Assessing the Impact of Physical Infrastructure, Border Efficiency, and Institutional Quality on the Export Performance of Pakistan: Gravity Model Analysis on Commodity Data

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Abstract

In this study, our primary objective is to examine the impact of physical quality infrastructure, border efficiency, and institutional quality on the commodity export flow from Pakistan to its top trading partners, utilizing the gravity trade model. For analysis, the study employs several econometric approaches, including the Poisson Pseudo-Maximum Likelihood (PPML), which is our primary estimator. Among the variables in basic gravity models, the GDP of partner countries proved to be a significant determinant, having a favorable impact on the export flows of most commodities. The analysis revealed a negative relationship between export flows and geographical distance across most industries. The findings suggest that rupee depreciation does not support increasing export flows for most of the selected industries. Furthermore, the exports of most industries significantly increase due to improved infrastructure quality and enhanced border efficiency in importing countries. In partner countries, the estimates associated with institutional quality provided mixed results, with most industries yielding positive or insignificant outcomes. Conversely, the physical quality of infrastructure, border efficiency, and institutional quality in Pakistan appeared insignificant in most industries.

Keywords: Pakistan; Commodity Trade; Gravity Model; Infrastructure; Institutional Quality; Border efficiency; PPML

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1. Introduction

International trade has expanded markedly in recent decades. Beyond tariff reductions, "trade facilitation"—policies and practices at and beyond the border that lower trade costs—has been pivotal (Portugal-Perez & Wilson, 2012; Fereira & Cateia, 2023). On the border, this includes streamlined customs procedures; beyond the border, it reflects the political-business environment and the quality of a country's infrastructure. Following Lee (2008), we distinguish hard (tangible) infrastructure—airports, seaports, roads, railways, electricity, gas, telephony, internet—from soft (institutional) infrastructure—law and order, corruption control, regulations, and border efficiency. Modern, reliable infrastructure reduces effective distance and transaction costs, making exports more competitive (World Economic Forum, 2014). Asia's trade growth has been closely tied to such improvements (Ahmad et al., 2011; Uchenna, 2019). A prominent illustration is China's One Belt One Road (OBOR), with Pakistan as a key node via the China–Pakistan Economic Corridor (CPEC), a US$60 billion transport- and energy-focused investment (Farr, 2017; Chaudhury, 2017; Irshad, 2015). For a developing economy like Pakistan, the trade–infrastructure nexus is therefore central to export performance.

Empirically, many studies link infrastructure to exports (Portugal-Perez & Wilson, 2012; Andrés et al., 2014; Ismail & Mahyideen, 2015; Lorz et al., 2020), yet few focus squarely on developing economies. For Pakistan, Rehman et al. (2019, 2020) examine this relationship using aggregate data. Aggregation can obscure heterogeneity: effects that are strong in one industry may be offset elsewhere, and policy levers (e.g., border procedures) may influence commodities differently. Commodity-level analysis is thus essential to reveal differential responses.

This study investigates how physical and non-physical infrastructure shape Pakistan's commodity exports to its top trading partners. We assemble a panel for nine two-digit SITC commodities exported to 23 partners over 2006–2017 and estimate a gravity model tailored to commodity-specific applications (Karemera et al., 2009, 2011, 2015; Jagdambe & Kannan, 2020; Çekyay et al., 2020). We quantify the roles of transportation, communication, and electricity infrastructure (in Pakistan and partner countries), border efficiency (time and documentation for trade), and institutional quality (size of government, legal structure and property rights, sound money, trade freedom, and regulation of credit). Methodologically, we apply Fixed Effects, Random Effects, the Hausman–Taylor estimator, and PPML to address unobserved heterogeneity, potential endogeneity, serial correlation, and zero trade values. The findings offer actionable insights for policies aimed at strengthening and diversifying Pakistan's export base.

2. Literature Review

Infrastructure, whether hard or soft, is central to economic growth and a catalyst for global trade. Consequently, the infrastructure–trade link has become a key research focus (Fereira and Cateia, 2023). Prior work examines how transportation, energy, ICT, border efficiency, the business environment, law and order, and corruption shape countries' trade flows (Karymshakov and Sulaimanova, 2021).

The incorporation of transportation expenses certainly reflects the influence of infrastructure on trade. Following the Dornbusch Fischer-Samuelson model, Bougheas et al. (1999) argue that infrastructure reduces transportation costs and accelerates trade. While country location and resources are crucial for the amount of infrastructure it accumulates, the precise division of gains between partners remains unclear; nevertheless, the overall effect on trade is positive. Empirical evidence broadly confirms this (Limao and Venables, 2001; Nordas and Piermartini, 2004; Cigu et al., 2019). For developing economies, advances in both physical and soft infrastructure raise export performance, implying the need for investment and regulatory reform (Portugal-Perez and Wilson, 2012). Using 2010–2018 data for three Central Asian economies, Karymshakov and Sulaimanova (2021) also find that exports increase with both the quantity and quality of infrastructure, though the effect appears to decline over time.

The relationship between trade facilitation and trade flows has also received great attention in the previous empirical literature. Trade facilitation refers to the set of policies and regulations that help reduce trade costs, ultimately enhancing trade (Iwanow and Kirkpatrick, 2009; Sénquiz-Díaz, 2021). In a gravity model for 75 economies, Wilson et al. (2005) show that improvements in port efficiency, customs, regulatory procedures, and service-sector infrastructure substantially boost global trade. This finding supports earlier Asia–Pacific evidence (Wilson et al., 2003), which predicts a 21% rise in intra-regional trade. For South Asia, Hertel and Mirza (2009) estimate a 75% increase within the region and 22% in other regions from facilitation reforms; however, Shepherd and Wilson (2009) report a 7.5% gain in South Asian region. Iwanow and Kirkpatrick (2009) similarly find positive effects for Africa. Time delays matter as well: Persson (2008) shows that export and import lags reduce bilateral trade. For three ASEAN countries, Sénquiz-Díaz (2021) confirms that facilitation strengthens regional trade connectivity.

Another group links ICT infrastructure to trade. Extending the gravity model with telecom variables, Park and Koo (2005) find that ICT in both exporting and importing countries raises bilateral trade. Fink et al. (2005) show that higher telephone-line costs depress trade. For Malaysia's exports to 36 partners, Ahmad, Ismail, and Hook (2011) report that mobile and fixed-line subscriptions, and greater personal-computer and internet use, significantly increase exports. By collecting data across 28 African countries, Bankole et al. (2015) suggested that information and communication technology have a positive influence on intra-African trade. These results are similar to those observed by Ismail and Mahyideen (2015) for Asian countries, as well as by Rodríguez-Crespo and Martínez-Zarzoso (2019) for 120 developed and developing economies.

Then, a group of studies investigated the role of institutional quality, as a part of the non-physical infrastructure, in augmenting trade. Using enforcement and corruption measures, Anderson and Marcoullier (2002) find that weak institutions depress trade, a result supported by Depken and Sonora (2005) and Levchenko (2007). Combining indicators via PCA, Francois and Manchin (2007) show that both physical (transport and communication) and institutional quality significantly determine exports. A few other studies also found a positive impact of some other aspects of institutional quality on trade, including investor protection (Hur et al., 2006), effective contract enforcement (Rajan and Lee, 2007), transparent trade-policy processes (Helble et al., 2009), and smooth business registration (Sadikov, 2007).

Overall, the infrastructure–trade nexus is well documented, yet most studies rely on aggregated data and often emphasize particular regions or developed economies. Although research on developing countries is expanding, evidence for Pakistan remains limited, especially within a commodity-specific gravity framework. Moreover, much of the literature examines only one or two infrastructure dimensions rather than jointly considering physical infrastructure, border efficiency, and institutional quality. These gaps motivate the present study. .

3. Data, Model, and Methodology

3.1. Data and variables

For the analysis, we have collected panel data over the period 2006-2017 and across 23 trading partners of Pakistan. The detail of the exporting partners of Pakistan is given in Table 2 of the appendix. Our study aims to investigate how different commodities respond to improvements in both physical and non-physical infrastructure. Therefore, we have selected nine 2-digit (SITC) commodities that are exported from Pakistan to 23 importing nations. The names and shares of each commodity in the total export volume of Pakistan are provided in Table 1 of the appendix. These nine commodities account for more than 80% of Pakistan's total export volume.

