The Relationship between Foreign Direct Investment and Environmental Pollution in Developing Countries: Evidence from simultaneous equations estimation

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Abstract

This study aimed at measuring the impact of Foreign Direct Investment (FDI) on four pollutant emissions in developing countries. To achieve this goal, the researcher used the unbalanced panel data of 73 developing countries, representing different regions and income levels, during the time period 1990 – 2016 with a total number of 1641 observations.

Following the steps of Copeland and Taylor (2003) and Bao, Chen and Song (2011), an econometric model of six simultaneous equations was designed and the 3 SLS method was applied to estimate the scale, technique and composition effects of Foreign Direct Investment on pollutant emissions in the countries under study.

According to the study results, Foreign Direct Investment reduces carbon emissions through encouraging the adoption of less polluting modern techniques and speeding up structural economic changes in developing countries. However, its positive effect through increasing the scale of the economy clearly outweighs its other two negative effects. Briefly, Foreign Direct Investment has a positive total effect on carbon emissions due to its large scale effect. On the other hand, the negative FDI technique and composition effects on the rest of the pollutants by far exceed the corresponding FDI positive scale effect. Hence, the total FDI effect varies according to the kind of pollutant under consideration.

Key words: Foreign Direct Investment, Environmental Pollution, Carbon Emissions, The Simultaneous Equations System, Developing Countries, The Scale Effect, The Technique Effect, The Composition Effect, The Three-Stages Least Squares (3SLS) Method, The Two-Stages Least Squares (2SLS) Method.

1. Introduction

Foreign direct investment is an instrument for filling the gap between local investment and local saving both in developing and developed countries. *(Ganioglu and Cihan, 2015)*. In fact, foreign direct investment is considered one of the main pillars for achieving economic growth; it also plays a major role in transforming developing countries, especially through establishing modern industries, increasing the production capacity, creating job opportunities, promoting trade and enhancing the technological capacity of the economy.

Moreover, we note a mutual relationship between environment and foreign direct investment inflows. One way of this relationship represents the impact of the environment on FDI inflows, as environmental regulations aiming at fighting environment degradation may deter FDI from operating in countries or regions subject to such strict regulations. Hence, the study of *Cole, M. A. et al., 2017* confirms that FDI moves from the economies imposing strict environment regulations to the economies where environment regulations are more relaxed. In this case, FDI is influenced by environmental conditions.

In the opposite direction, FDI may have either a negative or positive impact on environment. A negative impact occurs when a polluting industry is established in the host country; and when foreign companies choose to outsource their polluting operations through using the services of local companies.

A positive impact occurs when foreign companies using modern production techniques crowd out of the market local companies using more polluting methods. These later companies are then obliged to adopt more environment friendly techniques to be able to cope with the existence of foreign companies *(Moosa, I. A., 2019).*

Theoretically speaking, the impact of FDI on the environment can be disintegrated into three effects: The scale effect, the composition effect and the technique effect. The scale effect means that by increasing local production through using a bigger amount of resources, FDI leads to a greater amount of polluting missions. The composition effect points out to the fact that FDI may change the industrial structure of the host country through changing the composition of production factors; such as increasing the capital/labor ratio, for example, depending on the relative intensity of FDI components. The change in factor composition may in turn affect pollution levels. For instance, capital-intensive industries usually cause a greater amount of pollutant emissions in comparison to more labor-intensive industries. The technique effect underlines the fact that foreign companies may bring in more environment friendly techniques to the host country, thus mitigating production polluting emissions; in addition to positive indirect effects resulting from the adoption of cleaner technologies by the foreign companies. Furthermore, while the establishment of foreign companies in the host country leads to the improvement of the production capacity of local companies, whether through competition or cooperation, it may also have a positive impact on the quality of environment through a more efficient use of production resources and hence, the reduction of the pollution level *(Bao, Q. and Song, L., 2011).*

