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A Test for the Pollution Haven Effect in the Selected EU-Asian Countries

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Abstract

The pursuit of sustainable development requires balancing the objectives of FDI, Trade, economic growth and environmental protection. Achieving a balance between these often-conflicting priorities is difficult enough at the national level, where competing interests are at least grounded in a common environmental, social and economic context. At the international level, where different countries have vastly different circumstances and priorities, it is significantly harder. One of the many ways in which this challenge manifests itself in the real world is in the conflict between the desire to promote trade by reducing non-tariff barriers and the desire to protect the environment and health through the use of technical regulations and standards.

As competition becomes more global, people are concerned that relatively lenient environmental regulation and lax enforcement in developing countries give them a comparative advantage in pollution intensive goods. Lowering trade barrier may encourage a relocation of polluting industries from countries with strict environmental policy to those with lenient policy. These shifts may increase global pollution, as countries become reluctant to tighten environmental regulations due of their concerns over comparative advantage in international trade. Therefore, trade and FDI may encourage a relocation of polluting industries from countries with strict environmental policy to those with less stringent policy. We call this a pollution haven effect. The pattern of trade depends on which of these effects is stronger. The aim of this paper is to test the validation of the hypothesis of the pollution haven effect on water created by the different industries in the selected countries of Europe and Asia.

Overall, our results show that trade liberalization decreases the BOD emission crated by chemical, food, metal, paper and pulp, textile, wood and other industries but it increases this emission crated by clay and glass industry in the selected EU-Asian countries.

Keywords: International Trade, Environment, Pollution Haven Effect.

JEL Classification: Q51, Q56.

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1. Introduction

It has been widely accepted that economic globalization is here and that global trade plays an increasingly important role in determining relative economic growth among countries. International trade has grown considerably in recent decades.

This growth in trade has influenced the quality of the environment principally in exporting but also in importing countries. The notion that free trade among countries leads to welfare maximization becomes questionable, when environmental degradation lowers that welfare. While comparative advantage implies that a country might specialize in the production of a pollution intensive commodity, such pollution would cause the environmental quality of the country to deteriorate. In this case there is a trade-off between gains from trade and environmental deterioration in this country, compared to a country producing non-polluting goods, since income will increase only if gains from trade over compensate welfare losses from environmental damage. Stricter environmental policies in the first country would thus affect its comparative advantage and consequently its economic growth. Such interactions between trade and the environment have produced an increasingly greater need for a careful and balanced assessment of the issues involved and the challenges they pose to policy makers. Investigation of the interactions between trade and the environment can be traced back to the early 1970s and was stimulated by the first United Nations Conference on the Human Environment in 1972.

There are a number of theoretical models of North-South trade which predict that less stringent environmental regulations will lead to an increase in polluting production in the South when trade is liberalized. Since weaker environmental regulation leads to lower relative costs for the pollution-intensive industry, the South will have a comparative advantage in the “dirty” good. On the other hand, the North with its stricter environmental regulations will tend to specialize in relatively “clean” products. A crucial assumption of these models is that the key difference between the North and South is the level of environmental regulation. Those who believe that trade liberalization can have a positive effect on the environment have pointed out that environmental control costs in manufacturing industry are generally low and that factors other than environmental considerations are more important determinants of comparative advantage (Dean, 1992). In this case it is quite possible that a developing country with a less stringent environmental control system may nevertheless have a comparative advantage in less polluting industries. Where there is a correlation between capital intensity and pollution intensity, countries with a comparative advantage in labor intensive industries will benefit environmentally from specializing according to their comparative advantage.

Indeed, pollution will tend to increase in the North, because of its specialization in capital-intensive industries, and be reduced in the South (Antweiler, Copeland and Taylor, 1998). This is associated with the view that the structure of protection in developing countries has a “brown bias”. In other words, it is suggested that, under import substitution regimes, highly polluting industries tend to receive higher protection than less polluting industries (Birdsall and Wheeler, 1992).

The “pollution haven hypothesis” suggests that where trade is liberalized, there will be a tendency for the South, with its less stringent environmental regulation, to become more specialized in polluting industries. Put another way, it implies that the composition effects associated with trade liberalization will tend to increase pollution in the South. Likewise, the literature has emphasized that a tightening of environmental standards in the North would lead industries to relocate to the South according to what is referred to as the “pollution haven (PH) effect”. Overall, it is fair to say that empirical support for the PH hypothesis is weak, while the PH effect, which is often taken for granted, has proven elusive too, apart from recent empirical support for the US.

The aim of this paper is to examine of the validation of the pollution haven effect for the water pollution created by the different industries in the EU-South Asia region.The paper is organized as follows: Section 2 explicates the relation between trade and the environment. The pollution Haven effect is explicated in section 3. Section 4 describes the model and data set. The estimations results are presented in this Section. Finally, Section 5 is concluding the empirical results of the model.