The commodity export flow data in US$ is taken from the World Integrated Trade System (WITS). The constant GDP data in US dollars is collected from the World Development Indicators. Data on distance and dummy variables were obtained from CEPII. The main independent variables include physical infrastructure, border efficiency, and institutional quality. Following the literature, we have also employed the indices to capture the impact of both physical and non-physical infrastructure on export flows. Data on the physical quality of the infrastructure index is sourced from the World Economic Forum, and the institutional quality index is compiled from the Economic Freedom of the

World database by the Fraser Institute. Both indices are readily available; however, we have constructed an index of border efficiency based on four different components using principal component analysis (PCA), with data sourced from the Doing Business (DB) database. The name and descriptions of each variable and their data sources are proposed in Table 3 of the appendix.

The descriptive statistics are provided in Tables 4a and 4b of the appendix. Table 4a presents descriptive statistics for the aggregate model, including all variables. Table 4b provides descriptive statistics for the export variable (LnEXP) only, as the remaining variables are identical to those in the aggregate model. The descriptive statistics highlight Pakistan's trade dynamics with its partners. Export flows ($LnEXP_{ij}$) average 5.98, ranging from 3.50 to 8.38, showing moderate variation across trading partners. Pakistan's GDP ($LnGDP_i$) remains high and stable, with a mean of 12.25, while the GDP ($LnGDP_j$) of its partner countries is significantly smaller, at 3.32, with little variation. The distance to partners ($LnDIST_{ij}$) averages 8.40, reflecting a relatively consistent geographical separation. The quality performance index for Pakistan (QPI_i) averages 3.31 and is highly stable, whereas the index for partner countries (QPI_j) is higher at 5.03 and more dispersed. Border efficiency ($BDRE_i$) for Pakistan exhibits a wide variation (mean 0.89, standard deviation 2.39), indicating uneven trade facilitation, whereas partners' efficiency ($BDRE_j$) is less volatile. Institutional quality is stronger on the partner side (mean 7.24) compared to Pakistan (mean 5.91), but both show little variation. The descriptive statistics show clear differences in export performance across commodities. Commodity 65 has the highest and most stable exports (mean 4.89), followed by 84 (3.24) and 86 (1.30). In contrast, commodities 03, 05, 06, and 51 record low or even negative averages with high variability, indicating weaker and unstable trade flows. Overall, a few commodities dominate exports, while others remain volatile.

3.2. Model

For half a century, the gravity equation has been one of the most effective models in explaining the direction of trade between countries. Yotov et al. (2016) provide five compelling reasons for making the gravity equation a workhorse in global trade. These five reasons are; a) an intuitive model based on Newton's law of gravity; b) a Structural model with a firm theoretical base; c) quite closed to a real-world model with a lot of countries, firms, sectors, etc.; d) A flexible model that can incorporate other economic theories into it very easily; e) a good estimator of data whether aggregate or sectorial.

The traditional gravity model was founded by Isaac Newton in 1687 and had basic applications in the field of Physics. According to this, the larger the size of two objects, the more they will be attracted to each other. However, the larger the distance between them, the less attraction they will have for each other. The original equation of gravity is stated below.

$$T_{ij} = \frac{M_i^{\alpha} M_j^{\beta}}{D_{ij}^{\delta}} \qquad (1)$$

where T_{ij} is a force attraction between two objects; M_i and M_j represent the sizes of the objects; D_{ij} symbolizes the distance between them, and G is a constant term.

First of all, Tinbergen (1962) and Poyhonen (1963) explained this gravity equation in the context of universal trade. They examined the idea that a country's large economic size would attract more trade; hence, trade between two large economies would be greater compared to trade between small economies. They also established that the distance would reduce trade between the two nations. The theoretical basis of the gravity equation was first proposed by Anderson (1979) through the construction of a reduced-form model that incorporates product differentiation and expenditure approaches. In a series of studies, Bergstrand (1985, 1989, and 1990) derived the model by incorporating monopolistic competition and constant elasticity of substitution. Helpman and Krugman (1985) and Deardorff (1998) developed a gravity model that incorporates insights from other trade theories, particularly the Heckscher-Ohlin (H-

O) trade theory. McCallum (1995) and Anderson and van Wincoop (2003) further developed the theoretical base of the gravity equation of trade by explaining the trade response to the border effect.

After the great triumph of the gravity equation in explaining the mutual trade flows between the countries, a few studies following Leamer (1974) collected the data at the commodity level. They tested the influence of various factors on commodity-specific export and import flows among trading partners by applying the gravity equation of trade. For example, Koo et al. (1994) analyzed the meat trade, Sarker and Jayasinghe (2007) examined the trade of agrifood products, and Karemra et al. (2011, 2015) estimated the determinants of the trade in vegetables, fruits, and swine meat using the gravity model of trade. Hence, following these studies, after taking the log of specification (1), the simplest form of the commodity-specific gravity model of Pakistan takes the following form.

$$LnEXP_{ijt}^{k} = G + \alpha_1 LnGDP_{it} + \alpha_2 LnGDP_{jt} + \alpha_3 \mathrm{LnDIST}_{ij} \qquad (2)$$

Next, we follow the studies of Nordås and Piermartini (2004), Park and Koo (2005), Ismail (2011), and Ismail and Mahyideen (2015) and supplement the basic gravity model (2) by adding variables related to physical and non-physical infrastructure which could capture the impact of infrastructure on the export flows of a specific commodity (k) from Pakistan to its top export partner.

$$Ln\,EXP_{ijt}^{k} = G + \alpha_1 LnGDP_{it} + \alpha_2 LnGDP_{jt} + \alpha_3 LnDIST_{ij} + \alpha_4 X_{ijt} + \mu_{ijt} \qquad (3)$$

In the above model (2) $LnEXP^{k}_{ijt}$ is the export flow of a specific commodity (k) between Pakistan and its top trading partners; $LnGDP_{it}$ symbolizes the economic mass or size of Pakistan; $LnGDP_{jt}$ denotes the economic mass or size of a partner country; $LnDIST_{ij}$ is the distance from the capital of Pakistan to the capital of importing countries; Xit is a set of variables given in Table 3; μ_{it} is a random error term.

3.3. Methodology

In this section, we have closely followed the study by Gupta et al. (2019) and Ranivolic (2017). As our data is based on panel settings and we are applying the gravity model of trade, following the recent trend, we have used four different methodologies: Fixed Effect Model (FEM), Random Effect Model (REM), Hausman-Taylor (HT) estimator, and Poisson Pseudo-Maximum Likelihood (PPML) technique. The intuition behind using four estimators is to enhance the reliability of the results. We report all results to demonstrate the stability of our substantive conclusions across estimators and to show how estimator choice affects coefficient precision and significance. Our use of multiple estimators is consistent with past gravity model studies (Anderson & van Wincoop, 2003; Santos Silva & Tenreyro, 2006; Head & Mayer, 2014; Gupta et al., 2019; Ranivolic, 2017), which employ different approaches to address specific econometric issues. Almost every previous gravity model study that relies on panel data has employed the Fixed Effects Model (FEM) and Random Effects Model (REM) as baseline estimators, in addition to other estimators. Following the available literature on the gravity model, we have also used FEM and REM as our baseline estimators. The results of these are compared with the results of our main estimator, Poisson Pseudo Maximum Likelihood (PPML). In addition, the Hausman-Taylor is known for its ability to control endogeneity. It is used to determine whether the endogeneity-corrected results differ from the outcomes of PPML. We observe consistency in the results of both estimators, which adds reliability to our study. Below, we will discuss in detail each of the estimators used in this analysis, along with their benefits.

