


Article

Free Trade Agreements and Environment for Sustainable Development: A Gravity Model Analysis

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Abstract: Free trade agreements (FTAs) have a key role in the global value chain. In the meantime, these are also disturbing the environmental balance of the world. The objective of this study is to check whether the trade is good or bad for the environments of countries that are bonded by trade agreements. This study examines the impact of FTAs on bilateral carbon emissions within the gravity framework. We find a positive impact of FTA agreements on bilateral CO₂ pollution. However, in an income-based country group analysis, we find mixed evidence regarding FTAs. The analysis concerning high income countries indicates that free trade agreements are beneficial for high income countries, while, in the case of upper middle income and lower middle income countries, we find that the free trade agreements are not beneficial for their environments. These results of the effects of FTAs on bilateral CO₂ pollution imply that low income countries have a greater pollution effect even after the implementation of an FTA due to lenient environmental standards. There is a need for developing countries to learn from high income countries, as their FTAs are beneficial for decreasing pollution.

Keywords: free trade agreements; CO₂ emission; sustainable development; gravity model; pollution

1. Introduction

Sustainable development is directly linked with international trade and free trade agreements. In the era of globalization, each economy of the world is trying to achieve sustainable development through international trade. Free trade agreements (FTAs) are the broader category of agreements under which participant countries agree to remove trade barriers [1]. Once the process an FTA has been set up between partner countries, they make some negotiations on how the FTA will work. Such agreements probably boost employment and provide a comparative advantage in partner countries. By signing a trade agreement, a developing country gets access to large markets [2]. However, FTAs encompass a wide variety of economic and environment impacts on the partner countries and the rest of the world as well. It has been stated [3] that trade in dirty products has been increased by globalization and has had a detrimental effect on the environment. However, the picture of the FTAs impacts on sustainable development and the environment is still mixed [4]. A sizeable amount of theoretical and empirical literature has argued that trade policies have both

positive and negative consequences on the environment [5–13]. The supporters of free trade have opinions and suggest a comparative advantage whereby trade leads to a decline in pollution by endorsing eco-friendly technologies and producing green products [5,14–16]. They believe that a higher degree of trade openness can yield efficiency through modern production methods for trading countries [17]. On the other hand, free trade antagonists under pollution intensive theorem suppose that free trade is hazardous to the environment. They claim that low income level countries must consider having stretchy policies to improve production methods to acquire comparative advantages. Hence, the free trade of emission-intensive goods production may be perilous for goods from low income level countries [18–20].

However, the idea that trade is good or bad for a country's environment in a trade agreement is based on different hypotheses. One important hypothesis has emerged regarding the interaction of the environmental standard stringency and international trade is the "pollution haven hypothesis" (PHH) [21–24]. This hypothesis argues that low income countries will have more pollution after an FTA due to having lenient environmental standards [24–26]. For instance, pollution intensive industries will deliberately migrate to areas of lax environmental standards [27]. On the other hand, some argue that low income countries have more labor-intensive goods that are more unhygienic than capital-intensive goods [25]. These contrasting arguments are based on the "factor endowment hypothesis" (FEH). Moreover, according to the race-to-the-bottom hypothesis, high income countries intend to treat their environmental regulations leniently in order to compete with less environmentally friendly countries where production costs are lower due to resource limitations. These inconsistent debates on the environmental effects of free trade agreements on pollution encouraged us to conduct the current study, as is common to most of the research seeking to determine the free trade environment relationship. For instance, the authors of references [25,28] used the level of greenhouse gas emissions per capita through the aggregate CO₂, methane (CH₄), and nitrous oxide (N₂O) in their studies. It was determined that FTA can be fruitful when the agreement is among only developed or only developing countries [25]. A bilateral study of export pollution and FTAs is the missing linkage in previous studies. To do this, the current study develops a CO₂ variable based on bilateral export pollution of trading partner countries and also intends to identify other aspects of pollution-free trade agreements (FTAs) in different scenarios by posing the question, "who exports pollution to whom?"

More concretely, the present study contributes to existing literature by addressing three key questions regarding FTAs and pollution: First, whether a country "s" exports pollution to country "r". In light of this question, the present paper develops a CO₂ variable based on bilateral export pollution of trading partner countries. For instance, an increase in domestic country CO₂ emissions is caused by trade related to global value chains and international trade in intermediate products. Figure 1 specifies the breakdown of total emissions recorded in the total exports of the country.

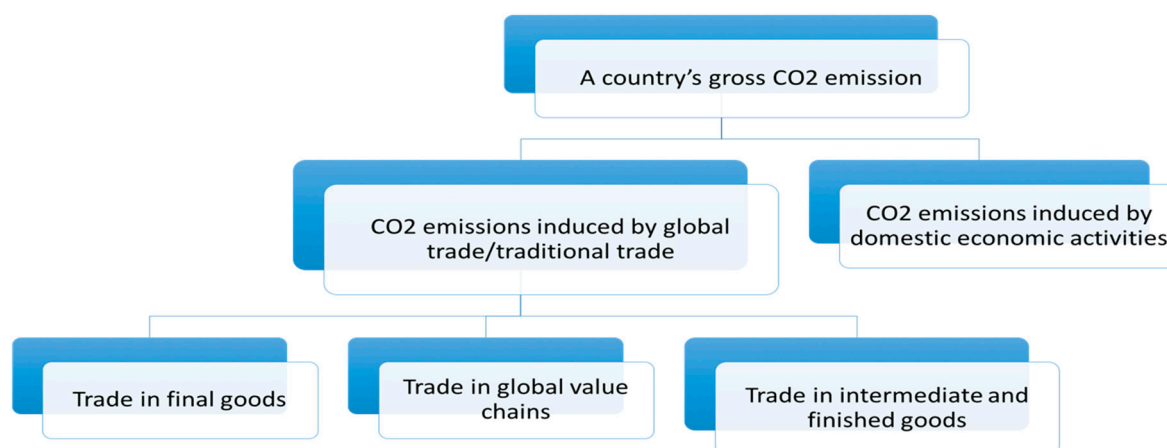


Figure 1. The disintegration of a country's CO₂ carbon emissions.