2. Trade and Environment

Economic interactions between environmental and trade polices concern the effects that these policies have on resource allocation, income distribution, and environmental consequences, both among and within trading countries.

Economic analysis of these interactions treats environmental and trade policies as having both positive and negative consequences, depending on the economic mechanism involved.

Understanding the impact of economic growth and trade liberalization policies on the environmental quality is becoming increasingly important as general environmental concerns are making their way into main public policy agenda. In particular, two areas of research have attracted the attention of economists and policy makers. Firstly, the relationship between environmental quality and economic growth has been empirically modeled through emissions-income relationship by many authors.

The impact of economic growth on environment has received an increasing attention in the last part of the previous century. Starting with Grosmann and Krueger (1991), empirical tests of this relationship have been carried out in a specific format: different indicators of environmental degradation have been assumed to be an ad hoc polynomial function of income per capita, and then it has been tested whether there would be a decline in environmental degradation for income levels higher than a threshold. This search for an inverted-U type relationship between pollution and income, i.e. the Environmental Kuznets Curve hypothesis (EKC) has been at the centre of discussion on the interaction between economic growth and environment.

Secondly, several methodological approaches have been employed to examine trade and environment linkage. All studies try to establish a direct linkage between income and pollution and/or between trade and pollution. They seem to overlook the more basic and fundamental interaction among these variables which is the impact of income growth and trade liberalization on environmental awareness and policy making.

There are three noted effects of free trade on the environment: the scale effect, technique effect, and composition effect. The scale effect states that free trade necessarily creates additional output thereby exacerbating existing environmental problems. To understand the impacts of free trade on the environment, we should first understand the effects of economic activity on the environment. The environment is impacted from economic activity in two ways: use of resources and harmful by-products. The most direct effect comes from simple consumption of resources. The earth has a finite stock of resources (it is for this scarcity concern that economics is a field of study) and it is feasible that some could be completely used up. Natural resources are found with varying availability. Resources are either relatively abundant or relatively scarce and renewable or non-renewable. Each type of resource (i.e. abundant and renewable or scarce and non-renewable) ought to be analyzed with its own considerations. Obviously scarce, non-renewable resources are of the most concern to those seeking to preserve the environment.

By-products of industry are another impact of economic activity on the environment. Many byproducts of production are harmful to the environment, such as pollution or other emissions. Most governments have policies regarding both the consumption of natural resources and emission limits.

The technique effect explains the tendency for higher income nations to value cleaner environments. The effect is indirect. Free trade leads to increased world income that has been positively linked with a higher demand for a clean environment (Antweiler et al., 2001). The term is derived from the altered production methods of firms to accommodate the demand for a cleaner environment. The altered production techniques reflect government regulations and consumer demand.

The composition effect identifies the change of goods production as a result of freer trade. Relative to environmental considerations a change of goods production might be a decrease in the percentage of exports that are environmentally damaging because of international preferences. However, it is difficult to determine whether or not these effects are changed as a result of environmental considerations. The composition effect measures only if a country changes the relative percentages of goods produced (perhaps regardless of environmental considerations). Two hypotheses seek to determine if the composition effect will have a positive or negative effect on pollution levels. The first is the “pollution haven” hypothesis that claims that countries with lax environmental standards will attract pollution-intensive producers. Costs of production will be less in those countries with more lenient standards, attracting potential producers. This is a major reason why governments are hesitant to place strict environmental standards on their firms; the resulting consequence could be reduced competitiveness. Evidence regarding the pollution haven hypothesis has been mixed. The second hypothesis is called the “factor endowment” hypothesis. It claims that because pollution-intensive industries are normally capital-intensive, as well the availability of capital will determine where "dirty" industries are located. The allocation of capital gives rise to name "factor endowment." The hypothesis notes that developed countries generally tend to have more available capital as well as stricter environmental regulations. Taken together these two factors can result in "dirty" industries being located in places that can deal with pollution. Those who find evidence against the pollution hypothesis, such as Busse, often point to the factor endowments of countries as the true indicators of where pollution-intensive industry will be located.

Although the three effects just discussed allow for identification of free trade impacts on the environment it should be noted that measuring the overall effect of environmental change is difficult. Scientists have a hard time measuring the true effects of what we call environmental damage or degradation. We can measure additional pollution as a consequence of increased production, but understanding the affect on the big picture can be difficult. Free trade advocates argue that environmentalists should try to identify the true environmental consequences of increased production rather than set limits on resource consumption and by-product emission (Tsai, 1999). Environmentalists point out that the environment is clearly damaged to a degree from these processes (scale effect) and should therefore be protected with explicit limits.

3. Pollution Haven Effect

Environmentalists ardently argue that trade liberalization brings together the expansion of production, consumption and transport of goods causing further environmental degradation, and then makes governments more concerned about their market share leading them not to give environmental issues the required priority (Sturm et al. (2002)).

