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DECOMPOSING THE TRADE-ENVIRONMENT NEXUS: WHAT DO SCALE, TECHNIQUE, AND SELECTION EFFECTS INDICATE?

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Abstract

In the past, most of the studies have focused on association between overall trade openness and environment, whereas little attention has been paid to the environmental implications of intra-industry trade. This study aims to decompose the impact of intra-industry trade into three main components as follows: a scale effect, a technique effect, and a selection effect for low-, middle- and high-income countries throughout 1993-2018 by taking the data of all variables from WDI. We have used different econometric methodologies i.e., Fixed Effect Model and Random Effect model. The empirical results demonstrate that selection and scale effects have negative impacts on environmental quality and strongly dominate the technique effect. The technique effect indicates that trade-induced technological improvement has contributed to environmental quality. The empirical evidence demonstrates that the overall impact of intra-industry trade negatively affects environment quality in upper-middle, lower-middle and high-income countries. However, the negative impact is greater in lower and middle-income countries compared to high-income countries. The empirical results also indicate that the inclusion of squared variables does not alter the findings of the paper. This paper opens new directions for policymakers to use intra-industry trade as an economic tool for improving environmental quality to achieve sustainable long-run economic development.

Keywords: Intra-industry Trade, Environment, Carbon Emissions

JEL Classification: F18, F19

1. INTRODUCTION

Degradation of environmental quality began long ago when the Industrial Revolution started. Environmental deterioration is connected with increased carbon emissions across the globe. The exponential increase in the population of the world has put pressure on agriculture and manufacturing sectors for increased production, thus leading to the release of increased amounts of poisonous gasses into the environment, as argued by Bretschger (2013). Environmental deterioration in the form of air pollution, water pollution, soil pollution, noise pollution, deforestation, resource depletion, climate shifts, desertification, and similar externalities is becoming worse with each passing day.

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The nexus between trade and environment have been the subject of heated discussions over the last decade (Baek, 2015; Hossain, 2012; Kohler, 2013; Salari *et. al.*, 2021; Sharma, 2011). Previous studies have extensively focused on the association between overall trade and environmental degradation (Fung & Maechler, 2005; Omoke & Opuala–Charles, 2021; A. Roy & Gupta, 2013; J. Roy & Yasar, 2015; Baek *et. al.*, 2009; Fung & Maechler, 2005; Omoke &Opuala–Charles, 2021; J. Roy & Yasar, 2015). However, the repercussions of intra-industry trade (IIT), i.e., trade within a given industry on the environment have received little attention.

Exploring the implications of IIT for the environment tends to be vital for different reasons. First, over the past few years, IIT has increased manifold, involving industries that are not environment-friendly (Frankel and Rose, 2005; and Tariq and Rahim, 2016).The trend of increasing intra-industry trade can be observed not only in developed but also developing countries. At the same time, increasing IIT flows can be observed across horizontal goods, e.g., in differentiated[2] finished goods, and vertical goods, e.g., trade-related to components and parts. e.g., (Greenaway *et. al.*, 1994; Helpman & Krugman, 1985; Neumann & Tabrizy, 2021). Horizontal trade is a kind of trade that takes place between countries that are supposed to be similar in development structure such as technology, capital endowment, and per capita income. On the other hand, vertical trade is the type of trade that takes place between developed and developing economies. In vertical trade, developed countries are supposed to export final goods while developing economies are supposed to export raw materials and parts to developed countries. Both horizontal and vertical trade have different implications for environmental degradation.

Secondly, previous studies have reported both beneficial and detrimental impacts of overall trade on the environment (Klepper, 1992; Krutilla, 1991; Rauscher,1995 and Jun *et. al.*, 2020. However, the relationship between IIT and the environment is very complex. For instance, IIT helps expand the range of commodities in intermediate, final, and environmental goods (Melitz & Trefler, 2012). Thus, IIT leads to increased demand for environmental-friendly goods thanks to the love-of-variety approach[3], which results in a variety of induced-income effects (Frankel & Rose, 2005; McAusland & Millimet, 2013). However,

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2 "The differentiated products are imperfectly substitutable in consumption. This means that if the price of one good were to rise, some consumers would switch their purchases to another product within the industry".

3"Consumer demand for differentiated products is sometimes described using two distinct approaches: the love of variety approach and the ideal variety approach. The love of variety approach assumes that each consumer has a demand for multiple varieties of a product over time."
"The ideal variety approach assumes that each product consists of a collection of different characteristics. For example, each automobile has a different color, interior, and exterior design, engine features, etc. Each consumer is assumed to have different preferences over these characteristics."

on the other hand, the variety-induced substitution effect is likely to mitigate the environmental-friendly effect of IIT (Benarroch & Gaisford, 2014; Copeland & Taylor, 2004; Cui *et. al.*, 2021; Fung & Maechler, 2005; Kirkpatrick & Scrieciu, 2008; Leitão & Balogh, 2020; Nasir *et. al.*, 2021). Thus, we expect a more profound environment-friendly technological effect from intra-industry trade compared to inter-industry trade (Dardati & Saygili, 2021; Hakura & Jaumotte, 1999; J. Roy & Yasar, 2015).