This decomposition sheds light on how a country bilaterally exports pollution to others under the global production trade. Recently, the production process has become scattered all over the world, and the pollution impact of global-wide trade is becoming more problematic. The analysis, in this context, makes this study different from existing literature. The second contribution of this paper is that we address whether a “free trade agreement” is actually a “pollution promoting agreement”. In trade agreements, low income countries attempt to increase their share of the goods in the global market by setting lax regulations. The third valuable contribution of this paper is based on whether rich countries export pollution to poor countries during their involvement in trade activities. Environmental concerns are also becoming more challenging under international trade agreements [29]. Further, the low production cost of developing countries is a key source through which developed countries outsource the production process [29]. Concerning this, we split our empirical study into income wise groups: High income countries, upper middle income countries, and lower middle income countries. This paper analyzes questions consistent with the “pollution haven hypothesis” (PHH), but this is done through different paths. Fourth, the current study also quantifies the effect of the internet on bilateral carbon emissions, because internet usage plays a significant role in making services tradable as well as the globalization of internet and internet-enabled services. Finally, from a robustness methodological point of view, this study applies more appropriate panel econometric techniques, such as the fixed effect (FE), random effect (RE), the pooled least squares (POLS), and the Poisson Pseudo-Maximum Likelihood (PPML). In short, the purpose of the current research work is to (i) complement the recently available literature relation among FTAs and bilateral CO₂ emissions by providing a regional prospective based on income level; (ii) determine the extent to which FTAs are responsible for promoting carbon emissions in high and low level income countries; (iii) lengthen the usage of FTAs and bilateral CO₂ emission datasets to measure the effect of FTAs on environmental sustainability. The rest of the paper is as follows: Section 2 discusses the recently available literature in the “Literature review” section. Section 3 elaborates the detailed methodology. Section 4 presents the details about the dataset, a description of the variables and econometric model specifications in the section on the “Data nature and econometric model”. The last section explains the results.

2. Literature Review

The debate for free trade agreement (FTAs) is still controversial regarding the environment and its consequences. In fact, this area first appeared in the literature in reference [30], who decomposed the impact of free trade on the environment into three different major effects: The scale effect, technique effect, and composition effects. Since trade increases production and income, it affects emissions through the scale effect and the technique effect. In terms of the scale effect, the impact of trade on environmental degradation is positive as a result of increased production and income, as environmental degradation increases rapidly in the early stages of development, rather than the income unaffordability of environmentally friendly technologies [13,31–33]. At the initial stages of the development, environmental quality has a secondary priority [6]. Moreover, pollution increases more speedily than income due to a lack of access to advanced technologies [30,32]. Additionally, as income increases, the government pays more attention to the environment, and people are willing to pay more than their income for healthy environs [32]. In the latter phase of the development, structural transformation occurs with economic growth, and obsolete machinery will be substituted by advanced technologies that improve environmental quality. So, trade impacts the environment by means of income and production changes. Therefore, we cannot infer that the overall impact of trade via income on the environment is positive or negative. For example, reference [34] found a positive impact of income on the reduction of emissions (i.e., negative net scale and technique effects). However, trade was found to be involved in increased emissions (i.e., positive composition effects), while reference [35] found a negative impact of economic growth on CO₂ emissions. In contrast, reference [36] stated that economic growth is not accountable for environmental degradation. Therefore, there is ambiguity about the overall sign of the effect of income on pollution. However, by applying the environmental Kuznets

curve (EKC) hypothesis, it is generally believed that environmental damage first increases with income, then soothes and eventually, falls off. However, these effects act contrarily depending on the level of income. The combined scale and composition effects accelerate pollution in developing countries due to the concentration of polluting industries. However, as the country's level of income increases, they invest more in advanced environmentally friendly technologies that reduce environmental damage. Based on empirical literature, the first hypothesis captures the income growth impact of a country on bilateral carbon emissions. The income growth impact is captured by GDP (gross domestic product) per capita.

Hypothesis 1. *If a trading partner's income increases, then bilateral CO₂ emissions increase.*

However, well ahead of the period of development, due to the access to better technology, trade can improve the structure of production to reduce pollution; this is known as the technique effect [12,31,37]. On the other hand, with the development process, whether a country specializes in clean or dirty industries is known as the composition effect. If a country is engaged in pollution-intensive production, then trade will increase pollution, because inflexibility of environmental regulations is a source of comparative advantage [38]. This flow of arguments regarding the trade–environment relationship further deepened when countries signed free trade agreement (FTAs). The free trade agreement scenario builds on the assumptions that tariff and non-tariff barriers should be reduced and sooner or later brought to an end among trading partners. Therefore, by considering the different measures of trade agreements, most of the researchers are seeking to determine its consequences on the environment [25]. They have re-examined the nexus of free trade and greenhouse gas (GHG) emissions for the Southern Common Market (MERCOSUR), the North American Free Trade Agreement (NAFTA) and the Australia–United States Free Trade Agreement (AUSFTA), respectively. The results showed that free trade agreements and environmental nexus depend upon the type of agreement. In other words, the net effect of free trade on pollution can be positive or negative depending upon the environmental regulations. Having more free trade agreements will decrease the comparative advantage of capital-intensive goods in higher income countries with stringent policies, while increasing the comparative advantage of such goods in countries that have less strict policies. Therefore, a second hypothesis was formulated to test the impact of free trade agreements on bilateral CO₂ emissions, because free trade agreements explain the extent to which the emissions of partner countries are affected by the degree of openness as well as by the comparative advantage.