One of the environmental impacts typically discussed in connection with trade liberalization are the composition effects. These occur when increased trade leads countries to specialize in industries where they enjoy a comparative advantage. If this advantage stems from differences in production technologies, it may well be that both partners benefit from trade. Although industries in developing countries are generally characterized by pollution intensities (i.e. per unit of gross output) that are higher than in developed countries, mutual benefits – in a Ricardian context – would be expected. However, if the comparative advantage stems from differences in environmental stringency, the composition effects of trade will exacerbate existing environmental problems in the countries with relatively lax regulations. This is known as the pollution haven effect.

This effect is typically felt to apply to developing countries. Several causes contribute to this. First, the higher incomes in the developed countries generate a greater demand for clean air and water. Similarly, in developing countries, with lower levels of income and higher discount rates, extra earnings and jobs are valued higher, relative to health and less pollution. Second, the relative costs of monitoring and enforcing pollution standards are higher in developing countries, given the scarcity of trained personnel, the difficulty of acquiring sophisticated equipment and the high marginal costs of undertaking such a new governmental activity (when the policy focus is usually on reducing fiscal burdens). Third, growth in developing countries results in a shift from agriculture to manufacturing with rapid urban growth and substantive investments in urban infrastructure, all of which raise the pollution intensity. In developed countries, however, growth is associated with a shift from manufacturing to services, leading to a decrease of the pollution intensity.

When countries open their economies to international trade and investment, the ones with low demand for environmental quality set lax environmental standards while others set tougher standards. The countries with laxer standards who are mostly the less developed countries engaging in environmental dumping-seek to attract more investments or try to get higher share from the world market by producing and exporting pollution-intensive goods. On the other hand, the countries with tougher standards import the pollution-intensive goods from these countries (Frankel, 2002).

4. The Model

In contrast, ACT (Antweiler, Copeland and Taylor)'s model allow comparative advantage to be driven by capital and labor endowments instead of, or as well as, differences in environmental regulations. Furthermore, such environmental regulations are exogenously. Since the findings and methodology of ACT are central to this paper it is useful to provide a brief outline of the model.

Assume a small open economy produces two goods, X and Y, with two factors, capital

(K) and labor (L). Assume industry X is capital intensive and generates pollution, whilst industry Y is labor intensive and clean. Assuming the existence of trade barriers, if p is the relative price of *X*, then domestic prices will differ from world prices,

$$p = \beta p^{w} \qquad (1)$$

where β denotes trade frictions and p^{w} is the common world relative price of X. Note that $\beta \succ 1$ if a country imports X and $\beta \prec 1$ if a country exports X.

ACT decompose pollution (z) into scale, composition and technique effects:

$$\hat{z} = \hat{S} + \hat{\varphi}_{x} + \hat{e} \qquad (2)$$

where ^ denotes percentage change and $\hat{z} = \partial z / z$.

The first term is the scale effect. It measures the increase in pollution that would be generated if the economy were simply scaled up, holding constant the mix of goods produced and production techniques.

The second term is the composition effect as captured by the change in the share of the dirty good in national output. If we hold the scale of the economy and emissions intensities constant, then an economy that devotes more of its resources to producing the pollution good will pollute more.

Finally, we have the technique effect, holding all else constant, a reduction in the emissions intensity will reduce pollution. Understanding the interaction between these effects will play an important role in determining how trade and growth affect the environment.

A further decomposition of Eq. (2) allows ACT to arrive at the private sector's demand for pollution. Pollution demand is a positive function of scale, capital abundance and the world price of dirty goods and is a negative function of a pollution tax. The degree of trade frictions also affects pollution demand but, as we shall see, the direction of this effect depends on whether a country is an importer or an exporter of dirty goods. In ACT's model pollution supply is determined by the price of polluting, as given by a pollution tax. In turn, real income is a determinant of the pollution tax, since an increase in real per capita income will increase the demand for environmental quality. Combining pollution demand and supply yields the following reduced form equation:

$$\hat{z} = \gamma_1 \hat{S} + \gamma_2 \hat{\kappa} - \gamma_3 \hat{I} - \gamma_4 \hat{T} + \gamma_5 \hat{p}^{w} + \gamma_6 \hat{\beta} \qquad (3)$$

where all γ_i are positive, κ denotes the capital–labor ratio, I represents real per capita income, T represents 'country type' and all other variables are as already defined. We can now clearly illustrate how the direction of the trade-induced composition effect will vary across countries.

For an exporter of the dirty good, $\beta \prec 1$. As trade is liberalized β will increase and hence $\hat{\beta} \succ 0$. Thus, for a country with a comparative advantage in pollution-intensive output, trade liberalization will increase emissions. In contrast, for a dirty good importer $\beta \succ 1$ and hence trade liberalization will mean $\hat{\beta} \prec 0$: Thus, for a country with a comparative advantage in clean output, trade liberalization will reduce pollution.

ACT model therefore derives an important result that is central in this paper. Holding other determinants of emissions constant, trade liberalization does not have a unique relationship with emissions. Rather, the effect of liberalization on the environment will be country specific and depends crucially on a country's comparative advantage.