The IIT and environment debate has not only practical and theoretical importance but also strong policy relevance since IIT is supposed to reduce trade-induced reallocation costs and is thus expected to facilitate trade agreements among countries (Cole & Elliott, 2003). Hence, IIT may potentially have positive or negative impacts on the environment; an empirical examination of the IIT-environment nexus is thus relevant and important. In doing so, this paper contributes to the existing literature in three aspects: (i) this paper investigates the impact of trade-induced selection, technique, and scale effects on the environment. (ii) this study also contributes to the existing literature by investigating the trade-induced selection, "technique and scale effects" on the environment separately for lower-middle-income, upper-middle-income, and high-income countries. (iii) Trade intensity, which measures the share of two-way intra-industry trade of the overall trade occurring in the selected countries, is also used. Our empirical evidence indicates that intra-industry trade impedes environmental quality. To test all aspects, we have taken the data for all variables from *World Development Indicator (WDI)* over 1993-2018. For empirical examination, we have used the Fixed Effect model and Random Effect model.

The remainder of the paper is organized as follows: Section 2 presents a review of the literature, Section 3 discusses the model and methodology, Section 4 presents the estimation results, and Section 5 concludes.

2. EMPIRICAL EVIDENCE

Regarding the empirical literature about trade and environment, different studies have used different model specifications, econometric techniques, and proxy variables for IIT and the environment. Although the empirical results regarding trade and environment provide evidence of positive, negative, and ambiguous effects, yet, the majority of the studies have reported favorable impacts of trade on the environment (Chintrakarn & Millimet, 2006; Cole & Elliott, 2003; Hossain, 2012; Kellenberg, 2009; Kohler, 2013; Lean & Smyth, 2010; Shafik, 1994; Shahbaz, Ozturk, Afza, & Ali, 2013; Sharma, 2011; Suri & Chapman, 1998). Addressing endogeneity, which was over-looked by several studies in the 1990s, was the priority of many studies afterward. In this context, Frankel and Rose (2005) particularly considered the effect of trade on the environment and found a positive impact.

Concerning empirical estimates regarding IIT – environment nexus, Fung and Maechler (2007) and Grossman and Krueger (1991) argued that the environmental consequences of international trade can be decomposed into three effects: scale, technique, and selection effects. The scale effect indicates that increase in trade among countries result in an increase in pollution. It is based on the reasoning that an increase in trade increases the output in an economy, which ultimately adds more pollution to the environment due to the increased use of energy. The technique effect is the opposite of the scale effect. It states that an increase in trade activity causes a decrease in pollution. The fact is that with trade flows, there tends to be an inflow of technological advancements, which decreases the pollution associated with production. Thus, as a result, the environment becomes cleaner. The selection effect states that changes in the number of product varieties change the level of pollution emissions (Fung & Maechler, 2005; Grossman & Krueger, 1991).

3. THEORETICAL MODEL

The empirical literature has comprehensively considered a wide range of aspects of the trade-environment debate. There appear to be areas 'where the impact of the three effects of IIT on the environment in the case of countries was not previously differentiated in terms of their income level (Tariq & Rahim, 2016). Thus, the purpose of this study is to investigate the environmental effects of intra-industry trade. These effects must be divided into scale, technique, and selection effects. For this purpose, following Aralas and Hoehn (2010) a model that incorporates the externality of pollution to analyze the impact of intra-industry trade on environmental quality is employed. It is based on several assumptions. It is assumed that the economy consists of consumers, firms, and an authority that regulates the equilibrium. The model also assumes that a monopolistically competitive market structure exists and that the firms in the economy produce differentiated goods. The firms jointly produce pollution because it is a by-product of the production process. Furthermore, it is also assumed that the technology used by the firms is the same. The technology used exhibits increasing returns to scale in their production. Moreover, the products made by the firms are produced with a large number of varieties. It is also assumed that there are zero transportation costs. The equilibrium in the economy is reached when consumption and production are equalized in their respective sets of equations. For this purpose, consumption and production components of the model, which are later decomposed into the trade-induced effects of IIT, are explained.

3.1. Consumption

Consumers in the economy target maximization of their utility. They do so with a very limited budget. The budget of the consumer consists of total income, which is represented by the total wage of a consumer. In the process of deriving their maximization, it is assumed that consumers can be generalized to have similar preferences. The utility function 'that consumers have is symmetric, and utility from leisure is not present in the model for consumers. Consumers in the economy are of number 'N'. Each consumer achieves utility from using the i^{th} good. This utility is positive because it benefits the consumer. Similarly, each consumer achieves negative utility from the emission of pollution which is indicated by the social damage caused by the production process in the economy.

The consumer's utility function is represented by the following equation:

$$U = \sum_{i=1}^{n} v(x_i) - \sum_{i=1}^{n} z_i v'>0, \quad v<0, \quad u'>0 \tag{1}$$

v'>0 indicates that the first-order condition of utility with respect to consumption is positive while the second-order condition is negative. u'>0 indicates that the overall utility function in eq (1) is positive, given the utility function v(x) that is positive because of consumption while it is negative because of pollution u(z)

Now, the utility maximization problem of the consumer can be stated as below:

$$\text{Max}U = \sum_{i=1}^{n} v(x_i) - \sum_{i=1}^{n} z_i \tag{2}$$

subject to $y = w$

where

$y = \sum_{i=1}^{n} p_i x_i$.

pi = i^{th} good price.

n = Total quantity of varieties.

u = Utility achieved from the consumption of goods.

i = One individual variety of a good.

y = Total income.

x= Good.

z= Pollution's disutility.

w= Wage.