Hypothesis 2. *If FTAs increase, then bilateral CO₂ emissions decrease in sample countries.*

Further, FTAs can be beneficial for the world environment, only when the agreement is set between developed and developed countries or developing and developing countries. Conversely, FTAs seem to not be advantageous for the world environment if they occur between dissimilar states of conditions. Similarly, reference [39] studied the impact of NAFTA on GHG emissions in the United States (US) and Mexico. They reported that pollution in the United States and Mexico increased after the NAFTA passage. Further, they reported that the intensifying rate of pollution is higher in Mexico than in the United States. They also inferred that the hypothesis of haven pollution could be applied to Mexico because of the broad trade within the companies between the two countries.

However, the findings of [39] negated those of [29], which suggested an insignificant impact of trade openness on the Mexican environment under NAFTA. Reference [40] also concentrated on the effects of NAFTA on industrial pollution in the United States, Mexico, and Canada. It showed that the metal, transportation equipment, and petroleum sectors had severe adverse effects on the environment, and industrial pollution in Mexico under NAFTA. However, their results in the chemical sector are consistent with those of reference [29]. In the United States and Mexico, but not in Canada, the chemical sector is a major source of industrial toxin pollution [29]. Reference [41] estimated the determinants of carbon dioxide emission convergence and pointed out that the CO₂ emissions of the Regional Trade Agreements (RTA) countries tend to converge to produce environmental degradation.

Furthermore, it also found that emissions converge more quickly for EU-27 countries, rather than in Euro-Med countries [41]. Based on the literature, the following hypothesis was designed to assess whether free trade agreements act differently in terms of promoting pollution for lower and rich income level countries.

Hypothesis 3. *In low income level countries, FTAs are responsible for promoting carbon emission production.*

3. Methodology and Empirical Strategy

3.1. Methodology

To calculate the bilateral CO₂ emissions, we adopted the input–output analysis framework for the country to country sector. To understand this mechanism, we supposed that the world consists of “G” countries and “N” sectorial industries. These countries are linked by international trade in intermediate products and final products, and the production of each country is used to satisfy intermediate or final consumption. Based on the work of Leontief, the current study adopts the multi-regional (countries) input–output (IO) analysis framework. The Leontief framework (IO) contains the multipart linkages among different industries across countries. These countries can be stated as cross-country transactions systematized into a matrix form, known as input–output (IO) tables. Every single column in the IO table indicates the requisite inputs from other industries to produce the given amount of goods denoted by that column. After normalization, the technical coefficient of the IO table indicates that the number of intermediate inputs is required in the production of one unit of gross output which is denoted by A^{sr} in Equation (1). By means of these coefficients, the gross output from all stages of the production process that is desired to produce one unit of final goods can be examined through the Leontief inverse matrix.

Under the decomposition technique, the Leontief input–output analysis framework [37] Y^{sr} begins by determining the balance of monetary flow:

$$\begin{bmatrix} X^1 \\ X^2 \\ \vdots \\ X^g \end{bmatrix} = \begin{bmatrix} A^{11} & A^{12} & \dots & A^{1g} \\ A^{21} & A^{22} & \dots & A^{2g} \\ \vdots & \vdots & \ddots & \vdots \\ A^{g1} & A^{g2} & \dots & A^{gg} \end{bmatrix} \begin{bmatrix} X^1 \\ X^2 \\ \vdots \\ X^g \end{bmatrix} + \begin{bmatrix} \sum_r^G Y^{1r} \\ \sum_r^G Y^{2r} \\ \vdots \\ \sum_r^G Y^{gr} \end{bmatrix} \quad (1)$$

where $1, 2, 3, \dots, G$ denotes that the world consists of “G” countries, X^s signifies the gross output of country “s” where s is $s = 1, 2, 3, \dots, g$, and Y^{sr} denotes the final demand of country “r” from country “s”, i.e., r ($r = 1, 2, 3, \dots, g$). A^{sr} is the input to the coefficient matrix that denotes the intermediate use in country “r” of goods produced in country “s”. The elements of the input coefficient matrix satisfy $a_{ij}^{sr} = z_{ij}^{sr} / x_j^r$, where z_{ij}^{sr} ($i, j = 1, \dots, n$) represents the transfer from sector “i” of country “s” to sector “j” of country “r”. The intermediate input matrix from country “s” to country “r” is represented by $z^{sr} = A^{sr} X^s$. Equation (1) can be reordered as

$$\begin{bmatrix} X^1 \\ X^2 \\ \vdots \\ X^g \end{bmatrix} = \begin{bmatrix} I - A^{11} & -A^{12} & \dots & -A^{1g} \\ -A^{21} & I - A^{22} & \dots & -A^{2g} \\ \vdots & \vdots & \ddots & \vdots \\ -A^{g1} & -A^{g2} & \dots & I - A^{gg} \end{bmatrix}^{-1} \begin{bmatrix} \sum_r^G Y^{1r} \\ \sum_r^G Y^{2r} \\ \vdots \\ \sum_r^G Y^{gr} \end{bmatrix} = \begin{bmatrix} B^{11} & B^{12} & \dots & B^{1g} \\ B^{21} & B^{22} & \dots & B^{2g} \\ \vdots & \vdots & \ddots & \vdots \\ B^{g1} & B^{g2} & \dots & B^{gg} \end{bmatrix} \begin{bmatrix} \sum_r^G Y^{1r} \\ \sum_r^G Y^{2r} \\ \vdots \\ \sum_r^G Y^{gr} \end{bmatrix} \quad (2)$$

where

$$X = (I - A)^{-1}Y$$

$$B = (I - A)^{-1}$$

where B^{sr} , the Leontief inverse matrix, indicates the gross output of country "s" that is used to meet the final demands of country "r". From Equation (2), the gross output of country "r" is as follows:

$$X^r = \sum_t^G B^{rt} \sum_u^G Y^{tu} \quad (3)$$

The intermediate input of country "r" from country "s" is $z^{sr} = A^{sr} X^r$. The exports from country "s" to country "r" is $T^{sr} = Y^{sr} + A^{sr} X^r$.