Based on our theoretical considerations, we estimate the following equation using ifxed and/or random effects of panel data speciifcati s. Panel data analyses offer different ways to deal with the possibility of country-specific variables. Fixed Effect (FE) model is a suitable estimation approach that treats the level effects as constants, whereas Random Effect (RE) model is suitable to capture the level effect. It should be mentioned that RE model treats the level effects as uncorrelated with other variables, while FE model does not. In this analysis we estimate both FE and RE models. Now the estimating equation is:

$$Z_{it} = b_0 + b_1 GDPPC_{it} + b_2 KL_{it} + b_3 (KL_{it})^2 + b_4 I_{it-1} + b_5 (I_{it-1})^2 + b_6 OP_{it} + b_7 OP_{it} KL_{it} + b_8 OP_{it} (KL_{it})^2 + b_9 OP_{it} I_{it} + b_{10} OP_{it} (I_{it})^2 + b_{11} OP_{it} FDI_{it} + e_{it} \qquad (4)$$

where Z_{it} denotes emissions of organic matter in wastewater created by the industries, measured as biological oxygen demand (BOD) emission / per capital.

Our analysis covers the different industries defined as a tree-digit group in ISIC classification:

Code 351: chemical industry,
Code 362: clay and glass industry,
Code 311: food industry,
Code 381: metal industry,
Code 341: paper and pulp industry,
Code 321: textile industry,
Code 331: wood industry,
Code 390: other manufacturing industries.

$GDPC_{it}$: gross domestic product per capita is the scale effect. We use GDP per capita as proxy for scale effect. It measures the increase in pollution that would be generated if the economy were simply scaled up, holding constant the mix of goods produced and production techniques. Trade and growth both increase real income, and therefore both increase the economy's scale.

KL_{it}, $(KL_{it})^2$: A nation's capital to labor ratio captured to the composition effect. In our estimations we will include both a country's capital to labor ratio and its square. This non-linearity is appealing because theory suggests capital accumulation should have a diminishing effect at the margin.

I_{t-1}, I^2_{t-1}: One lagged Gross national income per capita is the technique effect. Because we believe the transmission of income gains into policy is slow and reflects one period lagged, we use one period lagged Gross national income as our proxy for our technique effect. We have also allowed the technique effect to have a diminishing impact at the margin by including both the level and the square of lagged gross national income in our regression.

This use of lagged gross national income and its squared to capture technique effects is consistent with the environmental Kuznets curve literature. This literature is the inverted-U-shaped relationship between per capita income and pollution: increased incomes are associated with an increase in pollution in poor countries, but a decline in pollution in rich countries.

OP_{it}: We include trade intensity (the ratio of imports+exports to GDP) as a measure of trade frictions.

$OP_{it}KL_{it}$, $OP_{it}(KL_{it})^2$: Trade intensity is interacted with a country's relative capital–labor ratio to capture the role of endowments as trade be liberalized.

$OP_{it}I_{it}$, $OP_{it}(I_{it})^2$: Trade intensity is interacted with a country's income per capita.

OP_{it} FDI_{it}: Trade intensity is interacted with a country's FDI for capture the Pollution Haven effect. The differences in environmental policy among countries are a source of comparative advantage. When trade is liberalized, the developed countries with the strict environmental regulations replace the most polluting-intensive industries to the development countries with the environmental regulations, therefore, the production of such industries increase in the developed countries. The other part, the developed countries for the world market access exports of such industries to other countries, thus transport costs increase in the world. Therefore, the pollution haven effect causes the more pollution in the world.

4.1. Data Sources

The time period used in the estimations is 1980-2011 across the 8 developed and development countries (Italy, France, Greece, Spain, China, India, Indonesia, Malaysia and Philippines).

Data are obtained from the World Bank's 2012 World Development Indicators' (WDI's) CD-Rom and on-line WDI 2011 (http://publications.worldbank.org/wdi).

5. Empirical Results

We estimate Equation (4) using ifxed and/or random effects of panel for the BOD pollution created by the different industries. The random effects model examines how group and/or time affect error variances. Lagrange-multiplier technique tests for random effects developed by Breusch and Pagan (1980) and as modified by Baltagi and Li (1990). The Breusch-Pagan Lagrange Multiplier is used to detect heteroskedasticity which is an arbitrary function of some set of regressors. The null hypothesis of the one-way random group effect model is that variances of groups are zero. If the null hypothesis is not rejected, the pooled regression model is appropriate.

The fixed effects regression model estimated invokes the ordinary least squares (OLS) estimator for point and interval estimates under the classical assumptions that the error process is independently and identically distributed. The error process may be homoskedastic within cross-sectional units, but its variance may differ across units: a condition known as groupwise heteroskedasticity. We need to calculate a modified Wald statistic for groupwise heteroskedasticity in the residuals of a fixed-effect regression model.