In other words, FDI may have a positive impact on the pollution level in host countries as demonstrated in the Pollution Haven Hypothesis (PHH). However, this kind of impact may depend on the economic conditions prevailing in the host countries *(Zheng, J. and Sheng P., 2016).*

The impact of FDI on the environment is actually a controversial issue since FDI may have different influences on environmental performance. On one hand, FDI may have a positive impact on environmental performance through advancing technologies, improving management capabilities and enhancing the quality of environment in host countries. Hence, an increase in FDI leads to an increase in capital accumulation and productivity which implies an improvement in the technological level as well as an increase in technological innovations and invention patents, thus reducing local environmental pollution and improving environmental performance. On the other hand, FDI may have a negative impact on environmental performance and lead to environment degradation through moving polluting industries to host countries *.(Li, Z. et al., 2019).*

Our question now is the following: Has the increasing movement of capital transfer associated with global liberalization, the abolition of restrictions and privatization under the so-called New Liberal International Order, been effectively contributing to intensifying the problems of higher levels of polluting emissions, ozone depletion, water sources' pollution, and the creation of economic bubbles leading to excessive consumption and environment impairment in developing countries? Or is the technique effect the overwhelming factor so that increasing FDI inflows has a positive impact on the quality of the environment, i.e. a negative impact on the pollution level?.

Using panel data, the present study investigates the relationship between FDI and environmental pollution in developing countries during the time period 1990 – 2016. The following structure has been adopted: Section 2 of this paper discusses the evolution of relevant previous studies. Section 3 describes the study model and variables. In section 4 the econometric analysis and its empirical results are presented. Section 5 discusses the results and deductions and presents recommendations for future studies.

2. Previous studies

All countries around the World, of different income levels, increasingly compete to improve their investment climate and attract larger amounts of FDI, as a crucial way of backing up the national economy especially in terms of technical assistance and transfer of technology. However, for the last three decades, the World has been increasingly concerned with the issue of the green growth economy and sustainable economic development. Previous research indicates that FDI may have negative effects on the environment in the host country. This issue has been debated for many years in the relevant literature, whereas most applied studies confirmed that FDI had a strong positive impact on environment degradation, whether the analysis included only one country or several countries, and whether panel data or time series were used.

The present study chose to investigate the FDI-pollution relationship from several perspectives in order to reach more conclusive results. An extensive econometric model was designed to analyze the impact of FDI inflows on four pollutant emissions. The FDI scale, technique and composition effects were estimated regarding each kind of pollutant emissions while taking account of both the direct and indirect components of each effect. Furthermore, the analysis also covered two other important factors: The pollution feedback effect and the determinants of FDI.

2.1. Previous studies using panel data

Zomorrodi & Zhou (2017) analyzed the impact of FDI on environment degradation through dividing the Chinese counties into four economic regions: The eastern, the central, the western and the eastern-north regions. The results revealed a significant and positive, yet weak, relationship between FDI and sulfur dioxide emissions. At the macro-economic level, that study rejected the existence of a correlation between FDI and water pollutant emissions. According to the cross-regional analysis of panel data, FDI contributed only to water pollutant emissions in the eastern region, while FDI led to increasing both wastewater and sulfur in the central, east-northern and western regions.

On the other hand, other studies proved the existence of a negative relationship between FDI and environmental degradation. For instance, Bao and Song (2011) investigated the impact of FDI on five pollutants in China depending on the panel data of 29 counties during the time period 1992 – 2004. The study used a simultaneous equations model to estimate the scale, technique and composition effects of FDI on total and regional pollutant emissions in China. Results showed that generally speaking, FDI contributed to the reduction of pollutant emissions in China, due to the importance of the technique effect. However, the study also underlined the great differences in FDI impact between different Chinese regions and with respect to different pollutants.

