capita GDP indicates whether two countries have similar or dissimilar economies. A small difference suggests economic similarity, while a larger difference implies economic dissimilarity.
Scl	Scale	Million US$	Scale is defined as the entire population of two countries added together. If both countries have larger populations, we expect them to trade more than a country with a lesser population.

ER	Exchange Rate	$\frac{\text{US\$ ERi}}{\text{US\$ ERj}}$	Exchange rate is simply expressed in US dollars and is calculated as the direct exchange rate for individual partner countries for Bangladesh. In this instance, i represent for Bangladesh's exchange rate with US dollar and j represent as partner countries exchange rate with US dollar. The calculated result shows the Bangladesh's exchange rate with individual partner countries in US$.
CPI	Consumer price index	Percentage	This variable simply captures the national price level changes.

The variables listed above are crucial indicators for understanding the structure and potential of a country's international trade. On the one hand, these variables provide a simple and reliable estimate of the well-known gravity model; while on the other hand, they provide insight into the nature of its trading partners.

3.2. Data Sources

Panel data covering 29 trading partners of Bangladesh from 1999 to 2019 were used in this study in order to confirm the effectiveness of the trade gravity model. Some of the important factors utilized in this analysis are Total Trade with Partner Countries, Remoteness, GDP of Bangladesh and Partner Countries, Per Capita GDP Difference with Partner, Scale, CPI, and Exchange Rate. A range of secondary sources provided the data for the variables stated above.

The International Monetary Fund (IMF) website, the Direction of Trade Statistics, the CD-ROM databases, and the sum of the exports and imports between partner nations are used to compute Bangladesh's overall trade. www.distancecalculator.net provides information on the distance (in kilometers) between the capital cities of other nations (denoted as "j") and Dhaka, the capital city of Bangladesh. In addition, information on GDP, GDP per capita, population as a whole, the Consumer Prices Index (CPI), and currency rates is obtained from the World Bank's World Development Indicators (WDI) database.

3.3. Theoretical Background

In 1954, Walter Isard first presented the Gravity model to the economics community. The undamental model for trade between two countries (i and j) is expressed as:

$$T_{ij}=A\cdot(Y_i\, Y_j)/D_{ij} \qquad \text{....(1)}$$

Here,

In the given context, T_{ij} denotes the trade value between country i and j, 'A' signifies the constant term, Yi represents the GDP of country i, Y_J is the GDP of country j, and D_{IJ} represents the distance between country i and country j.

3.4. Model Specification

Our primary objective is to employ gravity model variables along with other control variables to articulate an expanded gravity model. The gravity model and other related variables are presented as follows for estimation purposes:

$$T_{ijt} = \beta_1 + \beta_2\, GDP_{it} + \beta_3\, GDP_{jt} + \beta_4\, Rem_{ijt} + \beta_5\, GDP\_D_{ijt} + \beta_6\, Scl_{ijt} + \beta_7\, CPI_{jt} + \beta_8\, ER_{ijt} + \beta_9\, D_8 + \beta_{10}\, BIMSTEC + U_{ijt} \qquad \text{....(2)}$$

Where, i = Bangladesh

j = 1, 2…29 countries

t = years of 1999, 2000……. 2019.

U_{ijt} = Stochastic error term

D_8 = 1, if the country is member of D_8

And 0, otherwise

BIMSTEC = 1, if the country is member of BIMSTEC

And 0, otherwise

3.5. Methods

Since the Gravity model depends on panel data by design, this study uses panel data estimation approaches. Therefore, in our trade estimating model, panel data is recommended since it makes it possible to examine particular impacts like fixed or random effects. Pooled Ordinary Least Squares, Fixed Effect Estimator (Within Effect), Random Effect Estimator, and the Hausman Specification Test are some of the specifications that are included in our model. A panel data regression has two subscripts on its variables, which sets it apart from a cross-sectional or regular time-series regression.

i.e.

$$y_{it} = \beta x_{it} + \alpha + u_{it} \qquad \text{....(3)}$$

i = 1, 2…….n; t = 1, 2……. t

For disturbances, most panel data applications use a one-way error component model with

$$u_{it} = \mu_i + v_{it} \qquad \text{....(4)}$$

In this case, v_{it} stands for the residual disturbance and μ_i for the unobservable individual-specific effect. It's critical to remember that μ_i is time-invariant and represents any individual-specific effect that the regression did not take into account.