The fixed-effects model (FEM) is suitable for cases where predetermined cross-sectional units are selected, unlike the random-effects model (REM), where cross-sectional units are randomly selected from a larger population. The FEM, on the one hand, addresses the unobserved country-specific heterogeneous effect; on the other hand, it excludes time-invariant explanatory variables (distance and dummy variables) due to their perfect collinearity with the country-specific effect. Hence, we also apply REM, which assumes that country-specific effects are uncorrelated with any of the regressors; in this case, we can include dummy variables. However, we can experience biased and unreliable results if this assumption is violated. The solution provided by Hausman and Taylor (1981) permits some of the independent variables to be correlated with country-specific time-invariant effects. Baltagi et al. (2003) referred to it as the HT estimator, which provides unbiased results. Finally, we employ the PPML methodology, one of our favourites, to measure the impact of various indicators on bilateral trade flows between countries. The zero-export value is a fundamental problem in estimating bilateral trade flows using the gravity model, as it renders the log value of zero exports unidentified.

Moreover, Silva and Tenreyro (2006) noted that estimates from the log-linearized model are biased because the standard errors are affected by heteroskedasticity. Hence, various studies have suggested that the Poisson model is preferable to the log-linearization model (Silva & Tenreyro, 2006, 2011; Sun & Reed, 2010; Lateef et al., 2017; Alaamshani et al., 2020). Additionally, the problem of zero trade value is also addressed by the PPML estimator without requiring any modifications to the original model (Shepherd, 2016; Silva and Tenreyro, 2006, 2011; Pfaffermayr, 2023). For other estimation techniques using the log-linearised model, we have replaced all zero trade values with one (Sun & Reed, 2010; Lateef et al., 2017; Gul and Iqbal, 2021).

Our dependent variable is the export value, $LnEXP_{ijt}$, of a specific commodity (k) from Pakistan to its partners, and there are missing values in it. We consider these missing values as zero, as suggested by Silva and Tenreyro (2006) and Francois and Manchin (2013). The zero-export value is a fundamental issue in estimating the export flow using the gravity model from one country to another, as if the log value of zero exports is unidentified (Lateef et al., 2017; Irshad and Anwar, 2019). However, this problem can be overcome if we don't apply the log-linearization; instead, we use the Poisson estimator. Thus, in the Poisson model, we use the EXP_{ijt} as a dependent variable.

Some diagnostic tests are also applied that enhance the reliability of our estimates. The correlation matrix is employed to detect possible correlation among explanatory variables, followed by the computation of the Variance Inflation Factor (VIF) to quantify the existence of multicollinearity. The Hausman test is used to determine whether we should prefer REM over FEM. The Ramsey RESET test is conducted to identify any misspecification in the model, while the Breusch–Pagan test is used to ascertain the existence of heteroskedasticity. The Box–Pierce test was ultimately performed to assess autocorrelation in the residuals.

4. The Results

To ensure the robustness and reliability of the econometric models, several diagnostic tests are also conducted, as reported in Tables 5, 6, and 7. The correlation matrix confirmed that none of the correlation coefficients between the two variables equals 1, indicating that our variables are not perfectly correlated. The highest correlation coefficient (-0.847) is between $BDRE_i$ and QPI_j, followed by the positive correlation coefficient (0.736) between BDREi and $LnGDP_i$, implying that $BDRE_i$ and QPI_j are negatively correlated, or move in opposite directions, while the correlation between $BDRE_i$ and $LnGDP_i$ is positive. The results of the correlation matrix indicate that we can retain all variables within the model, as no correlation coefficient is exactly equal to 1. The VIF findings demonstrate that multicollinearity is not a significant issue in the model. All variables have VIF values that are much below the widely recognized criterion of 10, and even the more stringent threshold of 5, indicating that the regressors are not substantially associated with one another. The largest Variance Inflation Factor (VIF) is for QPI_i (3.95), followed by IQ_j (3.45), both of which remain below acceptable thresholds.The average VIF of 2.33 further substantiates that multicollinearity is minimal, indicating that the model don't suffer from multicollinearity**.** In addition, the RESET test confirms that most of our models are correctly specified, while the LM test highlights that the residuals in most models are not serially correlated. Moreover, the Breusch–Pagan test indicates that heteroskedasticity is not a concern in our models. Last but not least, the Hausman test confirms that REM is a preferred model in comparison to the FEM, as we fail to reject the null hypothesis in all our models.

We have applied four different methodologies to obtain the estimates of coefficients; hence, for each commodity, we have produced four sets of estimates, which are provided in Tables 9-13. Moreover, we have also estimated the impact of our related variables on Pakistan's aggregate export flow, which is reported in Table 8.

4.1. Estimates of Aggregate Exports

First, we discuss the estimates of the aggregate export model of Pakistan, presented in Table 8, using all four estimation techniques. The estimates attached to the variables $LnGDP_i$, $LnGDP_j$, and $LnDIST_{ij}$ are significant, and, according to previous literature, they are positive for Pakistan's GDP and its partner countries, and negative for the distance between Pakistan and its importing partners. These results suggest that Pakistan's exports will flourish due to an increase in Pakistan's GDP and that of its partner countries; conversely, the distance between Pakistan and its importing partners will reduce the exports from Pakistan to these countries. These results match the results of previous studies by Gul and Yasin (2011), Akhter and Ghani (2010), Akram (2013), Hussain (2017), and Salahuddin et al. (2020). Moreover, in all models, the export flows of Pakistan are positively impacted by the better quality of physical infrastructure and improved institutional quality in importing countries. Conversely, the estimate of border efficiency in importing countries is positive and significant in the RE and PPML models, and positive but insignificant in the FE and HT estimators. The estimates of QPI_i and IQ_i are found to be insignificant using all estimation techniques. Lastly, the estimate attached to the common language variable is significant and positive in all models. The estimates of the remaining variables — border efficiency in Pakistan, common border, and common colony — appear insignificant.

4.2. Estimates of Commodity Exports

We have divided our commodity results into three categories. First, we discuss the effects of three variables from the basic gravity model: Pakistan's income, partners' income, and geographical distance between Pakistan and its partners. After that, we discussed the real exchange rate results and three time-invariant variables, i.e., common border, language, and colony. Lastly, we discuss the variables of our main interest: physical infrastructure quality, border efficiency, and institutional quality.

4.2.1. Discussion on the effects of the GDP of Pakistan, the GDP of partner(s), and Geographical distance

Tables 9-13 present the coefficient estimates for all variables related to each commodity and across all models. To save space, we present the detailed results of the PPML model and briefly discuss the results of other models. From the estimates, we gather that the GDP of Pakistan is found to be significant in three industries (05, 61, and 84) in the FE model, four industries (05, 06, 61, and 84) in the RE model, three industries (05, 84 and 61) in HT model and four industries (05, 06, 61, 84) in PPML model. In all these industries, the sign attached to the $LnGDP_i$ variable is positive, indicating that Pakistan's exports are expected to increase as a result of higher income. Similarly, the $LnGDP_j$ (partner income) variable carries a significant coefficient estimate in seven industries (03, 04, 05, 06, 65, 84, and 86) in the case of FE model, eight industries (03, 04, 05, 06, 61, 65, 84 and 86) HT models and four industries in the case of RE model. The number of industries in the PPML model that are affected by the partners' income is six, and out of these, the exports of two industries, 03 and 04, are hurt by the increase in GDP of partner countries, which suggests that the increased income of the partner countries is due to the augmented domestic production of these commodities. In the remaining four industries, 61, 65, 84, and 86, the estimates attached to $LnGDP_j$ are positive, which show that the export flows of these commodities will increase as a result of the high economic growth rate of partner countries. Hence, we can say that the GDP of partner countries is proven to be an important determinant of Pakistan's export flows, and our results are similar to those of previous studies by Akhter and Ghani (2010), Akram (2013), Hussain (2017), and Salahuddin et al. (2020). The distance variable is excluded from the FE model due to perfect collinearity with country-specific effects. In the case of an HT estimator, the estimates attached to $LnDIST_{ij}$ are insignificant in most industries. In the RE model, the estimates are negative and significant in four industries: 05, 61, 84, and 86. However, in the PPML model, the coefficient estimates of $LnDISTt_{ij}$ are found to be significant and negative for industries 04, 05, 06, 84, 61, and 86, and positively significant for industries 03 and 65. This result is not surprising as more than 25% of Pakistan's textile exports are directed toward North American and European countries. These findings align with the traditional gravity theory, which suggests that, for most industries, Pakistan's exports will decrease with distant trading partners. This result implies that distance increases the traveling cost of trade, ultimately reducing trade volume. A few other studies, such as those by Butt (2008), Gul and Yasin (2011), Jayasinghe and Sarkar (2008), Abbas and Waheed (2015), Karemera et al. (2009, 2015), and Hussain (2017), have also found a negative impact of distance on trade flows.