Gharmit et al. (2019) explored the relationship between FDI inflows and carbon dioxide emissions in order to verify the validity of the Pollution Haven Hypothesis in 54 African countries during the time period 1960 – 2018. The researchers used panel data and a co-integration analysis and applied the dynamic ordinary least squares (DOLS) and the fully modified ordinary least squares (FMOLS) methods. They found a positive causal relationship between FDI inflows and carbon emissions in the long run. Moreover, according to the Granger-Engle causality test a positive causal relationship existed between FDI inflows and carbon emissions both in the short run and the long run. Their findings thus confirmed the valid application of the Pollution Haven Hypothesis to the African countries. However, they concluded that those countries should continue to attract FDI while adopting strict environmental policies, establishing procedures and using devices in view of to mitigating carbon dioxide emissions.

Zheng and Sheng (2016) researched the impact of FDI inflows on carbon dioxide emissions in China during the market-oriented reform. They reached the following conclusions: First, FDI inflows directly increase carbon dioxide emissions in

China. Second: Along with the market-oriented reform, this positive impact of FDI inflows is decreasing year after year. In other words, the market-oriented reform in China can alleviate the positive effect of FDI inflows on carbon dioxide emissions. Third: Given that the market-oriented reform in China has been gradually implemented starting from experimental regions then expanding to the whole country, different regions have been unevenly market developed. Therefore, the effect of FDI inflows on carbon dioxide emissions has varied from one county to another. The eastern region, in general, has been more market oriented, and the impact of FDI inflows on carbon dioxide emissions was found lower in that region. Four counties in the western region were less market-oriented, and the impact of FDI inflows on carbon dioxide emissions was found greater in those counties.

Those empirical results may not be conclusive since other studies (although only a few) found that FDI had no impact on environmental performance. For example LI, Z. et al. (2019) explored the influence of FDI on environmental performance via building a quantitative regression model using the panel data of a group of 40 developed and developing countries during the time period 1990 – 2014. The directional slack-based model applied in that study revealed the following results: First, FDI had an insignificant effect on the environmental performance of the group of countries under study as a whole. Second: FDI had a significant positive effect on the environmental performance of the developed countries; whereas the FDI effect on environmental performance was found statistically insignificant in developing countries.

Other studies insisted that FDI led to increasing environmental degradation. Thus, Moosa (2019) proved that the hypothesis of the environmental Kuznets curve was applicable to his chosen group of MENA counties.

Yet other studies investigated the influence of FDI from the PHH perspective. Wagner and Timmins (2008) concluded that environmental regulations reduced the international competiveness of pollution-intensive industries, obliging them to move to countries with less restrictive regulations, thus turning those countries into pollution havens. The researchers tested the validity of the Pollution Haven Hypothesis using the panel data of FDI outflows from diverse German Industries. Meanwhile, Zwerg and V.L.C.A. (2008) revealed the existence of an inverted U-shaped relationship between capital movements and rising income levels, on one hand, and pollution on the other hand, provided that increasing pollution taxes were levied to keep up with capital movements and economic growth. This result can be explained by the fact that, in a flourishing economy, heavy taxes incentivize the producers who are realizing maximum profits to adopt cleaner technologies or to exploit cleaner sectors of production.

2.2. Previous studies using time series analysis

Studies investigating the relationship between FDI and environmental performance at the level of a single economy reached similar conclusions.

Hitam (2012) studied the main benefits and costs of FDI in Malaysia, measured by the increase of the gross domestic product (GDP) and the increase of the environmental degradation respectively, during the time period 1965 – 2010. The results of the non-linear study model showed the applicability of the environmental Kuznets curve and confirmed that FDI inflows increased environmental degradation.