The fixed-effect model takes subject heterogeneity into account. Each cross-sectional unit has a set intercept value in this model. The reason the phrase "fixed effect" is employed is that, although the intercept may change between subjects, it is time-invariant for each entity, meaning it does not change over time. The remaining disturbances, v_{it} in equation (4) are stochastic and have independent and identically distributed (IID) features (0, σ^2_v). The μ_i parameters are assumed to be constant and to be approximated. Assuming that the individual-specific effect μ_i is random, similar to a general disturbance term v_{it} can help ameliorate the reduction of degrees of freedom associated with the fixed effects model's many parameters. Every cross-sectional unit has a common intercept value in the random-effect model.

The Hausman test can assist in choosing between a fixed-effect or random-effect model. These tests are designed to examine whether a relationship exists between the individual-specific errors and the model's regressors. Taking into account the linear model:

$$y = Xb + e \qquad ....(5)$$

In this context, y represents the dependent variable, Xis the vector of regressors, b is a vector of coefficients, and e is the error term in the linear model. We have two estimators for b: b0 and b1.Then the Hausman statistics is:

$$H = (b_0 - b_1)\ (var(b_0) - var(b_1))^{\dagger}\ (b_1 - b_0) \qquad ....(6)$$

Where † denotes the Moore-Penrose pseudoinverse . In this test, the statistic asymptotically follows a chi-squared distribution, with the number of degrees of freedom equal to the rank of the matrix $var(b_0) - var(b_1)$ under the null hypothesis.

H_0 = Random effect model is efficient

H_1 = Fixed effect model is efficient

If the test statistics reject the null hypothesis in favor of fixed effects, it indicates that country-specific effects are correlated with regressors, and estimating the random-effects model would be inconsistent.

In the context of panel data estimation, inefficiencies in the estimated results often arise from cross-sectional dependence problems. Cross-sectional dependence can emerge from the existence of common shocks and unobserved components that are ultimately incorporated into the error term. Assuming that cross-sectional dependence is attributed to unobserved and uncorrelated common factors with the included regressors, both standard fixed-effects and random-effects estimators are consistent but not efficient. The estimated standard errors are biased in this scenario. Conversely, when the unobserved components leading to interdependencies across cross-sections are correlated with the included regressors, both fixed effect and random effect estimators become biased and inconsistent. In this context, one might adopt the approach suggested by Pesaran (2004). If we use equation (4) to test cross-sectional dependence, the hypothesis takes the following form:

H_0: $\rho_{ij} = \rho_{ji} = cor\ (u_{it}, u_{jt}) = 0 \quad$ for $i \neq j$

H_1: $\rho_{ij} = \rho_{ji} \neq 0 \quad$ for $i \neq j$

Where ρ_{ij} and ρ_{ji} is the Pearson correlation coefficient of the disturbances and is given by:

$$\hat{\rho}_{ij} = \hat{\rho}_{ji} = \frac{\sum_{t=1}^{T} \hat{u}_{it}\hat{u}_{jt}}{\left(\sum_{t=1}^{T} \hat{u}_{it}^2\right)^{1/2}\left(\sum_{t=1}^{T} \hat{u}_{jt}^2\right)^{1/2}} \qquad ....(7)$$

Under this consideration, Pesaran proposed the following formula for testing cross-sectional dependence:

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}\right) \qquad ....(8)$$

Pesaran's cross-sectional dependence (CD) test depends on the hypothesis that the panel cross-sectional dimension (N) and panel time-series dimension (T) are finite as well as this test are valid when N > T and can be used with balanced and unbalanced panels See De Hoyos & Sarafidis (2006).

In a panel data regression model, the regression disturbances are typically assumed to be homoscedastic, meaning they have the same variance across both time and individuals. However, heteroscedasticity issues may arise in the panel regression model, especially when cross-sectional units vary in size, leading to differing levels of variability. Consequently, if one assumes homoscedastic disturbances in the presence of heteroscedasticity, the resulting regression coefficient estimates will remain inconsistent. However, these estimates will be inefficient, and the standard errors of the estimation will be biased. The proposition of heteroscedasticity through the unobservable individual-specific disturbance term was initially introduced by Mazodier and Trognon (1978). For heteroscedasticity at the group level, a modified Wald test is employed, with the null hypothesis suggesting homoscedastic residuals and the alternative hypothesis indicating heteroscedastic residuals. Recognizing that a regression model affected by heteroscedasticity leads to inefficient estimates, a remedy for this situation involves using Heteroscedasticity-Corrected Feasible Generalized Least Squares (FGLS) or Panels Corrected Standard Errors (PCSEs) regression. FGLS is appropriate when the number of cross-sectional units (N) is less than the number of time periods (T), whereas PCSEs are preferred when N exceeds T.