Greene's discussion of Lagrange multiplier, likelihood ratio, and standard Wald test statistics points out that these statistics are sensitive to the assumption of normality of the errors. The modified Wald statistic computed here is viable when the assumption of normality is violated, at least in asymptotic terms.

Levin, Lin & Chu and Im Pesaran and Shin W-stat tests show unit-root process. The null hypothesis is that the variable contains a unit root, and the alternative is that the variable was generated by a stationary process. We may optionally exclude the constant, include a trend term, and include lagged values of the difference of the variable in the regression (Table 1).

We calculate the different elasticises for examination of trade liberalization effect on environmental quality. Tables 2-17 display the results for the model and the relevant statistics, including the selected products. Based on the results reported, the significant and positive coefficient of $OP_{it}KL_{it}$ shows that the selected countries have totally comparative advantage in the chemical and other industry production and exports, the implication is that trade may be liberalized.

According to results, the significant and negative coefficient of $GDPPC_{it}$ shows a rise in trade causes a decrease in products of chemical, clay and glass, food, metal, paper and pulp, textile, wood and other industries in the sampling countries. Additionally, the results reported indicated that the countries are not involved in dirty industries because the coefficient of KL_{it} is significantly negative. Therefore, as trade raises the industries' products in our sampling countries decrease.

The coefficient of I_{it-1} has been estimated significantly and negatively, that is, the technology progress in the metal and wood industries lessen the region's BOD emission.

A relocation of polluting industries from EU countries with strict environmental policy to Asian countries with less stringent policy raises the world BOD pollution per capital created by the different industries. The sign of the coefficients $OP_{it}FDI_{it}$ is significant and positive; therefore the hypothesis of pollution haven effect is accepted in the selected EU-Asian countries.

In addition, trade liberalization has a negative impact on the BOD emission crated by chemical, food, metal, paper and pulp, textile, wood and other industries while has a positive impact on BOD pollution crated by clay and glass industry (See estimates reported by the tables).

5. Conclusion

This paper has evaluated the literature on the links between environmental policy and international trade. The main goal of this study was to test the validity of the pollution haven effect of water created by the different industries in the selected EU- Asia countries. Due to differences in environmental policy among countries that increase the trade and FDI in the world, this research has took into account the interaction between trade and FDI as an indicator to test the pollution haven effect. We know that when the developed countries displace the polluting-intensive industries factories to the developing countries then the production of the polluting-intensive industries increases in these countries, leading totally the global pollution to increase.

The statistically significant positive coefficient associated to the interaction between trade intensity and FDI has also indicated that the hypothesis of the pollution haven effect on water by the different industries, defined as a tree-digit group in ISIC classification, has been accepted for the selected EU-Asian countries.

Overall, our results showed that trade liberalization has decrease the BOD emission crated by chemical, food, metal, paper and pulp, textile, wood and other industries, but it has increased such emission crated by clay and glass industries in the EU-Asian countries.

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Table 1: Results of Panel Unit Root Tests for the Model Variables

Variables	Levin, Lin & Chu- Test		Im, Pesaran and Shin W-stat -Test	
	Statistic	Prob.	Statistic	Prob.
BOD per capital in chemical industry	-4.77349	0.0000	-3.84810	0.0000
BOD per capital in clay and glass industry	-3.59624	0.0002	-6.66326	0.0000
BOD per capital in food industry	-4.01180	0.0000	-3.58896	0.0000
BOD per capital in metal industry	-6.47739	0.0000	-7.35282	0.0000
BOD per capital in paper and pulp industry	-8.10948	0.0000	-7.81576	0.0000
BOD per capital in textile industry	-7.71577	0.0000	-8.27169	0.0000
BOD per capital in wood industry	-4.57411	0.0000	-6.60998	0.0000
BOD per capital in other manufacturing industry	-3.72814	0.0001	-4.60123	0.0000
$GDPC_{it}$	-4.41737	0.0000	-5.71341	0.0001
I_{t-1}	-6.60943	0.0000	-8.00896	0.0000
I^2_{t-1}	-5.58246	0.0000	-7.23777	0.0000
KL_{it}	-3.58957	0.0002	-5.32614	0.0000
KL^2_{it}	-7.85527	0.0001	-9.90992	0.0003
OP_{it}	-3.56699	0.0000	-5.01448	0.0002
$OP_{it}KL_{it}$	-2.20945	0.0000	--3.72641	0.0000
$OP_{it}\,(KL_{it})^2$	-7.57166	0.0000	-9.65661	0.0000
$OP_{it}I_{it}$	-7.82695	0.0000	-9.98544	0.0000
$OP_{it}\,(I_{it})^2$	-5.80449	0.0000	-7.73786	0.0000
$OP_{it}\,FDI_{it}$	-5.60545	0.0000	-10.4410	0.0000