Trade-related goods transit more than once and may eventually be absorbed by exporters, importers, or third parties. Based on the balance of the gross output of country "s", $X^s = A^{ss} X^s + Y^{ss} + \sum_{s \neq r}^M T^{sr}$ can decompose the gross output generated from each industry of a country into different components:

$$X^s = L^{ss} Y^{ss} + L^{ss} \sum_{s \neq r}^G T - f^{sr} + L^{ss} \sum_{s \neq r}^G T - i^{sr} + L^{ss} \sum_{s \neq r}^G T - g^{sr}. \quad (4)$$

In Equation (4), the first expression of the gross output of country "s" indicates that the output resulting from the domestic final demand is caused by the local industrial chain, which has nothing to do with the international fragmentation of production. The other three terms represent the outputs induced by the final product trade, the traditional trade in intermediate products, and the global value chain related trade, respectively, while " $T - f^{sr}$ " represents the trade in final products. " $T - i^{sr}$ " denotes the traditional trade required for trade partners to process in the future. " $T - g^{sr}$ " shows the global value chain trade. The CO₂ emissions of sector "i" of country "s" are stated as $f_i^s = e_i^s / x_i^s$, where e_i^s represents the carbon emissions (CO₂) of sector "i" of country "s". F^s is a diagonal matrix composed of f_i^s . The emissions of country "s" are

$$\text{CO}_2 = F^s X^s = F^s L^{ss} Y^{ss} + F^s L^{ss} \sum_{s \neq r}^G T - f^{sr} + F^s L^{ss} \sum_{s \neq r}^G T - i^{sr} + F^s L^{ss} \sum_{s \neq r}^G T - g^{sr} \quad (5)$$

The carbon emission exports from country "s" to country "r" are

$$\text{CO}_2 X^{sr} = F^s L^{ss} T - f^{sr} + F^s L^{ss} T - i^{sr} + F^s L^{ss} T - g^{sr}. \quad (6)$$

Equation (6) indicates that the carbon emission exports from country "s" to country "r" have three trade patterns: Final products, intermediate products, and the global value chain.

3.2. Model and Database

The gravity framework is mainly used to examine the bilateral trade flows. Additionally, the GDP, distance and border are the time invariant factors that affect trade flows. Further, the gravity model is appropriate for explaining most of the variation in international trade [42]. A number of empirical studies have used a gravity model to determine bilateral trade between countries [42,43]. In line with these studies, we also applied the gravity framework to determine the role of environmental input in sorting "who exports pollution to whom". More concretely, the present study addresses three main questions: First, whether a country "s" exports pollution to country "r" during its involvement in trade activities; secondly, whether the term "free trade agreement" actually represents a "pollution trade agreement"; and third, whether rich countries are accountable for exporting pollution to poor countries. Therefore, under the gravity framework, let Z_{sr} symbolize the pollution in terms of the carbon emission (CO₂) content of exports from country "s" to country "r".

$$Z_{sr}^k = G_{sr} \frac{M_s M_r}{D^2}$$

where G_{sr}^k denotes the carbon emissions from pollutant k , and M_s and M_r captures all characteristics of the destination market that promote exports from all sources. Additionally, D is the distance between the two partners. Using the gravity framework, an estimate of the multilateral resistance term with fixed effects can be written in Equation (1), as follows:

$$\text{CO}_{2sr} = \delta_0 + \delta_1 G_{_O} + \delta_2 G_{_d} + \delta_3 \text{dist}_{sr} + \delta_4 \text{lan}_{sr} + \delta_5 \text{adj}_{sr} + \delta_6 \text{FTA}_{sr} + \delta_7 \text{int}_{_o} + \delta_8 \text{int}_{_d} + \delta_9 \text{year}_t + \mu_{sr} \quad (7)$$

where the term “ δ_0 ” indicates the multilateral resistance term with fixed effects, CO_{2sr} is the bilateral outsourcing of carbon emissions between trading countries and $G_{_O}$ is the income of the origin country, while $G_{_d}$ is the income of the destination/importer country. dist_{sr} symbolizes the distance between country “ i ” and country “ j ”. lan_{sr} signifies the common language between country “ s ” and its trading partner country “ r ”. adj_{sr} signifies the common border between country “ s ” and country “ r ”. FTA_{sr} measures whether the free trade agreement is truly a pollution promoting agreement between country “ s ” and its trading partner “ r ”. We include time-varying measures, such as the internet $\text{int}_{_o}$; $\text{int}_{_d}$, which show the convenience of communication between trading partners. year_t is the overall time effect which is not country-specific. μ_{sr} is the stochastic error term in Equation (7). The bilateral CO_2 emission dataset was constructed by using the World Input–Output (WIOD) [44] classifications database (for details, see Table 1). Owing to scant data accessibility, our dataset was reduced to 39 countries covering the period from 1995 to 2009. Thirty-two out of the 39 countries were signatories of both the Montreal Protocols and KOYOTO (see Table 2). By taking into account differences among countries’ income levels and their influential abilities under free trade agreements, we split our study into income wise groups: High income countries, upper middle income countries, and lower middle incomes countries based on the World Bank Data Base specification [45]. Gravity data were retrieved from CEPII [Centre d’Etudes Prospectives et d’Informations Internationales i.e., French: Institute for Research on the International Economy] [46].

Table 1. Data description.

Variables	Symbol	Unit Definition	Source	Time-Span
Carbon emissions	CO_2	Bilateral CO_2 emission	WIOD (2013)	1995–2009
GDP per capita	$G_{_O}$ & $G_{_d}$	constant 2010 US\$	WDI (2016)	1995–2009
Internet use	$\text{Int}_{_o}$ & $\text{Int}_{_d}$	Individuals using the internet % of the population	WDI (2016)	1995–2009
Gravity data			CEPII	
Free trade agreement	FTAs	Dummy = 0 if not dummy = 1 if yes	CEPII	1995–2009
Distance	Dist.	Time invariant	CEPII	1995–2009
language	lan	Time invariant	CEPII	1995–2009
Adjacent	Adj	Time invariant	CEPII	1995–2009

Table 2. Country list.