For consumer's utility maximization, the first-order condition is

$$v'(xi) = \lambda pi, \tag{3}$$

where i =1,2…,n

3.2. Production

Consumption is just one aspect of the economy; it is the fulfillment of the demand for consumption that leads the economy to the second aspect, i.e., production. The firm has the same technology and witnesses increasing returns to scale in the production process with the presence of positive fixed costs, declining average costs, and constant marginal costs. The output of the firms, qi, is an increasing function of labor, li, which is represented as:

$$li = \alpha+\beta qi \quad \alpha>0, \beta>0 \tag{4}$$

Pollution emissions are represented by zi. zi is the difference between the pollution level that is potential in the economy and the level that is abated, whereas the emissions per unit of output in the model are represented by ei, where ei is obtained by dividing zi by qi. Thus, the relationship between the two is

$$Zi = eiqi \tag{5}$$

If every individual firm allocates q_i^a units of their output to abatement, then the net output will be

$$q_i^{net} = qi(1- \theta i) \tag{6}$$

where θ represents the fraction of output allocated to emissions control in the economy. Moving to the model, the individual consumers are also workers in the production process, so the total labor force is represented by L. The total supply of output in the economy is equal to the demand:

$$(1- \theta i)qi = Lxi \quad 0<\theta<1 \tag{7}$$

The portion (1-θi) is the part that is allocated to consumption in the economy. Now, the study specifies a relationship between pollution emissions and output such that the following form of equation results in:

$$ei = (1-\theta i)\ \delta \quad 0<\theta<1 \tag{8}$$

In this equation, the parameter δ measures the responsiveness of any change in the level of emissions due to any change in the portion of output that is allocated to consumption. The tax that is imposed upon pollution is denoted by τ. It is assumed to be sufficiently high that it causes firms to engage in abatement activity in their production processes. The tax is, according to Copeland and Taylor (2001), given by the following equation:

$$\tau = -[(1/\psi)\ \varphi\rho\text{-}1(w\beta/(\theta\text{-}1))q]1/1+\rho \tag{9}$$

where

$$\psi = (np^{\rho/(\rho-1)})+n*p*^{\rho/(\rho-1)})1-\rho \tag{10}$$

In other words, the equation for the tax can be written in the following functional form:

$$\tau = \tau(\psi, w, \beta, \rho) \tag{11}$$

where,

ρ = Preference parameter.

B = Productivity of labor parameter.

Ψ = Varieties of domestic and foreign products combined.

N = Number of local firms.

P = Domestic price level.

n = Number of foreign firms.*

p = Foreign price level.*

W = Wages.

φ = Marginal disutility of pollution emitted.

If we denote profit by π, then the profit function is as follows:

$$\pi i = pi(1-\theta i)qi-w\alpha-w\beta qi-\tau zi \quad (12)$$

The identical nature of the firms and similarity among them means that p = pi, q = qi, and θ = θi. Thus, these subscripts can be omitted afterward. For equilibrium, the profit-maximizing first-order condition with respect to q and θ (after simplifying it to the reduced-form equation) yields the following value:

$$\theta =1-(w\beta/\tau(\delta-1))1/ \delta \quad (13)$$

$$\text{where} \quad 0\leq (w\beta/\tau(\delta-1))1/ \delta \leq 1$$

Substituting equation (10) into equation (8), the emissions per unit of output can be rewritten as

$$e = (w\beta/\tau(\delta-1)) \quad (14)$$

Equation (14) is now a varied form of the emissions intensity. It shows that emissions intensity decreases with more stringent environmental policy; however, it increases with an increase in the marginal cost of production of the output of the firm. As a result, a strict policy will cause firms to reduce their emissions levels, and they will work to abate the pollution by employing several techniques.

3.3. Decomposition of Impact into Scale, Technique, and Selection Effects

Aralas and Hoehn (2010) show that the impact of pollution-intensive production can be decomposed into three effects, i.e., scale, technique, and selection effects. This derivation is shown below after rewriting equation (5):

$$zi = eiqi \Rightarrow \sum_{i=1}^{n} z_i = \sum_{i=1}^{n} eiqi = \sum_{i=1}^{n} e_i(Lci/(1- \theta i) \quad (15)$$

When the economy is closed, L is fixed. When firms are similar,

$$\sum_{i=1}^{n} z_i = \sum_{i}^{n} e_i q_i \Rightarrow nz = n.e.q \quad (16)$$

The same equation can be rewritten as

$$\sum_{i=1}^{n} z_i = L\sum_{i}^{n} e_i x_i/(1-\theta i) \Rightarrow nz = L.n.ec/(1- \theta) \quad (17)$$

Here, we denote nz = Z as the total pollution and then write the above equation again in a differential form (where hats denote the percentage change). The resulting equation is

$$\hat{z} = \hat{n}+\hat{e}+\hat{q} \quad (18)$$

Equation (15) can be rewritten in a more detailed form as

$$\hat{Z} = \hat{n}+\hat{L}+\hat{x}+\hat{e}-(1-\hat{\theta}) \quad (19)$$

Thus, the above equation shows that any economic impact on pollution can be subsequently decomposed into the selection, scale, and technique effects, which are individually represented as follows:

The selection effect is denoted by $\hat{n}$. The scale effect is denoted by $\hat{S} = \hat{q}$ or $\hat{S} = \hat{L} + \hat{x} - (1-\hat{\theta})$.

The technique effect is denoted by $\hat{e}$.