Panel data can exhibit a intricate error structure, and the existence of non-technical errors can compromise the accuracy of coefficient estimation and introduce biases in standard error (SE) estimation if not adequately addressed. While serial correlation has been traditionally acknowledged as a potential issue in panel data, recent focus has been directed towards the issue of cross-sectional dependence, as highlighted by studies such as those by Driscoll and Kraay (1998) and De Hoyos and Sarafidis (2006). Addressing both serial correlation and cross-sectional dependence simultaneously poses a challenge because many panel data estimators are not equipped to handle both issues concurrently. The Parks' Feasible Generalized Least Squares (FGLS) estimator is applicable under the condition that the number of periods (T) is greater than or equal to the number of cross-sections (N). However, a notable drawback is that the Parks' FGLS estimator has a tendency to significantly underestimate standard errors (SEs) in finite samples. According to Beck and Katz (1995), a two-step modified version of the 'inefficient' Ordinary Least Squares (OLS), referred to as 'Panel Corrected Standard Error' (PCSE) estimation, exhibits significantly better performance than the asymptotically efficient FGLS (Parks) estimator in certain situations. Examine the given equation:

$$y_{it} = \beta x_{it} + \alpha + u_{it} \qquad ....(9)$$

Wherein i represents the count of cross-sectional units; y_i denotes a T × 1 vector containing observations of the dependent variable for the i^{th} cross-sectional unit; x_i is a T×1 vector comprising observations of the exogenous explanatory variable, and u_i is a T × 1 vector of error terms, with u following a normal distribution N (0, Ω_{it}).
Contemplate an autoregressive model for the disturbances u_i. The assumption is that the components of the disturbance vector u_i are produced by a stationary autoregressive process.

$$u_{it} = \rho_i u_{it} + e_{it} \quad ....(10)$$

In this context, u_{it} is a random variable sourced from a population with a zero mean and $\sigma_{u,ij} = (\sigma_{e,ij})/(1-\rho_t^2)$. Essentially, this initial term maintains a consistent mean and variance with the other elements in the process. The residuals derived from these regressions are employed for estimating the components of Parks-type error variance-covariance matrices (Parks, 1967).
We seek a framework for Ω_{it} _it that can concurrently encompass both serial correlation and cross-sectional dependence within the error term. Consequently, we embrace a variation of Parks' (1967) widely recognized model. This model assumes (i) heteroscedasticity at the group level; (ii) first-order serial correlation; and (iii) cross-sectional dependence that remain constant over time. We adopt the subsequent configuration for Ω_{it}.

$$\Omega_{it} = \sum \otimes \Pi \quad ....(11)$$

Here, $\otimes$ is the Kronecker product and the other becomes:

$$\Sigma = \begin{bmatrix} \sigma_{u,11} & \sigma_{u,12} & \cdots & \sigma_{u,1i} \\ \sigma_{u,21} & \sigma_{u,22} & \cdots & \sigma_{u,2i} \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{u,i1} & \sigma_{u,i2} & \cdots & \sigma_{u,ii} \end{bmatrix} \quad ....(12)$$

$$\Pi = \begin{bmatrix} 1 & \rho & \rho^2 & \cdots & \rho^{t-1} \\ \rho & 1 & \rho & \cdots & \rho^{t-2} \\ \rho^2 & \rho & 1 & \cdots & \rho^{t-3} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \rho^{t-1} & \rho^{t-2} & \rho^{t-3} & \cdots & 1 \end{bmatrix} \quad ....(13)$$

Taking this into account, we can calculate Beck and Katz's (1995) two-step PCSE estimator utilizing the subsequent formula:

$$\hat{\beta} = (\tilde{x}'\tilde{x})^{-1}\tilde{x}'\tilde{y} \quad ....(14)$$

$$Var(\hat{\beta}) = (\tilde{x}'\tilde{x})^{-1}(\tilde{x}'\hat{\Sigma}\tilde{x})$$

Where $x^{\sim}$ and $y^{\sim}$ are the Prais-transformed vectors of the explanatory and dependent variables, and $\sum^{\wedge}$ is the estimate of $\sum$ in equation (11).