The huge size of the Indian economy and its status as one of the World main sources of carbon emissions were inducing factors for studying the determinants of environmental degradation in India. Adamu et al. (2019) analyzed the impact of energy consumption, diversification of exports and FDI on environmental degradation in India, within the hypothesis of Kuznets' environmental curve. A long run relationship was detected between the study variables, based on the co-integration test. Long run estimations were obtained using both the co-integration and the dynamic ordinary least squares (DOLS) analysis. The study results also revealed a positive relationship between energy consumption, diversification of exports, FDI and income levels on one hand and environmental degradation on the other hand. Kuznets' curve was found inapplicable in India. Moreover the applied causality tests underscored a one-way causal influence from income levels and FDI inflows on environmental degradation; as well as a two-way relationship between energy consumption and environmental degradation and also between exports' diversification and environmental degradation in the long run. Those causal relationships in, found the short run and the long run, underscore that India should give up economic growth in the short run in view of improving the quality of environment and reducing carbon emissions.

Sharma (2019) showed that increasing FDI inflows led to increasing expenditure on pollution control equipment at the level of the productive unit.

Sasana et al. (2018) found a significant positive impact of FDI inflows on carbon dioxide emissions in Indonesia.

3. Model specification and data sources

Based on the studies of Copeland and Taylor (2003) and Bao, Chen and Song (2011), The impact of FDI on the environmental performance was decomposed into three effects:

i. The scale effect is measured by the gross domestic product (GDP) index, as commonly practiced by other studies.

ii. The composition effect: The present study adopts the ratio of the industrial output to the domestic product as a measure of the pollution effect resulting from the change in industrial composition.

iii. The technique effect: Following Copeland and Taylor (2003) and Bao, Chen and Song (2011), the ratio of the total pollutant emissions to the industrial output is adopted as a measure of the technique effect. This index expresses pollution intensity per unit of industrial output.

All used data[1] are obtained from the World Bank Indicators (WDI) and the International Financial Statistics (IFS), the researcher used the unbalanced panel data of 73 developing countries (Argentina, Jordan, Bahrain, Brazil, Czech Republic, Slovakia, Senegal, Sudan, China, Iraq, Philippines, Kuwait, Morocco, Mexico, Saudi Arabia, India, Estonia, Israel, Ecuador, Indonesia, Armenia, Angola, Uruguay, Ukraine, Paraguay, Brunei Darussalam, Bulgaria, Panama, Botswana, Bolivia, Peru, Thailand, Turkey, Trinidad and Tobago, Tanzania, Togo, Tunisia, Jamaica, Iran , Kyrgyzstan, Egypt, South Africa, Romania, Zambia, Sri Lanka, Slovenia, Chile, Serbia, Tajikistan, Gabon, Guatemala, Venezuela, Cyprus, Qatar, Kazakhstan, Croatia, Côte d'Ivoire, Costa Rica, Colombia, Kenya, Latvia, Lithuania, Malta, Malaysia, Mongolia, Mauritius, Mozambique, Moldova, Namibia. Nigeria, Nicaragua, Honduras, Hungary) , representing different regions and income levels, during the time period 1990 – 2016 with a total number of 1641 observations.

According to the study of Copeland and Taylor (2003), the technique effect is influenced not only by the pollution tax rate but also by other factors such as technological progress, and research and development expenditure in the field of environment protection. Therefore pollution per unit of industrial output may be a more adequate direct measure of the technique effect. However, as that index was not available for

[1] CO2 emissions (kt), Nitrous oxide emissions (thousands of metric tons of carbon dioxide equivalent), Methane emissions (ktCO2e), Other GHG emissions, HFCs, PFCs, and SF6 (thousand metric tons of CO2-equivalent), HFC gas emissions (thousand metric tons of carbon dioxide equivalent), PFC gas emissions (thousand metric tons of carbon dioxide equivalent), Sulfur hexafluoride emissions (thousand metric tons of carbon dioxide equivalent), GDP (constant 2010 US dollars), CO2 emissions (kg per US$ of GDP in 2010 value), Industry, value added (% of GDP), Foreign direct investment, net inflows (balance of payments, in current US dollars), Capital stock at constant 2017 national prices (in mil. 2017US$),accumulation of human capital, workforce(, total), TFP at constant national prices (2017=1), Population density, GDP per capita (constant 2010 US dollars), The level of physical capital for each worker, GDP growth (per year), Official exchange rate (local currency to US dollar, average period) .

all the countries under study, the ratio of the pollutant emissions per each dollar of the gross domestic product was used instead of the above-mentioned index, to express pollution intensity per each dollar of GDP.