3.4. Reduced-Form Equation

Equation (16) gives the demand for pollution as stated by Tariq and Rahim (2016). Similarly, the supply of pollution is given by equations (9) and (10). The decomposed equation and the demand for pollution and the supply for pollution give us a reduced-form equation of the following form:

$$\hat{Z} = \Omega 1\hat{n} +\Omega 2\hat{S} + \Omega 3\hat{\beta} +\Omega 4\hat{\alpha} +\Omega 5\hat{\delta} +\Omega 6\hat{\varphi} +\Omega 7\hat{L} +\Omega 8\hat{\rho} + \Omega 9\hat{w} +\Omega 10\hat{n}^* +\Omega 11\hat{p}^* \quad (20)$$

Equation (20) now connects pollution emission levels to the study's desired economic variables. The total emissions of the economy are affected by the total number of domestic firms (n), the output level that is meant to be used for consumption purposes (S); the productivity of labor parameter (β); the fixed cost (α); the elasticity of emissions as represented by the fraction of the output that is allocated to consumption purposes (δ); the marginal disutility of total pollution (φ); production's main factor in the economy (L); the preference parameter (ρ); the wage of labor, which is net income (w); imported product varieties (n*); and the world price level (p*).

4. EMPIRICAL MODEL

To analyze the environmental impact of intra-industry trade, the total impact of trade is divided into its parts. These are the scale, technique, and selection effects. The following equation gives us the model to see the impact of intra-industry trade on the environment:

$$Z^{c}_{kt} = \alpha_0 + \alpha_1 FIRM_{KT} + \alpha_2 SCALE_{KT} + \alpha_3 INC_{KT} + \alpha_4 TR_{KT} + \alpha_5 SLTR_{KT} + \alpha_7 TECTR_{KT} + \alpha_8 SCTR_{KT} + \alpha_9 INC^2_{KT} + \alpha_{10} TR^2_{KT} + U_{KT} \quad (21)$$

Z^{c}_{kt} is carbon dioxide (CO_2) emissions. Carbon emissions are measured in kilotons and then divided by the area of each country, i.e., (CO_2/ km^2).

The emissions of CO_2 from every country are divided by the country's area to standardize the variable. This process is performed because we have three groups of countries. Every group contains large countries, such as China, the United States, Brazil, and India. Similarly, there are also small countries, such as Sri Lanka and Malaysia, for example, that make it necessary to standardize the analysis for estimation purposes. The variable for carbon emissions is computed by dividing CO_2 by km^2, i.e., (CO_2/ km^2). One reason for standardization is that it makes the results unbiased (Aralas & Hoehn, 2010). Second, it is reasonable to do so because differences in the sizes of countries can only be countered by converting the variable into a ratio (Tariq & Rahim, 2016). Theory suggests that carbon emissions are increasing in developing nations, whereas they are decreasing in developed nations. This is supported by the fact that the former does not employ pollution control techniques, whereas the latter do employ pollution abatement procedure owing to strict regulations in their economies. $FIRM_{kt}$ is the first independent variable in equation (21). It represents the environmental selection effect in the economy. The environmental selection effect indicates how many varieties of a good in an economy must be considered to capture the product differentiation. This particular variable is very necessary for identifying the determinants of intra-industry trade. In that scenario, it is strictly particular about the product and its different varieties. Thus, there is a relaxed proxy used by (Aralas & Hoehn, 2010). The proxy for the selection effect is the no. of listed companies in a country. Again, owing to the difference in size among nations, the variable is standardized by dividing it by the countries' respective areas. Thus, the variable is (no. of listed companies/km^2)kt. Theory suggests that the sign of the parameter with this variable is positive (negative) when the number of listed companies in the economy per square kilometer increases (decreases). Consequently, it leads to more (less) emissions.

$SCALE_{kt}$ represents the environmental scale effect in the model. It represents the level of production of all the goods and services that are produced within the boundaries of the concerned economy. The variable that proxies it is the gross domestic product (GDP). Furthermore, this variable is standardized by dividing it by the area of each country. Copeland and Taylor (2001) stated this variable as country-specific, (GDP/km^2)kt, which is replicated in this study. The sign of the parameter is such that as it increases, the level of emissions also increases, so it has a positive sign for developing nations. For a developed nation, the sign tends to be ambiguous because, on one hand, it increases the absolute level of pollution.

INC_{kt} refers to the environmental technique effect. It is in general the national income of a country. In the environment and trade debate, whether income affects the environment is widely debated. The environmental Kuznets curve is used by environmental economists in their debate about the role of income in affecting the environment. Here, it is included to show that high income or low income might induce individuals to employ techniques for the betterment of the environment. It has been used by Copeland and Taylor (2001), Aralas and Hoehn (2010), and Tariq and Rahim (2016). They used per capita income, and which is computed as (GNP/L)kt in the model.

TR_{kt} is the indicator of trade openness. It is defined as the ratio of exports plus imports to GDP. $SLTR_{kt}$ is the trade-induced selection effect. The proxy that we use in this study is the no. of listed companies per square kilometer multiplied by the openness of trade index, i.e., $[(\text{no. of listed companies/km}^2)*(X+M)/GDP]_{kt.}$ It quantifies the intensity of trade for a country. The greater its intensity, the more trade a country is doing with the world. However, in the case of an exception, the case will be mentioned along with evidence from the existing literature i.e., Fung and Maechler (2007), Aralas and Hoehn (2010), and Tariq and Rahim (2016).