4. Result Analysis and Discussion

4.1. Estimated Result of Gravity Model

In Table 2, Column (1) represents pooled OLS, where no time and entity effects are computed. Column (2) illustrates a fixed-effect model, accounting for country-specific heterogeneity, while Column (3) outlines a random-effect model, assuming the country-specific heterogeneity to be random. In this model, each country is assumed to share the same constant mean value.

Table 2: Result on Gravity Model of Trade.

	OLS Model(pooled)		**Fixed Effect (within) Model**		**Random Effect GLS Model**	
Variables	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
GDP Home	.0036025 (0.000)	.0003847	.0021057 (0.000)	.0003049	.0033896 (0.000)	.0003456
GDP Foreign	.0004596 (0.000)	.0000236	.0005014 (0.000)	.0000248	.000539 (0.000)	.0000246
Remoteness	-1.436989 (0.000)	.1031543	.5157236 (0.012)	.205677	-.9636012 (0.000)	.1445062
GDP Distance	.0098558 (0.003)	.0032842	-.0030014 (0.574)	.0053384	-.0054157 (0.334)	.0056025
Scale	.0178168 (0.000)	.000824	.0651307 (0.000)	.003814	.0249717 (0.000)	.0020283
CPI	-5.184967 (0.137)	3.478163	1.921513 (0.484)	2.744781	1.79693 (0.594)	3.366962
Exchange Rate	8.62892 (0.000)	1.401097	7.175732 (0.018)	3.023912	6.82867 (0.019)	2.910507
BIMSTEC	309.4535 (0.000)	88.16774	-	-	138.4345 (0.561)	237.9834
D-8	103.3743 (0.221)	84.30742	-	-	221.9697 (0.376)	250.5847
Constant	-684.6183 (0.000)	86.89706	-1942.858 (0.000)	102.9162	-863.0158 (0.000)	167.8591
R-square	0.8438		0.8438		0.7827	
F-statistics Prob.	359.51 0.0000		442.08 0.0000		1974.26 0.0000	

Notes: p-values mentioned in parentheses. Source: Author's computation.

The initial model characterizes the OLS model (pooled) and the coefficients of the independent variables exhibit the precise signs as observed in the traditional gravity model (refer to column 1). The second model does not fully validate the pooled OLS model (see column 2). Although it contradicts the Gravity model, the elevated coefficient of remoteness variable shows that Bangladesh exports greater amounts with its far-off neighbors, which is consistent with the findings of Abidin *et al.* (2013) about Malaysia's export trends. In addition, GDP distance has a significant negative coefficient indicates that Bangladesh trade more when per capita GDP difference is small. A limitation of the fixed-effect model is its inability to estimate the time-independent variable, which makes it impossible to estimate the dummy variables for D-8 and BIMSTEC that are indicated in the fixed-effect model. The random-effect model is indicated by the third model. Similar to pooled OLS, the random-effect model produces expected signals consistent with the classical gravity model, with the exception of GDP distance (see column 3). This finding aligns with the results of Hasan Maruf *et al.* (2020), which indicate that Bangladesh gains more from trading with neighboring countries compared to those that are farther away.

To comprehend the disparity between these models and determine the appropriate choice among them, further scrutiny of subsequent specification tests is necessary. The appropriateness of the fixed effect model in comparison to the random effect model is evaluated using the Hausman specification test. The alternative hypothesis proposes that the model is fixed effects, whereas the null hypothesis contends that the preferred model is random effects.

Table 3: Hausman Specification Test.

The Hausman Specification Test		
H_0 = preferred model is random effect		
Chi-square (6)	=	466.80
Prob>chi-square	=	0.0000

Source: Author's computation.

Table 3 shows that the associated p-value is less than 1% level and the coefficient of chi-square with six degrees of freedom is extremely high. Thus, it is clear that the fixed effect model is supported by the Hausman Specification test, which rejects the null hypothesis that was previously stated. This suggests that the unexplained individual-specific error term and regressors are correlated. In this case, we can conclude that for the time being the suitability of the FE model is affirmed and the other specification tests of the FE model can talk more accurately about the appropriate model.