Australia x,y	Estonia y	Japan x,y	Romania x,y
Austria x	Finland x,y	Korea, Rep.	Russia x,y
Belgium x,y	France x,y	Lithuania x,y	Spain x,y
Bulgaria x,y	Germany x,y	Luxembourg x,y	Slovak x,y
Brazil y	Greece x,y	Latvia x,y	Slovenia x,y
Canada x,y	Hungary x	Mexico x,y	Sweden x,y
China y	Indonesia x,y	Malta x,y	Turkey
Cyprus x	India	Netherlands x,y	United States x
Czech Republic x,y	Ireland x,y	Poland x,y	United Kingdom x,y
Denmark x,y	Italy x,y	Portugal x,y	

Note: x refers to the signatories of the Montreal Protocol; y refers to KOYOTO signatory countries.

3.3. Econometric Strategy

In the literature, a number of methods have been suggested for the estimation of the gravity model. However, this study applied the pooled OLS, the fixed effect (FE), and the random effect (RE). FE has the ability to remove the effects of time-invariant characteristics. So, by applying FE, we were able to evaluate the net effect of the predictors on the outcome variable. The FE model is unique as it assumes that time-invariant characteristics are not correlated with other individual characteristics. However, if the error terms are correlated, then the random effect method is more suitable. However, the random effect method assumes that differences across entities have an influence on dependent variables, the Hausman test is also applied to select between the FE and RE estimation techniques. Apart from these, for robustness, a new estimation technique called the Poisson pseudo-maximum likelihood method (PPML) is also applied. Poisson pseudo-maximum likelihood (PPML) is more suitable and has appropriate characteristics for estimating the gravity model [47]. PPML has the ability to deal with the heteroskedasticity in the error term compared to the OLS estimator. PPML also provides efficient estimators in the presence of zero as a larger portion of the observations of the dependent variable [47].

4. Results and Discussion

The panel correlation matrix for the concerned series is shown in Table 3. The incomes of a country (G_O) and its trading partner (G_d) showed positive relationships with bilateral CO₂ emissions, while the correlation between a country's income and its trading partner income was negative, and free trade agreements (FTAs) were negatively associated with CO₂ emissions. On the other hand, the FTAs showed positive correlations with a country's income and its trading partner's income. These contrasting results of the effects of FTAs on CO₂ emissions suggest two points: (i) Free trade agreements have the potential to reduce environmental degradation; and (ii) free trade agreements can help to increase both the income of a country and its trading partner. Distance showed a negative correlation for all concerned variables. The distance was shown to play a positive role in improving the environmental conditions, while common language, adjacency, a country's internet access, and its trading partner's internet access all showed positive correlations with CO₂ emissions and the other concerned variables, except distance (Dist.).

Table 3. Panel correlation matrix.

Variables	CO ₂	G_O	G_d	FTA	Dist.	Lan	Adj	Int _o	Int _d
CO ₂	1.0000								
G_O	0.0722	1.0000							
G_d	0.1518	−0.0080	1.0000						
FTA	−0.0511	0.2403	0.2403	1.0000					
Dist.	−0.0495	−0.1529	−0.1529	−0.7142	1.0000				
Lan	0.1000	0.1003	0.1004	0.0339	−0.0127	1.0000			
Adj	0.2317	0.0114	0.0114	0.1633	−0.3928	0.1971	1.0000		
Int _o	0.0064	0.6156	0.0824	0.2523	−0.1247	0.0357	0.0112	1.0000	
Int _d	0.1089	0.0822	0.6156	0.2523	−0.1247	0.0357	0.0112	0.5670	1.0000

Note: All coefficients were estimated to be significant at the 5% level.

The empirical outcomes of the panel gravity model are reported in Table 4. Hausman test showed that the RE outcomes are more appropriate as their probability values were greater than 5 percent. Therefore, the RE rather than fixed effect results are discussed in detail based on the Hausman test. The results revealed that the impact of a country's income on pollution is negative but insignificant. Conversely, the impact of trading partner/importing country income on CO₂ emissions is positive and statistically significant. This validates hypothesis 1: There is a positive relationship between trading partners' incomes and bilateral CO₂ emissions. The positive impact of income on CO₂ emissions is consistent with [6,48–50], while the results of FTA effects on bilateral CO₂ emission are positive but insignificant. Although the free trade agreement coefficient is statistically insignificant, it is based

on a positive trend, so it can be argued that free trade agreements possibly enhance bilateral CO₂ emissions between trading countries. The full panel results affirmed the positive impact of FTAs on bilateral CO₂ emissions and also confirmed hypothesis 2: Is the impact of FTAs on bilateral CO₂ emissions in sample countries positive or negative? The positive impacts of FTAs on emissions are in line with [39]. The empirical outcomes reported in Table 4 suggest that internet usage in a country and communication convenience have positive and significant impacts on pollution. However, the impact of the internet use of the partner country on pollution is negative. This suggests that more awareness and accessibility towards advanced technology leads to less pollution. This study also includes other gravity measures (i.e., distance, common language, adjacent) that can affect bilateral CO₂ emissions. The results show that the overall impact of language on CO₂ emissions is positive and statistically meaningful. These results suggest that the common language includes relatively easy communication, that is, communication between international supply chain manufacturers, more trade and more pollution. In addition, the estimated results suggest that neighboring countries also positively contribute to increased pollution. These results imply that nearby countries have more strength to influence pollution, as mostly they have common language and ease of transportation. However, the distance has a significantly negative impact on CO₂ emissions. This implies that remote areas have less power to affect the pollution of trade partner countries. For the sensitivity analysis, this study also applied the POLS which validated the impact of all concerned variables on carbon emissions.