$SLTR_{kt}$, $TECTR_{kt}$, and $SCTR_{kt}$ are the three key variables in the analysis. These three key variables are important because these trade-induced effects sum up together to differentiate intra-industry trade's impact on the environment, as stated by Aralas and Hoehn (2010). $SLTR_{kt}$ is the trade-induced selection effect. It represents the environmental effect of changes in the number of firms in the economy due to trade. The existence of economies of scale makes it profitable and valuable for a firm to specialize in a limited amount of goods. $TECTR_{kt}$ is the trade-induced technique effect. The effect reveals the variations in income level on emissions in the economy as a result of changes in trade intensity. It is constructed as the environmental technique effect multiplied by trade openness, i.e., (GNP/L)*(X+M/GDP). $SCTR_{kt}$ is the trade-induced scale effect. It shows that changes in the scale effect that are caused by changes in the trade intensity affect the level of carbon emissions in the economy. It is measured as the gross domestic product per square kilometer in the economy multiplied by the trade intensity, i.e., $(GDP/km^2)*(X+M)/GDP_{kt}$.

5. DATA DESCRIPTION

The data for all variables come from the World Development Indicators (WDI), which are input in real form, e.g. constant 2010 US$. Based on availability, the data for each variable is from 1993 through 2018. Countries are classified into three groups according to their income levels. The classification is based on the World Bank Atlas method. The first group contains countries from the "lower-middle-income" group. The second group contains countries that belong to the upper-middle-income group. The third group contains high-income countries.

Group 1 contains eight countries. These are India, Pakistan, Bangladesh, Sri Lanka, Indonesia, Morocco, Philippines, and Kenya. The basis for their selection is that they exhibit the same trends in many economic variables. The inclusion of Kenya, the Philippines, Indonesia, and Morocco is based on the idea that their inclusion will add variety to the major SAARC nations included in one of the studies reviewed in the literature, Tariq and Rahim (2016). Group 2 contains nine countries. These include China, Brazil, Malaysia, South Africa, Thailand, Turkey, Mexico, Colombia, and Serbia. All of these are referred to as emerging economies. Group 3 also contains nine countries: the United States, the United Kingdom, Australia, Japan, Germany, Switzerland, France, Singapore, and Canada. These are highly developed nations.

5.1. Descriptive Statistics

Table-1 presents descriptive statistics for both dependent and independent variables in the case of lower-middle, upper-middle, and high-income countries. The results indicate that the maximum value of CO2 emission was found in the case of India, while the minimum value was found in the case of Kenya. Likewise, the minimum value of trade openness is 0.10 which was corresponding to Bangladesh. It indicates that in the sample of lower-income countries, Bangladesh is the least open economy. In the case of upper-middle-income countries, the minimum and maximum values of CO2 emissions are 0.027 and 1.114 respectively. Interestingly both the minimum value and maximum and maximum values belong to Brazil. Both of the values were found in 1993 and 2017 respectively. This may be attributed to the fact that Brazil is a fast-growing economy over the past two decades. Likewise, the maximum value of TR is 1.747 which is related to Malaysia, indicating that it is a more open economy in upper-middle-income countries. In the case of high-income countries, it is clear that the mean value of CO2 emission and trade openness are greater than in upper-middle and lower-middle-income countries. It indicates that developed and industrialized countries have a major role in increasing CO2 emissions.

Table 1. Descriptive Statistics

Grouping	Variable	MIN	MAX	Mean	SD
Lower Middle Income Countries	CO2	0.011	0.619	0.182	0.136
	$FIRM_{kt}$	0	0.004	0.001	0.001
	$Scale_{kt}$	23545.959	1109303	334870.3	258474.392
	INC	439.309	3581.676	1580.009	829.245
	TR	0.1	0.808	0.468	0.166
Middle Income Countries	CO2	0.027	1.144	0.325	0.227
	$FIRM_{kt}$	0	0.007	0.001	0.002
	$Scale_{kt}$	123305.65	1112634	421092.1	227069.462
	INC	999.029	11468.39	6344.298	2411.172
	TR	0.132	1.747	0.624	0.434
High Income Countries	CO2	0.036	96.569	8.071	20.184
	FIRMkt	0	0.787	0.064	0.179
	Scalekt	82167.511	3.92E+08	32231122	78457686.91
	INC	25444.412	78772	44477.16	11089.863
	TR	0.173	4.003	0.834	0.927

5.2. Econometric Methodology

Three types of panel models are usually used to deal with the panel data. These are pooled least square method, fixed-effect model, and random-effect model. In this study, we follow the fixed as well as the random-effect model to investigate the impact of intra- industry trade on the environment along with other explanatory variables. The models are specified as follows:

$$Z^{c}_{kt}=\alpha_{kt}\theta_{kt}+\mu_{kt} \quad (22)$$

Where Zc indicates CO2 emission, θ indicates vector of explanatory variables while α represents slope coefficients, k is used "for the countries t denotes time and µit is the error term which is assumed to be white noised and varies over both country and time." In the case of using the pooled least square approach," countries' unobservable individual effects are therefore not controlled. "Hence, the fixed-effect model is considered to be the appropriate model to take into account a county's heterogeneity. "The fixed-effects model can be derived from equation (22) relative to the notations used in the study as follows:"

$$Z^{c}_{kt} = \theta_{k} + Ɪ_{k} + \alpha_1 \mathrm{FIRM}_{it} + \alpha_2 \mathrm{SCALE}_{KT} + \alpha_3 \mathrm{INC}_{KT} + \alpha_4 \mathrm{TR}_{KT} + \alpha_5 \mathrm{SLTR}_{KT} + \alpha_7 \mathrm{TECTR}_{KT} + \alpha_8 \mathrm{SCTR}_{KT} + \alpha_9 \mathrm{INC}^2_{KT} + \alpha_{10} \mathrm{TR}^2_{KT} + \mathrm{U}_{KT} \quad (23)$$