4.2.2. Discussion on the effects of Real Exchange Rate, Colony, Border, and Language

The impact of rupee depreciation on the export flows of Pakistan is a mix (positive, negative, or insignificant) in FEM, REM, and HT estimation. The exchange rate variable estimates in PPML models appear to be significant and positive in four industries (06, 65, 84, and 86), whereas the estimates are negative and significant in three industries (03, 51, and 61). The exchange rate variable with a negative sign indicates that, despite the depreciation of the Pakistani rupee, export flows from these industries to Pakistan's major partners exhibit a downward trend. The probable reason could be the inelastic demand of these industries 03, 51, and 61 abroad. Although the depreciation of the Pakistani currency lowers the prices of these commodities, the inelastic demand means that exports don't rise, and ultimately, export revenue further shrinks. On the other side, in industries 06, 65, 84, and 86, where the estimate of the RER variable is positive, it signifies that a positive change in the exchange rate will enhance Pakistan's exports for these commodities.

We have augmented our gravity model with a few time-invariant variables, such as common borders, colonies, and languages. In the FE model, all these variables are omitted; however, in the HT model, the coefficient estimate of the CLNY variable in all industries appears insignificant. Conversely, in RE models, the estimate attached to the CLNY variable in almost half of the industries comes out to be significant. The estimate attached to the CLNY variable in industries 03, 04, 65, and 84 is negative, whereas it is positive in the case of industry 05. Similarly, the BDR variable carries a significant coefficient estimate in three industries (05, 84, and 86) in the RE model and in two industries (05 and 84) in the HT model. Moreover, the estimate of the LNG variable in the RE model appears to be significantly negative in only two industries, 03, 51, and 61. In the remaining industries, the effect of the same variable does not show any noticeable impact on Pakistan's export flows. Likewise, HT analysis does not produce any significant effect on any commodity.

Lastly, we have applied the PPML methodology, which yielded the most significant results among all estimation techniques. For instance, the BDR variable carries a significant and positive estimate in only two industries, 03 and 51, which implies that Pakistan's exports to these industries are more to countries sharing a common border with Pakistan compared to those without a common border. However, in all other industries (04, 05, 06, 51, 61, 65, 84, 86) the estimate is either insignificant or negative, confirming that, in general, Pakistan's export volume direction is less towards bordering countries. The bordering countries of Pakistan are Afghanistan, China, India, and Iran. In this study, only two bordering countries, i.e., China and India, are included in the sample. Afghanistan is excluded due to the unavailability of infrastructure data, and Iran is excluded because its share in Pakistan's exports is insufficient. Apart from China, Pakistan does not enjoy a cordial relationship with other bordering countries, particularly India. The diplomatic, political, and economic ties between Pakistan and India have not been very welcoming since the independence of Pakistan. Hence, these findings are not surprising and are in line with a few other studies by Gul and Yaseen (2011) and Iqbal (2016), although their data were aggregated. Salahuddin et al. (2020) also obtained similar results when using commodity trade data between Pakistan and its partners.

Next, we find that the CLNY variable carries a significant negative estimate in cases 03, 04, 61, 84, and 86, and a significant positive estimate in only one industry, i.e., 65. Hence, we can infer that if Pakistan and its exporting partner had remained under the same colonial power, exports from Pakistan to that country would be less compared to other trading partners. These results are also not surprising, as Bangladesh, Hong Kong, India, and Pakistan were among the countries that were once British colonies. These countries hold only 4% of shares in Pakistan's total exports.

Finally, the estimated coefficients of the last dummy variable, i.e., LNG from the PPML technique, are statistically significant in eight out of nine industries. There are three industries, 03, 51, and 61, where the estimated coefficients are negative, suggesting that Pakistan's exports in these industries are lower compared to countries where English is the official language, as opposed to non-English speaking partners. However, in industries 05, 06, 65, 84, and 86, the estimate of LNG is positive, implying that exports of these products are directed more towards English-speaking countries. This result is quite reasonable as all English-speaking countries, Australia, Canada, the USA, and the UK, together they account for almost 25% of Pakistan's total exports.

4.2.3. Discussion on the Effects of Physical Infrastructure, Border Efficiency, and Institutional Quality

Now we see how export flows of various commodities from Pakistan to its partners respond to the quality of physical infrastructure, border efficiency, and institutional quality. The estimated coefficients of the status of physical infrastructure in the partner countries show a positive impact on the export flows of four industries (03, 61, 65, and 84) when the FE model is applied. In the case of RE and HT estimation techniques, the export flows of two industries (61 and 65) and three industries (03, 61, 65, and 84) are positively influenced by the development of physical infrastructure in partners. In the case of the PPML model, the export flows of five industries 03, 04, 05, 61, and 65, benefited from an improvement in the physical infrastructure of importing countries. In one of the industries utilizing the PPML technique, the coefficient associated with the QPI_j variable is negative, indicating that the export of commodity 84 from Pakistan to importing countries decreased due to improvements in their physical infrastructure. The implied reason behind this negative effect could be the improved connectivity of importing countries to other markets and reduced trade costs due to better quality infrastructure; hence, importers substitute exports from Pakistan with other, better options from across the globe. Overall, we can say that Pakistan's export flows will see a boost due to improved quality physical infrastructure in importing countries. The results of physical quality infrastructure are similar to those of Park and Koo (2005), Portugal-Perez and Wilson (2012), Ismail and Mahyideen (2015), and Baita (2020).Conversely, the estimated coefficients of QPI_i are insignificant in most industries, irrespective of the estimation technique used. These results suggest that the improved physical infrastructure within Pakistan will not have a noticeable impact on Pakistan's export performance. However, in one industry 05, the QPI_i variable hurts Pakistan's exports. Conversely, the export of the largest industry, 65, exhibits an upward trend following the development of physical infrastructure in Pakistan.

Next, we examine the impact of institutional quality, both in Pakistan (IQ_i) and among importing partners (IQ_j), on Pakistan's export flow. Here again, the institutional quality in partner countries proved to be an important determinant of Pakistan's export flows. In the FE model, the number of industries with significant estimates is three (06, 61, 65, and 84), two industries (61, 65, and 84) each in RE and HT estimation techniques, and five industries (03, 06, 61, 65, 84) in the PPML model. Most industries, including the two largest, 65 and 84, with significant estimates of IQ_j, are positively impacting the favorable effect of institutional quality in importing countries on Pakistan's export performance. Surprisingly, institutional quality in Pakistan (IQ_i) does not significantly affect most industries in all four models, particularly with the PPML estimation technique. Similarly, the coefficient attached to $BDRE_j$ is found to be significant in more industries compared to the significant estimates attached to $BDRE_i$. For example, in the case of the PPML estimation technique, improved border efficiency in importing countries boosts the exports of Pakistan for industries 04, 06, 51, 61, 65, 84, and 86. However, border efficiency in Pakistan yields significant results in only one industry, 06, regardless of the estimation technique applied.

5. The Conclusion

The modernized and well-built infrastructure reduces the distance between countries and helps connect economies at a low cost. Moreover, the better-quality infrastructure lowers production costs, making the prices of export commodities more competitive. Therefore, it is essential to comprehend the relationship between infrastructure and commodity trade. Literature on the infrastructure–trade nexus has relied on aggregate data, particularly in the context of the Pakistan gravity model framework, thereby leaving a gap in the literature. This analysis aims to address this gap by investigating the influence of physical quality infrastructure, border efficiency, and institutional quality on Pakistan's export commodities to its 23 partners from 2006 to 2017, using the gravity model of trade. For empirical analysis, we utilize the FEM, REM, HT, and PPML estimators.