Table 4. Overall pooled least squares (POLS), fixed effect and random effect results.

Variables	POLS	FE	RE
G _O	−0.210 *** (0.05)	−0.185 (0.13)	−0.210 *** (0.05)
G _d	0.464 * (0.000)	0.464 * (0.000)	0.464 * (0.000)
FTA	0.030 (0.388)	0.030 (0.38)	0.030 (0.38)
Dist.	−0.089 * (0.000)	−0.088 * (0.000)	−0.089 * (0.000)
Lan	0.5001 * (0.000)	0.5005 * (0.000)	0.5001 * (0.000)
Adj	1.895 * (0.000)	1.893 * (0.000)	1.895 * (0.000)
Int _o	0.1170 * (0.000)	0.1167893 * (0.000)	0.1170 * (0.000)
Int _d	−0.167 * (0.000)	−0.167 * (0.000)	−0.167 * (0.000)
Year effect	Yes	Yes	Yes
No. obs	22,230	22,230	22,230
R-squared	0.98	0.97	0.94
Fixed or random			
Hausman	Prob > chi2 = 0.9417		
Group	39	39	39
constant	−93.899 * (0.000)	−92.781 * (0.000)	−93.899 * (0.000)

Note: Significance level, * $p < 0.01$, ** $p < 0.05$, *** $p < 0.1$. p -values are given in parentheses.

4.1. Income-Wise Analysis:

To articulate the impact of FTAs on bilateral CO₂ emissions, in this section, we describe the investigation of three income grouped countries. Because developed and developing countries can be affected differently by FTAs as they have their own concerns and aptitudes in the area of trade that affect the environment. This section also examines the PHH hypothesis: Are FTAs responsible for promoting carbon emissions in low income level countries but not in high income level countries?

4.1.1. High Income Countries

Table 5 describes the estimated results for high income countries. The main concern is the effect of free trade agreements on bilateral pollution between high income countries. In accordance with the Hausman test results, we explain the fixed effect (FE) results only. The empirical results suggested that free trade agreements are beneficial for high income countries as an increase by one step from a free trade agreement will lead to improved environmental conditions. This negative impact of FTAs on pollution gives two points. Firstly, countries with high income levels can achieve advanced levels of efficiency in production methods when trading is more open. Secondly, high income level countries probably shift pollution intensive industries to lax regulated areas. The estimates from Table 5 validate hypothesis 3, the PHH hypothesis, which infers that FTAs are responsible for promoting carbon emissions in low income level countries but not in high income level countries because FTAs are more beneficial for high income countries compared to low income countries. The impact of the exporter's country income on bilateral CO₂ emissions was found to be negative and insignificant. This result of the negative impact of income on pollution is consistent with reference [50]. However, the impact of the partner's income on pollution is positive and statistically significant. This implies that the environment is not the first priority for trading countries. In addition, partner countries may be involved in pollution intensive production or consumption activities that aggravate environmental conditions. The time between different distance factors grasped the convenience of bilateral trade geography and showed a negative and significant impact on bilateral CO₂ emissions. The empirical results regarding the effect of the internet in Table 3 suggest that a country's level of internet use has a positive and significant impact on pollution. A 1% increase in internet use leads to increased pollution by 0.069%. Nevertheless, the impact of a partner country's internet use on pollution is negative and statistically significant. However, the impacts of common language and adjacency on bilateral CO₂ emissions are positive and significant. To check the robustness of our estimated results, OLS was also applied. The outcomes of FE were validated by OLS, as the impacts of the concerned variables on emissions were found to be similar.

Table 5. Pooled least squares (POLS), fixed effect and random effect results for high income countries.

Variables	POLS	FE	RE
G _O	−0.0241 (0.86)	−0.1601 (0.299)	−0.0241 (0.86)
G _d	0.4351 * (0.000)	0.4347 * (0.000)	0.4351 * (0.000)
FTA	−0.0887 ** (0.021)	−0.0874 ** (0.023)	−0.0887 ** (0.021)
Dist.	−0.0476 ** (0.014)	−0.0470 ** (0.015)	−0.0476 ** (0.014)
Lan	0.4799 * (0.000)	0.4801 * (0.000)	0.4799 * (0.000)
Adj	1.926 * (0.000)	1.924 * (0.000)	1.926 * (0.000)
Int _o	0.0661 * (0.002)	0.0694 * (0.001)	0.0661 * (0.002)
Int _d	−0.1300 * (0.000)	−0.1297 * (0.000)	−0.1300 * (0.000)
Year effect	Yes	yes	Yes
No. obs	17,100	17,100	17,100
R-squared	0.104	0.87	0.104
Fixed or random			
Hausman-test	Prob > chi2 = 0.0000		
Group	30	30	30
constant	−91.568 * (0.000)	−96.178 * (0.000)	−91.568 * (0.000)

Note: Significance level, * $p < 0.01$, ** $p < 0.05$. p -values are given in parentheses.

4.1.2. Upper Middle Income Countries

The estimated results of upper middle income countries are reported in Table 6. The Hausman test reported that the fixed effect model is more appropriate for upper middle income countries. Therefore, in our explanation, we focus on the fixed effect results rather than the RE results. The empirical results showed that the effects of FTAs on upper middle income countries' pollution were positive and statistically significant. The results imply that free trade is not beneficial for upper middle income countries. Further, in attempting to increase their share of the goods in the global market, upper middle income countries can be involved in pollution intensive production of the goods. Similarly, the impacts of a country's income and its partner's income on pollution are positive. This implies that the environment may be a secondary priority for upper middle income countries because they are still undergoing development.