In equation (23), Z^cindicates CO2 emission, whereas, unobserved country-specific effects are captured by the parameter θ_k. To capture the specific country effect, we use dummy variables. This model in the literature is also called the least square dummy variables model (LSDV). To capture the year effects, many studies use the year dummy in the model and it is represented by the parameter$Ɪ_i$. The problem with the FEM is that it cannot capture the effects of time-invariant variables. In the FEM, we cannot estimate time-invariant factors, such as geographical distance and other binary variables, directly because of perfect multicollinearity among them. Thus, the effects of time-invariant variables cannot be determined. According to many studies, the best choice to address this problem is the REM. Finally, we turn to the REM and apply it as an estimation technique.

"From equation (22), this study derives the random-effects model as below":

$$Z^{c}_{kt} = Ɪ_{k} + \alpha_1 \mathrm{FIRM}_{KT} + \alpha_2 \mathrm{SCALE}_{KT} + \alpha_3 \mathrm{INC}_{KT} + \alpha_4 \mathrm{TR}_{KT} + \alpha_5 \mathrm{SLTR}_{KT} + \alpha_7 \mathrm{TECTR}_{KT} + \alpha_8 \mathrm{SCTR}_{KT} + \alpha_9 \mathrm{INC}^2_{KT} + \alpha_{10} \mathrm{TR}^2_{KT} + \mathrm{U}_{KT}, \Upsilon_k=\bar{\gamma} + \sigma_k \quad (24)$$

The explanatory variables remain as defined in equation (22). In the eq (24) above, U_{KT} and σ_k indicate error term and random country effect respectively. $\bar{\gamma}$ represents the mean of the coefficient vector. According to the random effect model, the slope coefficients have the characteristics that they vary randomly across countries. Hsiao *et. al.* (1996)" argue that the OLS procedure yields biased and inconsistent estimates, especially when the omitted country-specific variables are correlated with the explanatory variables. "For selection between Random Effects model and Fixed Effects model which model a numbers of criteria have been developed. For example, considering the correlation between an error component and explanatory variables, if it is correlated, the Fixed Effects

Model produce unbiased parameters, and if not, the parameters through Random Effects Model are unbiased. Further, if the numbers of cross-sectional units (N) are smaller than the amount of time series data (T), in such cases the estimated parameters of the Fixed Effects Model and Random Effects Model remain the same. Consequently, the ideal model is the Fixed Effects Model, and if the numbers of cross-sectional units (N) are larger than the number of time series data (T), the estimated parameters will be significantly diverse for FEM and REM.

In this study, we select the model based on a statistical test developed by Hausman (1978). The criteria of the Hausman test are given in the following equation :

$$W = (\hat{\beta}FEM - \hat{\beta}REM)` [v(\hat{\beta}FEM) - v(\hat{\beta}REM)]^{-1}(\hat{\beta}FEM - \hat{\beta}REM) \sim x^2 \quad (25)$$

It follows a Chi-square (x^2) distribution. The null hypothesis of the test is that differences in coefficient are not systematic. If the null hypothesis is rejected we will estimate the model, through the FEM, and if accepted, the REM will produce an unbiased estimate. Now, any of the estimators used from the above two estimations techniques (FEM and REM), we will test for the basic assumption that residuals are independent and identically distributed and for the problem of endogneity or omitted variable biases).

6. EMPIRICAL RESULTS

The present study aims to investigate the impact of intra-industry trade on the environmental quality of low, middle and high-income countries. For each sample of countries, we estimate the model in linear form, i.e., excluding non-linear variables. Similarly, we estimate a separate model in which we include both linear and non-linear variables. For estimation purposes, we use both fixed and random-effect models. Table 1 presents the estimation results of the linear model for lower-middle, upper-middle, and high-income countries. The test diagnostics provide the results of F-statistics for the fixed effects model and Wald (Chi2) test for the random-effects model, both of which indicate the overall significance of the model. The variable 'Firm' indicates that it affects carbon emissions negatively in lower-middle-income countries.

However, in the case of upper-middle-income countries, it tends to positively affect the environment. The findings of these coefficients are consistent with the theoretical expectation that the sign of the parameter for this variable is positive (negative), when the number of listed companies in the economy per square kilometer increases (decreases). Consequently, it leads to more (less) emissions. This is more prevalent in developing nations; however, in developed nations, the results might differ since they adopt strict emissions checks in their countries. As indicated in Table 1, unlike lower-middle-income countries, the coefficient of the "Firm" variable (selection effect) is positive in middle and high-income countries. Theoretically, the selection effect shows that as economies integrate by having more intra-industry trade, the number of domestic firms and the no. of product varieties decrease because of competition from abroad. As a result, a reduction in the emissions level is expected which supports the findings of (Aralas & Hoehn, 2010). The scale effect shows how the level of production of all the goods and services that are produced within the boundaries of the economy affects the environment. For all groups of countries, the scale effect is supposed to have a detrimental effect on the environment. For developed economies, the sign of the scale variable could be positive or negative. It can be positive if an increase in the scale of production causes an absolute increase in CO_2 emissions, whereas it can be negative if high-income countries adopt pollution-free techniques. In the case of our results, the former effect of an absolute increase in CO_2 emissions dominates. INCkt denotes the environmental technique effect. Our results indicate that income tends to have a benign effect on the environment for all groups of countries. The impact of INCkt on the environment in the case of developing countries is supposed to be positive; however, in our findings, this coefficient is negative, but it is insignificant.