The results highlight that the GDP of partner countries strongly drives exports, particularly in 65 and 84, while distance generally hinders trade, except for textiles, which are directed to distant markets such as Europe and the US. Exchange rate depreciation produced mixed outcomes, benefiting some industries (notably 65 and 84) but constraining others, reflecting varying price elasticities. Furthermore, Pakistan exports less to its bordering countries and former colonies, even though a common language could foster trade. Among infrastructure indicators, the physical infrastructure and border efficiency of partner countries prove to be the most important determinants of Pakistan's export flows for most of the selected commodities, including the two largest industries: 65 and 84. In contrast, Pakistan's own infrastructure quality shows limited effects. Improved institutional quality in the partner countries yields mixed results across industries, whereas in Pakistan, it has a limited impact on most industries.

The study's findings provided several important policy implications. Disaggregated data provided policymakers with the opportunity to view each commodity separately. For instance, rupee depreciation does not improve the export volume in a few selected industries. However, the export volume of the two largest industries improves after the rupee depreciation; hence, the policy of depreciation could prove favorable for some industries and detrimental for others. Moreover, the export flows for most industries, including the two largest, from Pakistan to bordering countries are lower compared to non-bordering countries, and could be increased by resolving political disputes with countries like India and Afghanistan. Distance and infrastructure are used as proxies for trade cost and trade facilitation. Our results imply that reduced trade costs and improved trade facilitation will positively impact export volume in general, particularly for commodities related to food and meat. Hence, reduced travel costs through improved physical infrastructure and minimizing distance are important for enhancing the exports of perishable items.

Despite several useful contributions from the study, some limitations remain that need to be addressed in the future. Firstly, we have performed this analysis on the exports of the top commodity from Pakistan to its 23 export partners. However, Pakistan exports only a small number of items in sizable quantities; more specifically, most commodities account for less than 5% of Pakistan's total exports, which may result in insignificant outcomes. Moreover, we cannot generalize the study's outcomes by selecting only one developing economy, such as Pakistan. Therefore, future studies should select economies that export a wide variety of goods with a sizable share and also include other developing economies to provide more valuable information. Second, a comparative analysis of advanced and developing economies, estimating the impact of hard and soft infrastructure on commodity exports across diverse socio-economic and political contexts with significant infrastructure differences, can add more value to the literature. Lastly, our study employs commodity-level data to capture heterogeneity across sectors. This explains why some items, especially low-share commodities, show weaker or non-significant results. On the other hand, the aggregate data may smooth out heterogeneity across product categories and may yield stronger overall significance. Thus, an in-depth comparison between the aggregate and disaggregate models could be an interesting choice for future studies.

Declarations:

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Conflict of Interest

None

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Appendix

Table 1: Commodity code, name, and % share in total exports of Pakistan

Code	Name	% Share in 2016	% Share in 2017	% Share in 2018
03	Fish and Fish Preparations	1.66%	1.87%	1.82%
04	Cereals and cereal preparations	9.45%	8.75%	10.61%
05	Fruits and vegetables	3.22%	2.42%	2.88%
06	Sugar, sugar preparations and honey	1.25%	2.36%	2.14%
51	Chemical elements and compounds	1.33%	1.87%	2.05%
61	Leather, leather manufs., nes and dressed fur skins	1.76%	1.57%	1.29%
65	Textile yarns, fabrics, made-up articles etc.	34.27%	25.07%	23.86%
84	Clothing	28.46%	36.35%	35.64%
86	Scientific instruments, photography instruments and clocks	1.79%	1.73%	1.65%

Source: Uncommon trade (Authors' own calculations)

Table 2: Export Partners of Pakistan

Country	% share	Country	% share	Country	% share
Australia	0.99%	Indonesia	1.28%	Spain	4.04%
Belgium	2.71%	Italy	3.43%	Thailand	1.16%
Bangladesh	3.23%	Japan	1.26%	Turkey	1.25%
Canada	1.18%	Malaysia	0.72%	UAE	4.02%
China	8.30%	Netherland	4.23%	United Kingdom	7.2%
France	1.72%	Saudi Arabia	1.43%	USA	17.03%
Germany	5.54%	Sri Lanka	1.37%	Veitnam	1.19%
India	1.81%	South Korea			

Source: Pakistan Bureau of Statistics

Table 3: **Variables Name, Definition, and Sources**

Variables	Definition	Sources
$LnEXP^{k}_{ij}$	This represents the export flows of a particular commodity (k) from Pakistan (i) to 23 other countries (j).	World Integrated Trade System (WITS)
$LnGDP_{i}$, $LnGDP_{j}$	Pakistan's (i) GDP and Trading Partner's (j) GDP. It is taken as the constant.	World Development Indicators (WDI)
LnRER	Real Exchange Rate between Pakistani rupee and its trading partners. The variable is constructed in a way that a positive change represents depreciation of the rupee.	International Financial Statistics(IFS)
$LnDIST_{ij}$	The geographical distance between the capital of Pakistan and the capital of its partner.	CEPII
QPI_{i}, QPI_{j}	Quality of physical infrastructure in Pakistan (i) and partner country (j). This index is based on various other indicators like quality of transport (airports, roads, railway, sea ports), quality of electricity and communication (fixed telephone lines, mobile phone subscriptions and electric supply)	World Economic Forum (WEF)
$BDRE_{i}$, $BDRE_{j}$	Border efficiency in Pakistan (i) and partner country (j). This index comprises indicators such as time to import, time to export, documents required for export, and documents required for import.	Doing Business
IQ_{i}, IQ_{j}	Instituional quality in Pakistan (i) and partner country (j). The institutional quality index is being proxied by the Economic Freedom Index of the Fraser Institute. This index is composed of five sub-indices: size of government, legal structure and protection of property rights, access to sound money, freedom to trade, and regulation of credit. These sub-indices are based upon several other indicators.	Fraser Institute
CLNY	Common colony is a dummy variable that takes the value of 1 if both the country (i) and the partner country (j) were colonies of the same country, and 0 otherwise.	CEPII
BDR	Common border is a dummy variable that takes the value of 1 if both the country (i) and its partner country (j) share a common border, and 0 otherwise.	CEPII
LNG	Common language is a dummy variable that takes the value of 1 if both the country (i) and partner country (j) share a common official language, and 0 otherwise.	CEPII

Table 4a: Descriptive Statistics (Aggregate)

Variables	Obs	Mean	Std. dev.	Min	Max
LnEXPij	276	5.979	0.973	3.499	8.375
$LnGDP_i$	276	12.252	0.255	11.830	12.658
$LnGDP_j$	276	3.317	0.049	3.181	3.422
$LnRER_{ij}$	276	2.008	3.091	-5.506	5.164
QPI_i	276	3.311	0.123	3.072	3.491
QPI_j	276	5.030	1.136	2.218	6.632
$BDRE_i$	276	0.888	2.390	-1.152	6.049
$BDRE_j$	276	-0.028	0.989	-1.532	2.707
IQ_i	276	5.913	0.131	5.688	6.110
IQ_j	276	7.243	0.754	5.667	8.530
$LnDIST_{ij}$	276	8.404	0.606	6.527	9.341
LNG	276	0.217	0.413	0.000	1.000
CLNY	276	0.174	0.380	0.000	1.000
BDR	276	0.087	0.282	0.000	1.000

Table 4b: Descriptive Statistics of Export Variable (Commodities)

Commodity	Obs	Mean	Std. dev.	Min	Max
03	276	0.380	2.908	-13.816	4.492
04	276	2.080	2.138	-4.178	6.115
05	276	0.810	2.098	-6.730	4.405
06	276	-0.669	2.846	-13.816	4.173
51	276	0.282	2.969	-13.816	5.055
61	276	1.487	1.765	-7.775	4.299
65	276	4.889	1.114	2.297	7.621
84	276	3.243	2.489	-2.644	7.619
86	276	1.302	1.353	-1.567	4.623

Note: We have only included LnEXP in this Table because the remaining variables are identical to those in the aggregate Table 4a.