Generalized cross-sectional dependency is a possibility for panel data, in which correlation is present for all entities in the same cross-section. To determine if any residuals show association between the entities, the cross-sectional dependence test, or Pesaran CD test, is utilized. The panel data regression model also assumes that the regression disturbances have the same variance over time and among individuals, i.e., they are homoscedastic. We also intend to evaluate the GroupWise heteroscedasticity test for the fixed-effect model in this study.

Table 4: Testing for Cross-Sectional Dependence and Heteroscedasticity.

Pesaran CD Test		Modified Wald test for GroupWise Heteroscedasticity	
H_0 = Cov $(u_{it}, u_{jt}) = 0$		$H_0 = \sigma^2_i = \sigma^2$	
Cross sectional independence	= 4.756	Chi-square(29)	= 13043.94
Prob	= 0.0000	Prob >chi-square	= 0.0000

Source: Author's computation.

A p-value of 0.0000, which is below the level of significance limit of 0.05, is revealed by the Pasaran CD test results. As a result, we support the alternative hypothesis and refute the null explanation, demonstrating cross-sectional relying in the fixed-effect framework. As a result, it can be concluded that cross-sectional dependency exists because residuals show correlation across cross-sectional units.

On the other hand, the results of the GroupWise heteroscedasticity Modified Wald test show that the p-value for the neighboring chi-square value is 0.0000, that is lower than the statistically significant threshold of 0.05. As a result, we conclude that the residuals are heteroscedastic and invalidate the null explanation that suggests constant or homoscedastic variance. In short, we find a residual heteroscedasticity issue. The conventional estimators for data from panels (fixed effect or random effect model) become inconsistent and ineffective when there is both heteroscedasticity and longitudinal dependence on others.

4.2. Model Considering Cross-Sectional Dependence and Heteroscedasticity

In the face of cross-sectional dependence and heteroscedasticity, the traditional fixed effect and random effect models prove to be unreliable and ineffective. In such circumstances, two clever approaches were suggested by Parks in 1967 and Beck, and Katz in 1995, respectively. The Parks' Feasible Generalized Least Squares (FGLS) estimator, first presented by Parks in 1967, is an alternate estimate that can be used in this situation. However, it can only be put into practice if the number of time periods (T) is at least as large as the number of cross-sectional segments (N). Another issue is that the Parks'

FGLS estimator generally underestimates the mean errors for small sample sizes. Alternatively, a two-step modified version of 'inefficient' Ordinary Least Squares (OLS) called 'Panel Corrected Standard Error' (PCSE) estimation is shown to perform substantially better than the asymptotically efficient FGLS (Parks) estimator in this specific case (Beck and Katz, 1995). It is advisable to opt for the PCSEs model when the number of cross-sectional units surpasses the number of time periods.

4.3. Panels Corrected Standard Errors (PCSE) Model

We chose the Corrected Standard Errors (PCSE) model for this study because our analysis indicated that there was a relationship between the error terms across different units and that the variability of the errors was not constant. Cross-sectional dependence means that the error terms from different units are related to each other, which goes against the idea that they should be independent in regular regression models. Additionally, heteroscedasticity means that the spread of the errors is not the same across all observations, which can result in less reliable estimates and conclusions. The PCSE model addresses these issues by providing robust standard errors, ensuring more accurate coefficient estimates and hypothesis testing. This enhances the reliability and validity of our results, making the model the most suitable choice for our investigation. The gravity model results as calculated by PCSE are shown in Table 5. Both the domestic and foreign GDP coefficients show a positive sign and are shown to be highly statistically significant at the 1 percent level.

Table 5: Panels Corrected Standard Errors (PCSE) Model.

Variable	Coef.	Panel-corrected Std. Err.	Prob.
GDP Home	.0032597	.0006802	0.000
GDP Foreign	.0005258	.0000707	0.000
Remoteness	-1.347161	.2877388	0.000
GDP Distance	-.0012439	.0060955	0.838
Scale	.0185344	.006117	0.002
CPI	.0849021	.9542834	0.929
Exchange Rate	3.753283	1.67304	0.025
BIMSTEC	-172.2907	169.8477	0.310
D-8	-1.779097	226.6085	0.994
Constant	-440.2316	170.4486	0.010
R-squared	0.5482		
Wald chi-square (9) Prob > chi-square	206.25 0.0000		

Source: Author's computation.