Similar to previous sections, the results for the impact of the internet suggested that a country's internet use has a positive significant impact on CO₂ emissions. The impact of a partner's internet use has a significant adverse effect on CO₂ emissions. The time in-varying factor distance was again shown to be negative and significant. The empirical impacts of common language and adjacency on bilateral CO₂ emission were shown to be positive and significant. These results were also validated by the OLS empirical findings.

Table 6. POLS, fixed effect and random effect results—upper middle income countries.

Variables	POLS	FE	RE
G _O	1.059 * (0.000)	0.2177 (0.355)	1.059 * (0.000)
G _d	0.633 * (0.000)	0.5057 * (0.000)	0.6336 * (0.000)
FTA	1.394 * (0.000)	0.598 * (0.000)	1.394 * (0.000)
Dist.	−0.1671 * (0.000)	−0.298 * (0.000)	−0.1671 * (0.000)
Lan	−0.666 ** (0.029)	0.0251 (0.921)	−0.666 ** (0.029)
Adj	2.222 * (0.000)	1.612 * (0.000)	2.222 * (0.000)
Int _o	0.204 * (0.000)	0.226 * (0.000)	0.204 * (0.000)
Int _d	−0.1672962 * (0.000)	−0.276 * (0.000)	−0.167 * (0.000)
Year effect	Yes	Yes	Yes
No. obs	3990	3990	3990
R-squared	0.22	0.70	0.22
Fixed or random			
Hausman-test	Prob > chi2 = 0.0000		
Group	7	7	7
constant	−473.789 * (0.000)	−0.93545 (0.981)	−473.789 * (0.000)

Note: Significance level * $p < 0.01$, ** $p < 0.05$. p -values are given in parentheses.

4.1.3. Lower Middle Income Countries

The empirical analysis for lower middle income countries is reported in Table 7. Based on the Hausman test, we go through the RE results. The empirical results revealed that free trade agreements are not constructive from an environmental point of view and have an adverse impact in terms of pollution. The empirical results illustrated that the effect of FTAs on pollution is positive and statistically significant as a 1 percent increase in free trade agreements leads to heightened pollution by

3.721 percent. However, the impact of a country's income on pollution is negative, whereas, the impact of a partner country's income on pollution is positive and significant.

Like the aforementioned sections, the empirical results concerning the impact of the internet suggested that a country's internet use has a positive and significant impact on pollution, while the impact of a partner country's internet use on pollution is negative and statistically significant. The time in-varying factor distance was again shown to be negative and significant for lower middle income countries. Moreover, the empirical results of time invariance indicated that common language and adjacency positively contribute to an increase in pollution.

Table 7. POLS, fixed effect and random effect results—lower middle income countries.

Variables	POLS	FE	RE
<i>G_o</i>	−0.733 * (0.000)	−0.799 (0.305)	−0.7339 * (0.000)
<i>G_d</i>	0.751 * (0.000)	0.751 * (0.000)	0.7515 * (0.000)
FTA	3.721 * (0.000)	3.715 * (0.000)	3.721 * (0.000)
Dist.	−0.4630 ** (0.023)	−0.4652 ** (0.024)	−0.4630 ** (0.023)
Lan	0.984 * (0.000)	0.9859 * (0.000)	0.9844 * (0.000)
Adj	3.450 * (0.000)	3.450 * (0.000)	3.450 * (0.000)
<i>Int_o</i>	0.4263 * (0.001)	0.4205 * (0.003)	0.4263 * (0.001)
<i>Int_d</i>	−0.352 * (0.000)	−0.3522 * (0.000)	−0.352 * (0.000)
Year effect	No	No	No
No. obs	1140	1140	1140
R-squared	0.197	0.196	0.197
Fixed or random			
Hausman-test	Prob > chi2 = 1.0000		
Group	2	2	2
constant	−33.20131 (0.696)	−41.57933 (0.749)	−33.20131 (0.696)

Note: Significance level * $p < 0.01$, ** $p < 0.05$, *** $p < 0.1$. p -value are given in parenthesis.

4.2. Robustness Analysis

In this section, the Poisson Pseudo-Maximum Likelihood is carried out to validate the previous section's results. Therefore, we just focus on comparison rather than an explanation. The multilateral resistance term for PPML can be computed [46] as follows:

$$X_{ij,t} = \exp^{[Equation 1]} \times \varepsilon_{it} \dots \dots (i).$$

4.2.1. PPML for Panel

Table 8 shows the estimates of the PPML of panel samples. The empirical results validated the previous results as the impact of a country income on pollution was shown to be negative and that of the trading partner/importing country's income on CO₂ emissions was positive. The impact of FTAs on bilateral CO₂ emissions was positive and significant, implying that free trade agreement leads to bilateral CO₂ emissions between trading countries. In the present era, we cannot ignore the impact of internet use on even bilateral pollution. In the empirical results, we found that the more a country uses the internet, the more pollution there is. However, the impact of the use of the internet of

a partner country on pollution was shown to be negative and significant. In this robustness analysis, we observed little differences in significance level from previous results.

This study also included other gravity measures (i.e., distance, common language, adjacency) that can affect bilateral CO₂ emissions. The results indicated that the impact of a common language on emission is positive and statistically significant. In addition, we found that neighboring countries also positively contribute to an increase in pollution. However, the distance has a negative impact and a significant impact on emission. This implies that remote areas have less power to affect the pollution of trading partner countries.

Table 8. Poisson Pseudo-Maximum Likelihood (PPML).