Table 5: Correlation Matrix

	$LnGDP_i$	$lnGDP_j$	$LnDIST_{ij}$	LnRER	QPI_i	QPI_j	$BDRE_i$	$BDRE_j$	IQ_i	IQ_j
$LnGDP_i$	1									
$LnGDP_j$	0.069	1.000								
$LnDIST_{ij}$	-0.012	0.403	1.000							
LnRER	-0.032	0.441	0.381	1.000						
QPI_i	0.109	0.396	0.484	0.513	1.000					
QPIj	0.140	0.036	-0.005	0.007	0.066	1.000				
$BDRE_i$	0.736	0.051	-0.009	-0.037	0.080	-0.084	1.000			
$BDRE_j$	-0.096	-0.452	-0.505	-0.454	-0.847	-0.012	-0.081	1.000		
IQi	-0.635	-0.030	0.002	0.029	-0.039	0.143	-0.759	0.046	1.000	
IQ_j	0.051	0.538	0.715	0.531	0.709	-0.006	0.059	-0.780	-0.055	1

Table 6: Variance Inflation Factor

Variable	**VIF**	**1/VIF**
$LnGDP_i$	2.19	0.456
$LnGDP_j$	1.5	0.667
$LnDIST_{ij}$	2.09	0.478
LnRER	1.59	0.628
$BDRE_i$	1.33	0.751
$BDRE_j$	2.8	0.357
IQ_i	3.45	0.289
IQj	2.69	0.371
QPI_i	3.95	0.253
QPI_j	1.69	0.591
Mean VIF	2.328	

Table 7: Diagnostic Tests

Commodities/Aggregate Model	**RESET**	**BP**	**LM**	**Hausman**
Aggregate	1.49	2.19	0.553	1.14
03	2.17	4.81*	1.37	1.84
04	1.19	2.64	3.18*	8.64
05	2.06	6.41*	1.14	7.01
06	1.64	1.80	3.22*	2.34
51	0.86	1.70	1.29	3.64
61	0.61	1.30	0.75	10.41
65	1.30	0.23	0.99	2.60
84	1.99	2.24	2.18	10.39
86	2.12	2.33	1.56	8.86

Note:

(i) * represent that the test statistics is significant and we can reject the null hypothesis.

(ii) RESET, BP, and LM tests are used to determine omitted variable bias, heteroskedasticity, and serial correlation.

(iii) Hausman test is employed to decide whether FEM or REM is appropriate for our analysis.

Table 8: Estimates of the Aggregate Export Model

Models	FE	RE	HT	PPML
	LnEXP	LnEXP	LnEXP	EXP
$LnGDP_i$	1.070**	1.120**	1.038**	0.525**
	(3.29)	(3.69)	(3.23)	(1.77)
$LnGDP_j$	16.74**	15.32**	17.76**	14.12**
	(3.40)	(4.77)	(4.04)	(5.22)
$LnDIST_{ij}$	-	-0.89*	-0.82	-0.472**
	-	(-1.64)	(-1.08)	(-2.03)
LnRER	0.098	0.102	0.454	0.054**
	(0.33)	(1.36)	(-0.02)	(2.17)
QPI_i	0.236	0.23	0.239	0.312
	(1.60)	(-1.62)	(1.60)	(0.54)
QPI_j	0.721*	0.652*	0.737*	0.790*
	(1.84)	(1.79)	(1.86)	(1.89)
$BDRE_i$	-0.067*	-0.07*	-0.071*	-0.0347
	(-1.78)	(-1.95)	(-1.89)	(-0.26)
$BDER_j$	0.128	0.231*	0.128	0.646*
	(1.48)	(1.69)	(1.48)	(1.78)
IQ_i	0.261	0.258	0.254	0.106
	(1.54)	(1.55)	(1.48)	(0.17)
IQ_j	0.259*	0.259**	0.243*	0.239*
	(1.95)	(2.08)	(1.91)	(1.83)
BDR	-	-1.032	-1.177	-0.628*
	-	(-1.04)	(-1.25)	(-1.66)
CLNY	-	0.124	0.067	-0.486
	-	(0.18)	(0.03)	(-1.15)
LNG	-	0.25*	0.126*	0.453**
	-	(1.93)	(1.77)	(3.12)
_cons	-66.63**	-54.95**	-62.26**	-43.63**
	(4.75)	(5.29)	(5.11)	(3.1)
Time F.E	Yes	Yes	Yes	Yes
No. of obs.	253	253	253	253
R-sq.	0.526	0.526		0.721

Note: The values inside the parentheses are t-ratios. * represents a 10% level of significance, and ** represents 5% level of significance

Table 9: Estimates of Commodities 03 & 04

Commodity 03 (Fish and Fish Preparations)					Commodity 04 (Cereals and cereal preparations)				
Models	**FE**	**RE**	**HT**	**PPML**	**Models**	**FE**	**RE**	**HT**	**PPML**
	LnEXP	LnEXP	LnEXP	EXP		LnEXP	LnEXP	LnEXP	EXP
$LnGDP_i$	0.244	1.900	0.320	1.524	$LnGDP_i$	-0.370	2.040	-0.158	0.699
	(0.11)	(0.90)	(0.14)	(1.24)		(-0.17)	(1.04)	(-0.07)	(0.42)
$LnGDP_j$	-3.678**	-0.588	-3.592**	-0.728**	$LnGDP_j$	-2.293*	-0.107	-2.081*	-0.440**
	(-2.86)	(-1.22)	(-2.92)	(-6.70)		(-1.88)	(-0.21)	(-1.82)*	(-3.31)
$LnDIST_{ij}$	-	-0.191	-7.884	-0.451*	$LnDIST_{ij}$	-	-0.102	-4.326	-0.922*
	-	(-0.17)	(-0.75)	(-1.88)		-	(-0.09)	(-0.51)	(-2.41)
LnRER	-3.565*	-0.401**	-3.333*	-0.208**	LnRER	-2.882	0.207	-2.296	0.0292
	(-1.68)	(-2.56)	(-1.81)	(-5.44)		(-1.43)	(1.22)	(-1.39)	(0.76)
QPI_i	0.724	0.712	0.719	0.119	QPI_i	-0.522	-0.591	-0.538	0.860
	(0.69)	(0.66)	(0.69)	(0.20)		(-0.53)	(-0.59)	(-0.54)	(0.81)
QPI_j	1.339**	0.420	1.336**	0.791**	QPI_j	0.142	0.311*	0.145	0.904**
	(3.28)	(1.21)	(3.27)	(3.23)		(0.37)	(1.94)	(0.37)	(4.06)
$BDRE_i$	-0.220	-0.143	-0.212	-0.094	$BDRE_i$	-0.024	0.006	-0.005	-0.019
	(-0.82)	(-0.55)	(-0.80)	(-0.64)		(-0.10)	(0.03)	(-0.02)	(-0.09)
$BDRE_j$	-0.650	-1.080**	-0.645	-0.393	$BDRE_j$	-0.127	0.642*	0.941**	0.525*
	(-1.06)	(-2.29)	(-1.05)	(-1.56)		(-0.22)	(1.81)	(2.16)	(1.64)
IQ_i	0.575	0.583	0.592	-0.432	IQ_i	1.975*	2.079*	2.017*	0.936*
	(0.48)	(0.47)	(0.49)	(-0.64)		(1.73)	(1.82)	(1.77)	(1.72)
IQ_j	-0.029	-0.689	0.002	1.251**	IQ_j	0.889	0.629	0.948	-0.003
	(-0.03)	(-0.89)	(0.00)	(5.24)		(1.00)	(0.84)	(1.10)	(-0.01)
BDR	-	0.521	-8.807	3.736**	BDR	-	-1.124	-6.492	0.831
	-	(0.22)	(-0.69)	(8.87)		-	(-0.45)	(-0.63)	(0.67)
CLNY	-	-0.826*	-21.35	-1.506**	CLNY	-	0.825**	-12.43	-0.985*
	-	(-1.66)	(-0.88)	(-4.98)		-	(-1.96)	(-0.62)	(-2.13)
LNG	-	-2.844**	-2.762**	-1.791**	LNG	-	-0.551	3.964	0.417
	-	(-2.37)	(2.18)	(-3.51)		-	(-0.43)	(0.52)	(1.12)
_cons	-99.16	-61.21	-29.55	-14.09	_cons	-49.04	-50.21	-12.26	-7.940
	(-1.96)	(-1.20)	(-0.29)	(-0.46)		(-1.02)	(-1.06)	(-0.14)	(-0.19)
Time F.E	Yes	Yes	Yes	Yes	Time F.E	Yes	Yes	Yes	Yes
No. of obs.	253	253	253	253	No. of obs.	253	253	253	253
R-sq.	0.225	0.362		0.715	R-sq.	0.115	0.323		0.393