Source: Author

Table 2: Determinants of BOD Emission Per Capita Created by Chemical Industries

Variables	Random Effect		Fixed Effect	
C	7.53	(0.84)	3.20	(2.65)
$GDPPC$	-6.40*	(-5.74)	-6.95*	(-2.88)
KL_{it}	2.68	(0.29)	-1.41	(-1.90)
$(KL_{it})^2$	8.90*	(5.02)	6.86*	(3.92)
I_{it-1}	-7.82	(-0.51)	-3.74	(-0.16)
$(I_{it-1})^2$	4.80	(0.11)	4.92	(0.23)
OP_{it}	-3.86**	(-2.74)	-2.99	(0.23)
$OP_{it}KL_{it}$	3.32*	(3.01)	2.91**	(3.05)
$OP_{it}\,(KL_{it})^2$	-9.76*	(-5.04)	-6.60*	(-3.33)
$OP_{it}I_{it}$	2.08	(0.91)	1.99	(1.35)
$OP_{it}\,(I_{it})^2$	-1.66	(-0.27)	-2.24	(-0.99)
$OP_{it}\,FDI_{it}$	7.89**	(2.27)	6.80**	(1.73)
R^2	0.7558		0.7209	
Groups	9		9	
Number of observations	286		286	
Breusch and Pagan LM test			229.89	
Prob. > chi2			0.0000	
Modified Wald Test for group-wise Heteroskedasticity			3.1	
Prob. > chi2			0.0000	
Hausman Test	90.67			
Prob. > chi2	0.0000			

***Source*:** Author

Note: T-statistics are shown in parentheses. Significance at the 99%, 95% and 90% confidence levels are indicated by * , **and ***, respectively.

Table 3: Values of Triple Elasticities in Chemical Industries

Scale elasticity	-1.089
Technique elasticity	-0.283
Composition elasticity	0.265
Total effect	-1.107

***Source*:** Author

Table 4: Determinants of BOD Emission Per Capita Created by Clay and Glass Industries

Variables	Random Effect		Fixed Effect	
C	2.54	(0.45)	2.45**	(2.16)
GDPPCit	-2.84	(-0.41)	-3.24*	(-3.01)
KLit	-2.20	(-0.38)	-2.01*	(-3.52)
(KLit)2	6.21*	(5.62)	5.17*	(5.35)
Iit-1	-1.99**	(-2.09)	1.85	(0.90)
(Iit-1)2	2.63	(0.99)	-1.17	(-0.58)
OPit	-1.71***	(-1.95)	-1.07	(-0.95)
OPitKLit	1.32***	(1.92)	1.18 ***	(1.99)
OPit (KLit)2	-4.78*	(-3.96)	-2.59**	(-2.47)
OPitIit	5.19*	(3.63)	2.91	(1.79)
OPit (Iit)2	-7.14***	(-1.88)	-4.08	(-1.64)
OPit FDIit	4.03***	(1.86)	4.67**	(2.23)
R^2 *(overall)*	0.9241		0.9524	
Groups	9		9	
Number of observations	286		286	
Breusch and Pagan LM test	253.94			
Prob. > chi2	0.0000			
Modified Wald Test for group-wise Heteroskedasticity			8.9	
Prob. > chi2			0.0000	
Hausman Test	78.56			
Prob. > chi2	0.0000			

Source: Author

Note: T-statistics are shown in parentheses. Significance at the 99%, 95% and 90% confidence levels are indicated by * , **and ***, respectively.

Table 5: Values of Triple Elasticities in Clay and Glass Industries

Scale elasticity	0.692
Technique elasticity	-0.100
Composition elasticity	0.220
Total effect	0.812

Source: Author

Table 6: Determinants of BOD Emission Per Capita Created by Food Industries

Variables	Random Effect		Fixed Effect	
C	4.62	(0.52)	3.58**	(-2.77)
$GDPPC_{it}$	-3.73*	(-3.39)	-5.33**	(-2.67)
KL_{it}	-7.38	(-0.01)	-2.76*	(-3.30)
$(KL_{it})^2$	9.73*	(5.55)	7.36*	(4.60)
I_{it-1}	-2.33	(-1.55)	2.61	(0.99)
$(I_{it-1})^2$	2.77	(0.66)	-1.86	(-0.72)
OP_{it}	-2.81**	(-2.02)	-2.53**	(2.28)
$OP_{it}KL_{it}$	2.69**	(2.46)	2.43**	(2.65)
$OP_{it}\,(KL_{it})^2$	-9.29*	(-4.85)	-5.26*	(-2.99)
$OP_{it}I_{it}$	6.09**	(2.69)	4.01***	(1.96)
$OP_{it}\,(I_{it})^2$	-7.80	(-1.29)	-5.30	(-1.68)
$OP_{it}\,FDI_{it}$	7.84**	(2.28)	8.20**	(2.20)
R^2	0.8253		0.9114	
Groups	9		9	
Number of observations	286		286	
Breusch and Pagan LM tes	389.05			
Prob. > chi2	0.0000			
Modified Wald Test for group-wise Heteroskedasticity			1.6	
Prob. > chi2			0.0000	
Hausman Test	93.13			
Prob. > chi2	0.0000			

***Source*:** Authors

Note: T-statistics are shown in parentheses. Significance at the 99%, 95% and 90% confidence levels are indicated by * , **and ***, respectively.