The negative correlation of remoteness indicates that as geographical distance and the insignificance of a partner country in the global economy increase, Bangladesh's trade with that country diminishes. Projected outcomes suggest that a 1-unit rise in remoteness from partners will result in a drop of 1.347161 million US$ in Bangladesh's commerce. Bangladesh's trade pattern adheres to the conventional gravity model, a conclusion corroborated by other recent studies. Rahman and Ibon (2019); Rahman *et al.* (2019); Husain and Yasmin (2015); Oh and Rahman Sardar (2013). A vital element is the GDP distance, offering a clear understanding of the dynamics of Bangladesh's foreign trade. Although the actual result is statistically insignificant, the negative coefficient of this variable indicates that Bangladesh is inclined to trade more with economically analogous nations, consistent with the Linder hypothesis.

At the 1 percent level, the scale variable coefficient shows a positive sign and is highly significant in statistical terms. According to this, trade between Bangladesh and the partner nation should rise in tandem with population growth. However, Allayarov *et al.* (2018) estimated bilateral trade with Kyrgyzstan and discovered an adverse relationship between trade and partner nation populations. Consumer price index (CPI) and exchange rate variables have positive signed coefficients, although the CPI is statistically insignificant, but the exchange rate contributes a significant strong impact to the change in total trade. This implies that a decrease in the value of the local currency will lead to an increase in Bangladesh's overall trade volume. Lastly, the D-8 alliance based on religious predominance and the BIMSTEC regional cooperation alliance have no significant impact on Bangladesh's foreign trade. The PCSEs model's coefficient of determination shows that, on average, all of those independent variables can predict 54.8 percent of the variation in the dependent variable, total trade.

4.4. Size Matters: The Gravity Model

A strong empirical relationship has been observed between the magnitude of an economy and the amount of goods and services it ships abroad and purchases from abroad. Figure 1 depicts this relationship by plotting the average economic size of Bangladesh's partner countries, specifically the G-20, the world's richest countries, and other partners, from 1999 to 2019, against their average trade with Bangladesh during that time.

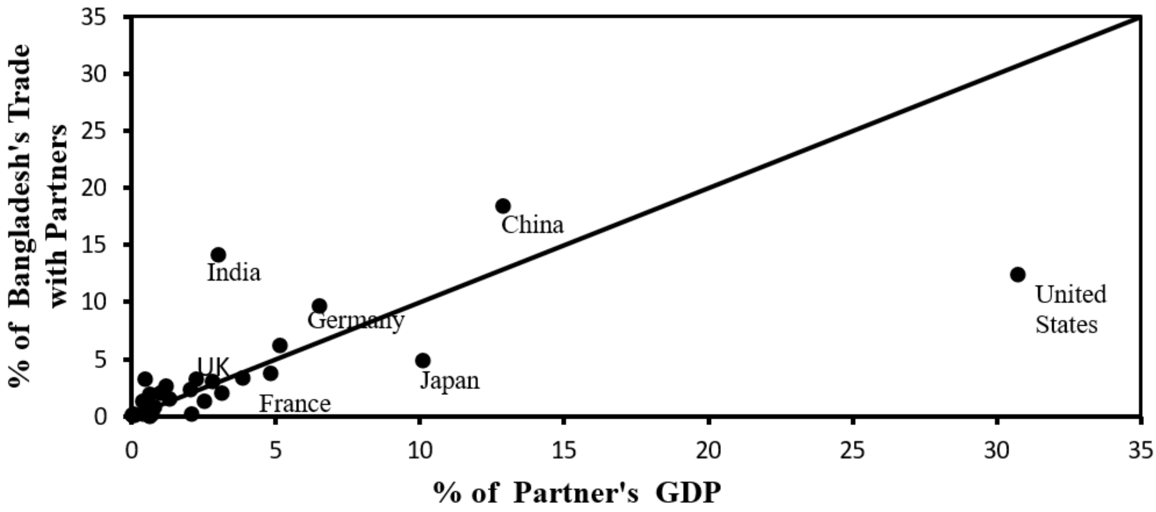

Figure 1: The Size of Bangladesh's Trade Partners Economics, and the Value of Their Trade with Bangladesh.
Source: Authors drawing

In the chart, the GDP of each nation is depicted as a percentage of the aggregate GDP of the study's partner countries, while each country's share of total trade with Bangladesh is illustrated on the vertical axis. As can be seen, the scatter of points clustered around the 45-degree line, indicating that each country's share of Bangladesh's trade with partners is roughly equal to its share of GDP.