Table-1. Impact of Intra-Industry Trade on Environment in Low-, Middle- and High-Income Countries

	Lower Middle Income Countries		Upper Middle Income Countries		High Income Countries	
Variables	Fixed Effects	Random Effects	Fixed Effects	Random Effects	Fixed Effects	Random Effects
C	-0.0129 (0.156)	-0.0129 (0.237)	-0.001 (0.567)	-0.007 (0.678)	-0.005 (0.600)	-0.004 (0.678)
Firm	-0.206 (0.000)	-0.212 (0.000)	0.213 (0.000)	0.206 (0.000)	--	--
Income	-0.0810 (0.331)	-0.076 (0.353)	-0.589 (0.000)	-0.1451 (0.000)	-1.509 (0.000)	-1.512 (0.000)
Trade Openness	0.3106 (0.001)	0.291 (0.002)	0.277 (0.044)	0.278 (0.053)	0.283 (0.000)	0.278 (0.235)
SLTR	0 .1252 (0.002)	0.128 (0.001)	0.13171 (0.000)	0.032 (0.000)	0.067 (0.199)	0.061 (0.000)
SCTR	1.011 (0.000)	1.013 (0.000)	1.047 (0.000)	1.053 (0.000)	0.656 (0.000)	0.666 (0.000)
TECTR	-0.3129 (0.000)	-0.322 (0.000)	-0.878 (0.000)	-0.891 (0.000)	-0.077 (0.030)	-0.078 (0.023)
R^2	0.91	0.92	0.78	0.79	0.97	0.97
F-Statistic	379.28 (0.000)		174.73 (0.000)		1202 (0.000)	
Wald (Chi^2)		195.23 (0.000)		719 (0.000)		6403.27 (0.000)

Note: The two values before each variable are slope coefficients and p- values in the brackets.

Trade openness causes more pollution in all groups of countries. In the existing literature, the majority of the studies indicate improvements in environmental quality, but many studies also indicate a negative impact of trade on the environment(Agras & Chapman, 1999; Brown *et. al.*, 2020). SLTRkt is the variable that represents the trade-induced selection effect of trade. The positive sign of the SLTR variable indicates that owing to foreign competition, reductions in the number of domestic firms and varieties cause the emissions level to decrease in all country samples. Thus, we have positive coefficients for the SCTR variable. The coefficient of SCTR is much stronger in low and middle-income countries compared to high-income countries. Our findings are consistent with the studies of Aralas and Hoehn (2010) and Tariq and Rahim (2016). SCTR and TECTR indicate the trade-induced scale and technique effects, respectively. The coefficients of these variables indicate that the effect of the former is significantly positive and that of the latter is significantly negative for all groups of countries studied.

The results are consistent with existing studies from the literature, such as Tariq and Rahim (2016). The variable SCTR shows that changes in the scale effect that are caused by trade intensity affect the level of carbon emissions in the economy. The coefficient of SCTR is positive for all samples of countries studied. The findings are consistent with the studies of Cole and Elliott (2003). The negative coefficients of TECTR indicate that trade-induced technological effects are negative. This result implies that the technique effect improves environmental quality. Furthermore, it can also be explained in the sense that increasing openness of trade helps increase the income of people, whereas increasing income makes people demand environmentally friendly technologies and products. The findings of the study are consistent with Colle and Elliott (2003).

Table 2 presents the impact of intra-industry trade on environmental quality in the case of lower-middle, upper-middle and high-income countries, where we include variable income and trade openness in quadratic form. With the inclusion of these two variables, the results do not exhibit notable differences. For example, the variable 'Firm' significantly and negatively affects carbon emissions of low-middle-income countries. Likewise, the variable 'Firm' has a significant and positive impact on the environment in the case of upper-middle- and high-income countries.[4]

The trade-induced selection effect inversely affects the pollution, in contradiction to the earlier studies of Aralas and Hoehn (2010) and Tariq and Rahim (2016). This might indicate that if firms engage in producing efficiently and in margins, it might lead to improvements in environmental quality. Regarding the variables of interest, the technique effect is insignificant, making its negative sign not worthy of note. The squared variables indicate that the technique effect is helping to reduce pollution, as advocated by Copeland and Taylor (2004); Fung and

[4]Few unnecessary variables are dropped in the second estimation due to the similarity in their values causing econometric problems in the results.

Maechler (2007); Aralas and Hoehn (2010) and Tariq & Rahim (2016). However, the income-squared value indicates that as the economies get developed and their income level increases, it results in increased pollution.