Note: The values inside the parentheses are t-ratios. * represents a 10% level of significance, and ** represents 5% level of significance

Table 10: Estimates of Commodities 05 & 06

Commodity 05 (Fruits and vegetables)					Commodity 06 (Sugar, sugar preparations and honey)				
Models	**FE**	**RE**	**HT**	**PPML**	**Models**	**FE**	**RE**	**HT**	**PPML**
	LnEXP	LnEXP	LnEXP	EXP		LnEXP	LnEXP	LnEXP	EXP
$LnGDP_i$	1.629*	2.223**	1.471*	2.541**	$LnGDP_i$	6.674	12.30**	6.952	7.614**
	(1.71)	(2.24)	(1.66)	(2.31)		(1.53)	(3.14)	(1.59)	(2.69)
$LnGDP_j$	2.021**	1.406**	2.270**	-0.0994	$LnGDP_j$	8.970**	0.535	8.629**	0.244
	(3.37)	(4.20)	(4.16)	(-0.87)		(3.70)	(0.73)	(3.61)	(1.24)
$LnDIST_{ij}$	-	-2.455**	-3.378	-1.329**	$LnDIST_{ij}$	-	-1.844	-24.99	-1.151**
	-	(-2.36)	(-1.59)	(-4.55)		-	(-1.16)	(-0.71)	(-2.83)
LnRER	0.052	0.064	-0.600	0.003	LnRER	10.27**	0.799**	9.349**	0.201**
	(0.05)	(0.44)	(-1.05)	(0.09)		(2.57)	(3.54)	(2.45)	(3.02)
QPI_i	-0.821*	-0.819*	-0.813*	-1.100**	QPI_i	-2.992	-3.076	-3.010	-0.928
	(-1.69)	(-1.68)	(-1.58)	(-2.35)		(-1.52)	(-1.51)	(-1.53)	(-0.64)
QPI_j	0.182	0.254*	0.163*	0.585***	QPI_j	-0.484	0.831	-0.469	-0.118
	(0.96)	(1.74)	(1.82)	(3.38)		(-0.63)	(1.35)	(-0.61)	(-0.41)
$BDRE_i$	0.027	-0.008	0.004	-0.129	$BDRE_i$	-1.419**	-1.229*	-1.388**	-1.149**
	(0.22)	(-0.07)	(0.03)	(-0.93)		(-2.81)	(-2.49)	(-2.75)	(-3.07)
$BDER_j$	-0.108	-0.0762	-0.0729	-0.116	$BDRE_j$	1.527**	0.424	1.526**	0.984*
	(-0.38)	(-0.29)	(-0.25)	(-0.53)		(2.31)	(0.52)	(2.31)	(1.95)
IQ_i	0.001	-0.046	-0.045	-0.180	IQ_i	-6.691**	-6.202**	-6.626**	-5.047**
	(0.00)	(-0.08)	(-0.08)	(-0.28)		(-2.95)	(-2.66)	(-2.92)	(-3.59)
IQ_j	-0.337	-0.383	-0.480	-0.00916	IQ_j	-2.889*	-0.133	-2.741	-1.030**
	(-0.77)	(-0.95)	(-1.11)	(-0.07)		(-1.64)	(-0.10)	(-1.56)	(-2.65)
BDR	-	-3.614*	-5.849**	0.0345	BDR	-	-5.197**	-32.64	-3.801*
	-	(-1.80)	(-2.17)	(0.03)		-	(-3.51)	(-0.76)	(-2.50)
CLNY	-	2.956*	0.483	0.249	CLNY	-	2.044	-78.90	0.581
	-	(2.16)	(0.08)	(0.80)		-	(0.95)	(-1.08)	(1.25)
LNG	-	0.727	1.783	0.723**	LNG	-	1.617	28.94	0.960**
	-	(0.66)	(0.87)	(2.28)		-	(0.92)	(1.00)	(2.20)
_cons	-93.23**	-71.19**	-64.81**	-48.79*	_cons	-315.4**	-265.5**	-96.08	-153.6**
	(-3.94)	(-2.88)	(-2.23)	(-1.83)		(-3.30)	(-2.81)	(-0.30)	(-2.22)
Time F.E	Yes	Yes	Yes	Yes	Time F.E	Yes	Yes	Yes	Yes
No. of obs.	253	253	253	253	No. of obs.	253	253	253	253
R-sq	0.406	0.451		0.754	R-sq	0.292	0.458		0.538

Note: The values inside the parentheses are t-ratios. * represents a 10% level of significance, and ** represents 5% level of significance

Table 11: Estimates of Commodities 51 & 61

Commodity 51 (Chemical elements and compounds)					Commodity 61 (Leather, leather manufs., nes and dressed fur skins)				
Models	**FE**	**RE**	**HT**	**PPML**	**Models**	**FE**	**RE**	**HT**	**PPML**
	LnEXP	LnEXP	LnEXP	EXP		LnEXP	LnEXP	LnEXP	EXP
$LnGDP_i$	-3.052	-0.683	-2.616	1.824	$LnGDP_i$	1.252*	1.447**	1.223*	0.968*
	(-1.01)	(-0.26)	(-0.91)	(0.79)		(1.78)	(2.22)	(1.77)	(1.66)
$LnGDP_j$	1.993	0.238	1.845	-0.0946	$LnGDP_j$	0.590	0.819**	0.631*	0.501**
	(1.19)	(0.39)	(1.34)	(-0.59)		(1.51)	(3.95)	(1.70)	(5.37)
$LnDIST_{ij}$	-	-1.407	-1.266	-0.556*	$LnDIST_{ij}$	-	-1.032*	1.921	-1.000**
	-	(-1.00)	(-0.34)	(-1.68)		-	(-1.74)	(0.58)	(-6.87)
LnRER	-0.920	-0.074	-0.383	-0.150**	LnRER	0.370	-0.212*	0.261	-0.046*
	(-0.33)	(-0.38)	(-0.36)	(-2.27)		(0.57)	(-2.54)	(0.46)	(-1.83)
QPI_i	-0.272	-0.358	-0.319	0.588	QPI_i	0.403	0.373	0.404	0.441
	(-0.20)	(-0.26)	(-0.24)	(0.59)		(1.27)	(1.16)	(1.28)	(0.98)
QPI_j	-0.118	-0.181	-0.167	-0.154	QPI_j	0.277**	0.400**	0.280**	0.445**
	(-0.22)	(-0.41)	(-0.32)	(-0.70)		(2.24)	(3.50)	(2.28)	(4.68)
$BDRE_i$	0.126	0.0213	0.136	-0.153	$BDRE_i$	-0.0540	-0.0940	-0.0579	-0.0390
	(0.36)	(0.06)	(0.41)	(-0.53)		(-0.67)	(-1.19)	(-0.72)	(-0.34)
$BDER_j$	1.901**	1.362**	1.651**	0.919**	$BDER_j$	0.093	0.369**	0.0971	0.463**
	(2.36)	(2.29)	(2.25)	(3.21)		(0.50)	(2.23)	(0.52)	(3.60)
IQ_i	-1.226	-1.247	-1.186	-0.885	IQ_i	0.017	-0.018	0.009	-0.181
	(-0.78)	(-0.80)	(-0.77)	(-0.69)		(0.05)	(-0.05)	(0.03)	(-0.34)
IQ_j	-0.525	-0.168	-0.715	0.645	IQ_j	1.816**	1.705**	1.795**	1.053**
	(-0.43)	(-0.17)	(-0.65)	(1.48)		(6.39)	(6.53)	(6.46)	(5.23)
BDR	-	1.573	-2.183	2.833**	BDR	-	1.039	2.822	0.383
	-	(0.53)	(-0.42)	(2.99)		-	(0.89)	(0.70)	(1.08)
CLNY	-	1.456	5.865	0.0546	CLNY	-	-0.262	8.968	-1.206**
	-	(0.77)	(0.58)	(0.17)		-	(-0.33)	(1.18)	(-4.89)
LNG	-	-2.847*	-3.695	-2.232**	LNG	-	-1.966**	-4.427	-1.370**
	-	(-1.87)	(-1.07)	(-5.89)		-	(-3.12)	(-1.52)	(-6.50)
_cons	39.12	34.44	42.94	-38.44	_cons	-61.28**	-60.69**	-78.23**	-33.79*
	(0.59)	(0.54)	(0.64)	(-0.70)		(-3.98)	(-3.80)	(-2.43)	(-1.65)
Time F.E	Yes	Yes	Yes	Yes	Time F.E	Yes	Yes	Yes	Yes
No. of obs.	253	253	253	253	No. of obs.	253	253	253	253
R-sq.	0.112	0.245		0.414	R-sq.	0.418	0.645		0.708