Table 6: Comparative Analysis of International Trade between Bangladesh and its Partner Countries.

Country	**% of Bangladesh's Trade with Partners**	**% of Partner's GDP**	**Gravity Model Prediction of Trade**
Argentina	0.843	0.778	▲
Australia	2.295	2.027	▲
Bhutan	0.069	0.003	▲
Brazil	2.136	3.112	▼
Canada	2.976	2.805	▲
China	18.455	12.879	▲
Egypt	0.274	0.389	▼
France	3.771	4.809	▼
Germany	9.645	6.481	▲
Indonesia	2.715	1.231	▲
India	14.147	2.986	▲
Iran	0.233	0.703	▼
Italy	3.296	3.842	▼
Japan	4.802	10.091	▼
Malaysia	3.217	0.459	▲
Mexico	0.254	2.067	▼
Myanmar	0.244	0.080	▲
Nepal	0.116	0.031	▲
Nigeria	0.039	0.609	▼
Pakistan	1.300	0.369	▲
Russian	1.280	2.514	▼

Saudi Arabia	2.055	1.002	▲
South Korea	3.192	2.281	▲
South Africa	0.304	0.577	▼
Sri Lanka	0.144	0.101	▲
Thailand	2.018	0.618	▲
Turkey	1.452	1.305	▲
United Kingdom	6.270	5.128	▲
United States	12.460	30.723	▼

Source: Author's computation

Table 6 shows the same thing as in figure 1, that if the geographical distance is being held constant, then the expected trade of Bangladesh according to the gravity model depends on the size of its partner countries GDP. According to this model, it has the potential to increase trade for Bangladesh with some countries like the United States, Russia, Mexico, Iran, Italy, Japan, Egypt, France, Brazil, South Africa, and Nigeria, which is partially similar to the study conducted by Husain & Yasmin (2015).

5. Conclusion, limitations, future research and recommendations

Bangladesh's economic growth has largely been based on international export-oriented industries since 1990. Importation is also used to supply important food items, industrial equipment, and raw materials. In this situation, it's easy to see how important foreign trade is to Bangladesh's development. Any kind of foreign trade crisis is a source of concern for the country, and the development of this sector is a tool for Bangladesh's socioeconomic development. Import dependence on a small number of countries has put the sector in jeopardy, just as it lacks diversity in its export portfolio in terms of both products and destinations. In this investigation, an expanded gravity model was employed to analyze the fundamental factors influencing Bangladesh's global trade. The study explored how the economic characteristics of partner countries impact the volume of international trade and assessed the projected trade levels using the gravity model, considering factors such as geographical distance and the relative significance of partners. It would be fascinating to examine the influence of the alliance, shaped by religious affinities and geographical proximity, on the international trade of Bangladesh.

The study reveals a positive correlation between Bangladesh's international trade and its GDP, exchange rates, and aggregate population with partner nations. Conversely, the concept of remoteness, accounting for both the economic importance of the partner and geographical distance, exerts a negative influence on bilateral trade. Contrary to the Heckscher-Ohlin theory, the findings support the Linder hypothesis in guiding the structure of Bangladesh's foreign trade. According to this model, Bangladesh holds substantial potential for enhancing trade with nations such as the United States, Mexico, Italy, Japan, Egypt, France, Brazil, South Africa, and Nigeria. Consequently, Bangladesh should promptly implement effective measures to capitalize on untapped trade opportunities with these countries, and increased diplomatic efforts are essential to foster trade with economically similar nations.

This study provides significant insights into the factors influencing Bangladesh's international trade; however, it has its limits. The study utilizes panel data from a designated time frame, which may inadequately reflect recent alterations in global trade dynamics or the impacts of new trade agreements and geopolitical developments, as these factors are excluded due to data unavailability. The gravity model utilized in this analysis, while prevalent, may not encompass all potential factors affecting trade, such as political instability or non-tariff obstacles, which could be substantial in actual trade dynamics but cannot be incorporated owing to data limitations.

For future research, we recommend exploring the impact of non-economic factors, such as political relations or cultural ties, on trade flows. Further investigation into the role of emerging markets and their trade relationships with Bangladesh could provide additional insights. Additionally, extending the dataset to more recent years could help capture the effects of global economic disruptions, such as the COVID-19 pandemic, on trade patterns. Future studies could also consider alternative models, such as those incorporating network analysis or gravity models with non-linear specifications, to address the complexities of modern global trade.

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