Table 7: Values of Triple Elasticities in Food Industries

Scale elasticity	-0.568
Technique elasticity	0.592
Composition elasticity	-1.709
Total effect	-1.685

***Source*:** Author

Table 8: Determinants of BOD Emission Per Capita Created by Metal Industries

Variables	Random Effect		Fixed Effect	
C	4.94	(0.17)	1.96**	(2.94)
$GDPPC_{it}$	-9.70**	(-2.69)	-4.07*	(-4.45)
KL_{it}	2.68	(0.89)	-3.92	(-1.18)
$(KL_{it})^2$	2.00**	(3.49)	2.20*	(3.75)
I_{it-1}	-1.30*	(-2.64)	-7.59	(-0.75)
$(I_{it-1})^2$	1.88	(1.36)	7.43	(0.51)
OP_{it}	-8.99**	(-1.98)	-2.85	(-0.84)
$OP_{it}KL_{it}$	4.07	(1.14)	4.33	(1.36)
$OP_{it}\,(KL_{it})^2$	-1.39**	(-2.23)	-1.09***	(-1.82)
$OP_{it}I_{it}$	3.36	(4.53)	4.48	(0.68)
$OP_{it}\,(I_{it})^2$	-4.85	(-2.46)	-4.83	(-0.48)
$OP_{it}\,FDI_{it}$	2.41**	(2.15)	3.04**	(2.52)
R^2	0.9641		0.9049	
Groups	9		9	
Number of observations	286		286	
Breusch and Pagan LM test(3)	19.57		44.48	
Prob. > chi2	0.0000		0.0000	
Modified Wald Test for group-wise Heteroskedasticity			1.6	
Prob. > chi2			0.0000	
Hausman Test	70.36			
Prob. > chi2	0.0000			

***Source*:** Authors

Note: T-statistics are shown in parentheses. Significance at the 99%, 95% and 90% confidence levels are indicated by * , **and ***, respectively.

Table 9: Values of Triple Elasticities in Metal Industries

Scale elasticity	-1.116
Technique elasticity	-0.443
Composition elasticity	-0.624
Total effect	-2.183

***Source*:** Author

Table 10: Determinants of BOD Emission Per Capita Created by Paper and Pulp Industries

Variables	Random Effect		Fixed Effect	
C	7.51	(0.37)	1.13**	(2.41)
GDPPCit	1.18*	(4.70)	-1.28**	(-2.97)
KLit	-3.01	(-1.43)	-1.06*	(-3.70)
(KLit)2	2.13*	(5.34)	2.40*	(5.62)
Iit-1	-4.82	(-1.41)	7.43	(1.14)
(Iit-1)2	6.10	(0.63)	-4.93	(-0.52)
OPit	-4.31	(-1.36)	-1.85	(-0.40)
OPitKLit	2.50	(1.01)	3.78	(1.27)
OPit $(KLit)^2$	-1.12*	(-2.57)	-9.81**	(-2.16)
OPitIit	1.29**	(2.50)	1.05	(-1.15)
OPit $(Iit)^2$	-1.73	(-1.26)	-1.48	(1.23)
OPit FDIi	8.36	(1.07)	1.78**	(2.30)
R^2	0.9779		0.9642	
Groups	9		9	
Number of observations	286		286	
Breusch and Pagan LM test	39.79			
Prob. > chi2	0.0000			
Modified Wald Test for group-wise Heteroskedasticity(4)			3.1	
Prob > chi2			0.0000	
Hausman Test	81.90			
Prob. > chi2	0.0000			

***Source*:** Authors

Note: T-statistics are shown in parentheses. Significance at the 99%, 95% and 90% confidence levels are indicated by * , **and ***, respectively.

Table 11: Values of Triple Elasticities in Paper and Pulp

Scale elasticity	-0.403
Technique elasticity	0.498
Composition elasticity	-1.940
Total effect	-1.845