Note: The values inside the parentheses are t-ratios. * represents a 10% level of significance, and ** represents 5% level of significance

Table 12: Estimates of Commodities 65 & 84

Commodity 65 (Textile yarns, fabrics, made-up articles etc)					Commodity 84 (Clothing)				
Models	**FE**	**RE**	**HT**	**PPML**	**Models**	**FE**	**RE**	**HT**	**PPML**
	LnEXP	LnEXP	LnEXP	EXP		LnEXP	LnEXP	LnEXP	EXP
$LnGDP_i$	-0.136	-0.0736	-0.115	-0.455	$LnGDP_i$	0.970**	0.927**	0.944**	0.552*
	(-0.39)	(-0.22)	(-0.33)	(-0.42)		(2.01)	(2.07)	(2.00)	(1.84)
$LnGDP_j$	0.599**	0.581***	0.581**	0.713***	$LnGDP_j$	0.957**	0.757**	0.973**	0.819**
	(3.08)	(4.53)	(3.21)	(10.27)		(2.88)	(3.77)	(3.13)	(12.36)
$LnDIST_{ij}$	-	-0.191	0.827	0.377*	$LnDIST_{ij}$	-	-1.058*	-2.970	-0.734**
	-	(-0.31)	(0.71)	(2.21)		-	(-1.64)	(-1.36)	(-3.35)
LnRER	0.139	0.113	0.190	0.124***	LnRER	0.447	0.568**	0.390	0.392**
	(0.43)	(1.34)	(0.76)	(4.88)		(0.80)	(6.19)	(0.87)	(7.00)
QPI_i	0.397*	0.392*	0.395*	0.246	QPI_i	-0.019	-0.016	-0.023	0.019
	(2.51)	(2.50)	(2.49)	(0.57)		(-0.08)	(-0.07)	(-0.09)	(0.05)
QPI_j	0.177**	0.186**	0.177**	0.170*	QPI_j	-0.282**	-0.187*	-0.278**	-0.189
	(2.87)	(3.16)	(2.86)	(2.64)		(-2.58)	(-1.81)	(-2.58)	(-1.98)
$BDRE_i$	0.038	0.032	0.039	0.001	$BDRE_i$	0.062	0.066	0.060	0.044
	(0.93)	(0.84)	(0.98)	(0.01)		(1.07)	(1.20)	(1.07)	(0.55)
$BDER_j$	0.129	0.095	0.225*	0.385**	$BDER_j$	0.572**	0.383**	0.556**	-0.644**
	(1.39)	(1.07)	(1.74)	(2.85)		(3.50)	(2.55)	(3.46)	(-5.15)
IQ_i	0.572**	0.569**	0.575**	0.214	IQ_i	0.444	0.427	0.439	0.122
	(3.14)	(3.17)	(3.15)	(0.42)		(1.43)	(1.36)	(1.43)	(0.27)
IQ_j	0.188*	0.287**	0.191*	0.530**	IQ_j	0.555**	0.665**	0.568**	0.208*
	(1.64)	(1.96)	(1.66)	(3.33)		(2.24)	(2.81)	(2.35)	(1.89)
BDR	-	-0.626	-0.220	-0.794**	BDR	-	-3.676**	-5.150*	-2.479**
	-	(-0.56)	(-0.16)	(-2.80)		-	(-2.94)	(-1.94)	(-6.37)
CLNY	-	0.614**	3.425	0.572**	CLNY	-	-0.716*	-5.809	-0.717**
	-	(1.77)	(1.19)	(2.33)		-	(-1.84)	(-1.10)	(-3.17)
LNG	-	-0.720	-1.356	0.265*	LNG	-	0.196	1.442	0.280
	-	(-1.10)	(-1.26)	(1.66)		-	(0.28)	(0.73)	(1.84)
_cons	-12.87*	-12.16	-20.29*	-27.82	_cons	-54.48**	-39.97**	-28.10	-11.40
	(-1.68)	(-1.33)	(-1.64)	(-1.07)		(-5.07)	(-3.35)	(-1.34)	(-0.72)
Time F.E	Yes	Yes	Yes	Yes	Time F.E	Yes	Yes	Yes	Yes
No. of obs.	253	253	253	253	No. of obs.	253	253	253	253
R-sq.	0.302	0.301	-	0.764	R-sq.	0.447	0.816	-	0.919

Note: The values inside the parentheses are t-ratios. * represents a 10% level of significance, and ** represents 5% level of significance

Table 13: Estimates of Commodity 86

Commodity 86 (Scientific instruments, photography instruments and clocks)				
Models	**FE**	**RE**	**HT**	**PPML**
	LnEXP	LnEXP	LnEXP	EXP
$LnGDP_i$	0.471	0.535	0.444	1.12
	(-0.87)	(-1.00)	(-0.82)	(-1.49)
$LnGDP_j$	1.386**	1.088**	1.397**	1.071**
	(4.06)	(6.25)	(4.08)	(23.12)
$LnDIST_{ij}$	-	-1.524**	-0.304	-1.677**
	-	(-3.56)	(-0.17)	(-13.38)
LnRER	0.573*	0.137*	0.454*	0.202**
	(1.98)	(2.34)	(1.68)	(8.77)
QPI_i	0.135	0.16	0.136	0.241
	(-0.89)	(-1.04)	(-0.90)	(-1.08)
QPI_j	-0.038	-0.007	-0.034	-0.092
	(-0.55)	(-0.11)	(-0.48)	(-1.50)
$BDRE_i$	0.032	0.0173	0.0263	-0.0211
	-0.82	-0.49	-0.67	(-0.46)
$BDER_j$	0.128	0.116	0.235**	0.449***
	(1.27)	(1.22)	(2.34)	(7.04)
IQ_i	-0.018	-0.055	-0.031	-0.112
	(-0.09)	(-0.28)	(-0.16)	(-0.40)
IQ_j	0.296*	0.281*	0.307**	0.224
	(1.94)	(1.90)	(2.01)	(1.66)
BDR	-	-2.959**	-3.367	-2.127**
	-	(-3.44)	(-1.45)	(-7.00)
CLNY	-	-0.424	5.028	-1.063**
	-	(-0.75)	-1.28	(-3.96)
LNG	-	0.683	-0.84	0.596***
	-	-1.53	(-0.55)	-6.63
_cons	-48.36**	-28.06*	-45.45**	-43.07**
	(-3.22)	(-1.93)	(-2.17)	(-2.17)
Time F.E	Yes	Yes	Yes	Yes
No. of obs.	253	253	253	253
R-sq.	0.593	0.767		0.962

Note: The values inside the parentheses are t-ratios. * represents a 10% level of significance and ** represents 5% level of significance.