Variables	Panel	High Income	Upper Middle Income	Lower Middle Income
G _O	−0.213 * (0.000)	−0.369 * (0.000)	0.758 * (0.000)	0.228 (0.229)
G _d	0.336 * (0.000)	0.212 * (0.000)	0.495 * (0.000)	0.300 * (0.000)
FTA	0.908 * (0.000)	−0.107 (0.385)	2.37 * (0.000)	1.929 * (0.000)
Dist.	−0.1248 * (0.000)	−0.484 * (0.000)	−0.468 * (0.000)	−0.680 ** (0.049)
Lan	0.493 * (0.000)	0.420 * (0.000)	1.628 * (0.000)	1.518 * (0.000)
Adj	1.958 * (0.000)	2.406 * (0.000)	1.003 * (0.000)	2.778 * (0.000)
Int _o	0.040 (0.241)	0.308 * (0.000)	0.181 * (0.000)	0.0740 (0.255)
Int _d	−0.116 * (0.000)	−0.056 * (0.05)	−0.119 * (0.033)	−0.1966 * (0.000)
Year effect	yes	Yes	Yes	No
No. obs	22,230	17,100	3990	1140
R-squared	0.68	0.271	0.15	0.26
Group	39	30	7	2
constant	−46.82 * (0.049)	160.33 * (0.000)	−304.77 * (0.000)	60.275 (0.490)

Note: Significance level * $p < 0.01$, ** $p < 0.05$, *** $p < 0.1$. p -values are given in parentheses.

4.2.2. PPML for High Income Countries

The estimates from Table 8 validate that the impact of income from exports has a statistically adverse effect on bilateral CO₂ emissions. However, the partner's income from exports has a significant positive impact on bilateral pollution. In particular, we found that free trade agreements have a negative but insignificant impact on bilateral CO₂ emissions. Here again, the effect of FTAs on bilateral pollutions supports the pollution haven hypothesis to some extent. Nevertheless, the impact of a partner country's internet use on pollution was shown to be negative and statistically significant. On the other hand, the impact of a country's internet use on pollution was shown to be positive and significant. The time in-varying factor distance was shown to have a negative and significant impact on the bilateral CO₂ emissions. However, the impacts of common language and adjacency on bilateral CO₂ emission were shown to be positive and significant. In these results, there are some differences in significance levels as compared with previous results.

4.2.3. PPML for Upper Middle Income Countries

The empirical results indicated that the effect of FTAs on upper middle income countries' pollution is again positive and statistically significant. These results suggest that free trade is not valuable in terms of the environment for upper middle income level countries. In addition, the impacts of a

country's income and partner incomes on bilateral pollution were shown to be positive and significant. Similar to previous results concerning internet impact, it was suggested that a country's internet use has a positive and significant impact on pollution. The impact of a partner country's internet use was shown to have an adverse effect on bilateral pollution. Distance again was shown to have a negative and significant impact on CO₂ emissions. The empirical impacts of common language and adjacency on bilateral CO₂ emission were shown to be positive and significant.

4.2.4. PPML for Lower Middle Income Countries

The empirical results for lower middle income countries, reported in Table 8, revealed that free trade agreements are not good and have an adverse impact on bilateral pollution since the impact of FTAs on pollution was shown to be positive and statistically significant. However, the impact of a country's income on pollution was shown to be negative but insignificant. However, the impact of a partner country's income on pollution was shown to be positive and significant.

Identical to previous sections, the empirical results concerning internet impact recommended that a country's internet use has a positive impact on bilateral pollution. However, the impact of a partner country's internet use has an adverse effect on bilateral pollution. The time in-varying factor distance was again shown to be negative and significant. Moreover, the empirical results of time invariance indicated that common language and adjacent positively contribute to increased pollution. The PPML estimation validated the impact of FTAs on bilateral CO₂ emissions. However, a difference in significance level was again observed here.

5. Conclusions

This study aimed to determine whether trade is good or bad for the environments of countries that are bonded in trade agreements, because with the expansion of trade, the share of emissions induced by free trade has increased gradually. Therefore, this study examined the impacts of free trade agreement (FTAs) on bilateral carbon emissions (CO₂) within the gravity framework over the period of 1995–2009. In our 39-panel sample we found a positive impact of FTA agreements on bilateral CO₂ pollution. However, in an income-based grouping analysis, we found mixed evidence regarding FTAs. The empirical analysis concerning high income countries indicated that free trade agreements are beneficial for high income countries. Hypothesis 1 affirmed that the trading partner's income has a positive impact on bilateral CO₂ emissions, whereas, hypothesis 2 was also validated from estimates and the positive impact of FTAs on bilateral CO₂ emissions in sample countries was revealed. For upper middle income and lower middle income countries, we found that free trade agreements are not beneficial for the environment. These results of the effects of FTAs on bilateral CO₂ pollution imply that low income countries have a greater pollution effect, even after an FTA, due to lenient environmental standards. In trade agreements, low income countries will attempt to increase their share of the goods in global market by setting lax regulations. On the other hand, developed countries have access to advanced technologies. Secondly, high income level countries probably shift pollution intensive industries to lax regulated areas. Therefore, we can say, to some extent, that the pollution haven hypothesis exists in our case study, and rich countries are possibly responsible for exporting pollution to poor countries, which validates hypothesis 3. Furthermore, the trade gravity model results show that less distance between trading partners leads to greater trade volumes and greater pollution. Concerning the use of the internet, it is suggested that the impact of a country's internet use on pollution is positive, while the effect of a partner country's internet use on pollution is negative and statistically significant. Other time invariant factors, common language, and adjacency have a positive and significant impact on CO₂ emissions.

The study has some relevant policy implications regarding free trade bilateral pollution nexuses. Although, free trade is good in the development of global value chains and global production, there is a need to be careful while setting agreements in terms of free trade, as it also significantly contributes to increasing or decreasing bilateral CO₂ emissions/pollution. Developing countries can learn from

high income countries as their FTAs are beneficial for decreasing pollution. The PHH hypothesis was validated in a selected sample set of 39 developed and developing countries. Thus, there is a need to establish clearer guidance for the development of environmental requirements for developing countries. Low income countries should also revise their rules and regulations while setting free trade agreements in order to meet environmental standards and for environmental protection. Low income level countries need to engage in cleaner production rather than dirty goods. Finally, to combat global environment problems, low income countries should be stringent in their environmental regulations.

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