Source: Author

Table 12: Determinants of BOD Emission per Capita Created by Textile Industries

Variables	Random Effect		Fixed Effect	
C	7.52	(0.37)	1.10*	(2.40)
$GDPPC_{it}$	1.20*	(4.81)	-1.17*	(-2.78)
KL_{it}	-2.96	(-1.42)	-1.06*	(-3.78)
$(KL_{it})^2$	2.13*	(5.36)	2.36*	(5.65)
I_{it-1}	-4.90	(-1.44)	7.47	(1.18)
$(I_{it-1})^2$	6.21	(0.65)	-4.84	(-0.52)
OP_{it}	-4.37	(-1.38)	-1.75	(-1.38)
$OP_{it}KL_{it}$	2.48	(1.00)	3.68	(1.27)
$OP_{it}(KL_{it})^2$	-1.13**	(-2.60)	-9.45**	(-2.59)
$OP_{it}I_{it}$	1.30**	(2.53)	1.08	(1.27)
$OP_{it}(I_{it})^2$	-1.75	(-1.28)	-1.54	(-1.19)
$OP_{it}FDI_{it}$	8.48	(1.09)	1.76**	(2.32)
R^2	0.9756		0.9690	
Groups	9		9	
Number of observations	286		286	
Breusch and Pagan LM test	53.05			
Prob. > chi2	0.0000			
Modified Wald Test for group-wise Heteroskedasticity			3.0	
Prob. > chi2			0.0000	
Hausman Test	88.03			
Prob. > chi2	0.0000			

***Source*:** Author

Note: T-statistics are shown in parentheses. Significance at the 99%, 95% and 90% confidence levels are indicated by * , **and ***, respectively.

Table 13: Values of Triple Elasticities in Textile Industries

Scale elasticity	-0.365
Technique elasticity	0.498
Composition elasticity	-1.920
Total effect	-1.787

***Source*:** Authors

Table 14: Determinants of BOD Emission per Capita Created by Wood Industries

Variables	Random Effect		Fixed Effect	
C	4.76	(0.16)	1.95**	(2.67)
$GDPPC_{it}$	-9.24**	(-2.57)	-3.99*	(-5.98)
KL_{it}	2.65	(0.88)	-3.96	(-0.89)
$(KL_{it})^2$	1.99*	(3.48)	2.18*	(3.29)
I_{it-1}	-1.30**	(-2.65)	-7.72	(-0.76)
$(I_{it-1})^2$	1.88	(1.36)	7.59	(0.52)
OP_{it}	-8.95**	(-1.97)	-2.92	(-0.41)
$OP_{it}KL_{it}$	4.03	(1.13)	4.30	(0.93)
$OP_{it}\,(KL_{it})^2$	-1.38**	(-2.21)	-1.08	(-1.53)
$OP_{it}I_{it}$	4.64*	(4.54)	4.64	(0.70)
$OP_{it}\,(I_{it})^2$	-4.86**	(-2.47)	-5.08	(-0.50)
$OP_{it}\,FDI_{it}$	2.44**	(2.17)	3.06**	(2.54)
R^2	0.8809		0.4994	
Groups	9		9	
Number of observations	286		286	
Breusch and Pagan LM test(3)	19.64			
Prob. > chi2	0.0000			
Modified Wald Test for group-wise			1.5	
Heteroskedasticity			0.0000	
Prob. > chi2				
Hausman Test	60.53			
Prob. > chi2	0.0000			

***Source*:** Author

Note: T-statistics are shown in parentheses. Significance at the 99%, 95% and 90% confidence levels are indicated by * , **and ***, respectively.

Table 15: Values of Triple Elasticities in Wood Industries

Scale elasticity	-0.253
Technique elasticity	-0.756
Composition elasticity	0.421
Total effect	-0.588

***Source*:** Authors

Table 16: Determinants of BOD Emission Per Capita Created by Other Industries

Variables	Random Effect		Fixed Effect	
C	9.26	(0.34)	1.06**	(2.18)
$GDPPC_{it}$	3.79	(0.11)	-7.79**	(2.17)
KL_{it}	-1.64	(-0.57)	-1.18*	(-3.95)
$(KL_{it})^2$	3.17*	(5.85)	2.38*	(5.39)
I_{it-1}	-1.48*	(-3.19)	1.47	(-1.75)
$(I_{it-1})^2$	2.06	(1.58)	-9.12	(-0.93)
OP_{it}	-6.27	(-1.46)	-6.47	(-1.35)
$OP_{it}KL_{it}$	6.15***	(1.83)	5.52***	(1.80)
$OP_{it}\,(KL_{it})^2$	-2.48*	(-4.20)	-1.08**	(-2.30)
$OP_{it}I_{it}$	3.80*	(5.43)	2.25**	(2.04)
$OP_{it}\,(I_{it})^2$	-5.43**	(-2.92)	-3.22***	(-1.90)
$OP_{it}\,FDI_{it}$	1.89	(1.78)	2.23**	(2.78)
R^2 *(overall)*	0.9091		0.4377	
Groups	9		9	
Number of observations	286		286	
Breusch and Pagan LM test	364.88			
Prob. > chi2	0.0000			
Modified Wald Test for group-wise			3.9	
Heteroskedasticity			0.0000	
Prob. > chi2				
Hausman Test	79.98			
Prob. > chi2	0.0000			

***Source*:** Author

Note: T-statistics are shown in parentheses. Significance at the 99%, 95% and 90% confidence levels are indicated by * , **and ***, respectively.

Table 17: Values of Triple Elasticities in Other Industries

Scale elasticity	0.009
Technique elasticity	-0.733
Composition elasticity	-0.222
Total effect	-0.946

***Source*:** Author