Table-2. Impact of Intra-Industry Trade on Environment in Low, Middle and High-Income Countries

	Lower Middle Income Countries		Upper Middle Income Countries		High Income Countries	
Variables	Fixed Effects	Random Effects	Fixed Effects	Fixed Effects	Random Effects	Fixed Effects
C	-0.003 (0.772)	-0.004 (0.775)	-0.003 (0.752)	-0.005 (0.600)	-0.024 (0.490)	-0.025 (0.583)
Firm	-0.030 (0.021)	-0.032 (0.014)	0.214 (0.00)	0.207 (0.000)	0.150 (0.000)	0.151 (0.000)
SLTR	0.125 (0.199)	-0.026 (0.008)	0.213 (0.000)	0.206 (0.008)	0.067 (0.199)	0.270 (0.000)
SCTR	1.053 (0.000)	0.991 (0.000)	1.146 (0.000)	1.162 (0.000)	0.657 (0.000)	0.665 (0.000)
TECTR	-0.081 (0.331)	-0.084 (0.783)	-0.589 (0.000)	-0.628 (0.000)	-0.061 (0.212)	-0.064 (0.000)
$Income^2$	0.324 (0.000)	0.852 (0.000)	-0.117 (0.107)	-0.130 (0.059)	-1.376 (0.000)	-1.37 (0.000)
Trade $Openness^2$	0.198 (0.000)	-0.289 (0.009)	0.523 (0.000)	0.516 (0.600)	1.299 (0.000)	1.29 (0.600)
R^2	0.91	0.91	0.79	0.78	0.94	0.79
F'-Statistic	448 (0.0000)	-	231.59 (0.0000)	-	763.72 (0.0000)	-
Wald (Chi^2)	-	1776.30 (0.0000)		714.45 (0.0000)	-	3222.27 (0.0000)

Note: The two values before each variable are slope coefficients and p- values in the brackets.

In a nutshell, the empirical results demonstrate that product differentiation, which is captured in the analysis via the selection effect, has caused environmental pollution to increase in middle and high-income countries, whereas in the case of low-income countries, it has a pollution-decreasing effect. However, the trade-induced selection effect has contributed to environmental degradation in all groups of countries. Similarly, scale and trade-induced scale effects have resulted in environmental degradation in all groups of countries. The empirical results indicate that trade has contributed to the improvement of technology and innovation, which in turn has caused environmental pollution to decline in all groups of countries. Moreover, the results indicate that in the case of middle and high-income countries, the environmental Kuznets curve hypothesis is supported, whereas it is not evident in developing nations.

6. CONCLUSION AND POLICY IMPLICATIONS

Intra-industry trade's share of international trade has been increasing since its inception. The increasing share of intra-industry trade has several externalities associated with it. The major negative externality is the pollution of toxic gasses, which has caused environmental degradation. This study tried to address the need to analyze this degradation caused by intra-industry trade in many global economies. The purpose of the present study was to capture the effects that intra-industry trade has on the environment. Intra-industry trade is negatively affecting the environmental quality in developed and developing nations. For developing countries, the results are not very different from what the previous literature predicted; however, for developed nations, the results are not in accordance with the existing literature. This discrepancy exists because the technique effect is less than the combined effect of the scale and selection effects. If we investigate the individual effects in both the models, then intra-industry trade may be beneficial for the environment in terms of technique effects in all types of economies, but in developed nations, this effect is much stronger than in developing nations. In comparison, developed nations obtain more environmental benefits from intra-industry trade than developing nations. Moreover, the results indicate that in the case of middle- and high-income countries, the environmental Kuznets curve's hypothesis is supported, whereas it is not supported for developing nations. The empirical investigation of the selection effect is important from the policy perspective because it differentiates the effect of trade driven by increasing return and market structure from the effect of trade associated with resource differences. In situations in which countries are involved in the trade of pollution-intensive production of homogenous and differentiated goods, empirical analysis of selection effects, in addition to the scale and technique effects, merits consideration.

In this study, we obtained strong evidence of a positive and significant selection effect in the case of the trade and environmental nexus across all country samples considered. The theoretical interpretation of the positive selection effect is that trade in differentiated goods prompts negative selection effects due to foreign completion caused by international trade. The increasing competition causes a reduction in the number and variety of domestic firms. Keeping the scale and technique effects constant, a reduction in domestic firms implies a reduction in emissions. Thus, the empirical results regarding the selection effect imply that intra-industry trade has a positive effect on the environment for low, middle- and high-income countries. Interestingly, the selection effect is stronger in low and middle-income countries compared to high-income countries. It indicates that low and middle-income countries benefit more in terms of environmental improvement by trading differentiated goods with high-income countries.

Trade-induced technological effects have pollution-reducing effects in all country samples considered, which highlights the important role of intra-industry trade in promoting environmental-friendly technologies. Income is used as a proxy for the technique effect; thus, increasing the per capita income can be considered a policy tool for environmental pollution control in lower-] and middle-income countries. Other interesting information that results from the empirical analysis is that the square of the income variable has a negative sign in the case of middle and high-income countries, which indicates the existence of the environmental Kuznets curve in all country samples considered and it implies that the technique effect is self-enforcing. However, one important point that might be of concern for all types of countries is the increase in the scale of pollution-intensive products. The coefficients of the scale variables for all samples of countries considered not only carry significant coefficients but also dominate the pollution-reducing selection and technological effects. The net effect on the environment could be negative. The role of domestic regulations and environmental policies may warrant more attention to address the negative impact of the scale effect and to encourage the use of more environmental-friendly technologies. Finally, overall trade tends to have a negative impact on the environment in almost all the samples of countries; however, through active governmental rules and regulations, trade can become a source of transfer for pollution-mitigating abatement technologies and environmental-friendly products.

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