The following equation shows the decomposition of the FDI pollution impact into the above-stated three effects:

$$\ln polu_{it} = \ln gdp_{it} + \ln tech_{it} + \ln comp_{it}$$

In order to estimate these three FDI pollution effects, this study depended on the panel data of 73 developing countries chosen from different geographical regions and having different income levels, during the time period 1990 – 2016, with a total of 1641 observations. Countries were chosen based on data availability. Even so, the original model used by Copeland and Taylor (2003) and Bao, Chen and Song (2011) could not be applied due to data restrictions. Moreover, the number of variables used for explaining each effect had to be reduced in some cases as later described.

The present study used five pollution indexes to express four kinds of pollutant emissions, specifically: Carbon dioxide emissions, the damage caused by carbon dioxide emissions, and nitrous oxide, methane gas, deep-buried gases, hydro fluoro carbons (HFCs), per fluoro carbons (PFCs) and sulfur hexa fluoride (SF6) emissions. All the pollution data used in this study were taken from the World Bank Open Data and Pennsylvania's World (pollution data) tables, the tenth edition.

3.1. The scale effect

In order to measure the FDI scale effect on pollution, the influence of FDI on the economy scale is firstly estimated by applying the following equation:

$$\ln gdp_{it} = a_0 + a_1 \ln fdi_{it} + a_2 \ln k_{it} + a_3 \ln l_{it} + a_4 \ln polu_{it} + a_5 \ln h_{it} + \lambda_i + \varepsilon_{it}$$

Where the subscript *it* refers to the country *i at the time t*, λ_i stands for the fixed effects of each country, a_0 is the constant term, and $\mathcal{E}_{it}$ is the error term endowed with the usual characteristics. The scale effect equation indicates that the GDP in any country (gdp_{it}) essentially depends on the stock of material capital (k_{it}); labor inputs (l_{it}) represented by the employment level at the end of the year in each country; the stock of human capital (h_{it}) reflecting the number of study years and the expected returns of education; pollutant emissions (pol_{it}); and the Foreign Direct Investment inflows in each country (fdi_{it}).

The pollutant emissions variable has been introduced in this equation to capture the influence of the environmental pollution feedback on economic growth. The coefficient (a_4) of the pollution variable is expected to be negative here as higher levels of pollution are liable to have a negative impact on economic growth due to the damage entailed by environmental degradation, besides the expenditures required to repair such damage.

In addition to the direct impact of FDI on economic growth, as reflected by the coefficient a_1, FDI may also influence economic growth indirectly through encouraging material capital stock accumulation. In order to take into account FDI impact on capital stock accumulation, the following equation was applied:

$$\ln k_{it} = d_0 + d_1 \ln fdi_{it} + d_2 \ln\left(gdp_{i,t-1} - gdp_{i,t-2}\right) + \varphi_i + \mu_{it}$$

Where μ_{it} is the error term, gdp_{it-1} is the one year-lagged value of GDP, while the coefficient d_2 measures the impact of the macroeconomic climate and economic fluctuations on capital accumulation. The term ϕ_i represents dummy variables which were introduced in the model to account for the fixed fluctuations pertaining to each individual country. Given that FDI is part of the stock of capital in the host countries, the coefficient d_1 reflects how the presence of foreign companies influences the investment decisions of local companies; and more specifically, whether or not does FDI crowd out local investments.

3.2. The technique effect

The next equation describes the FDI technique effect on the pollution level.

$$\ln tech_{it} = b_0 + b_1 \ln tfp_{it} + b_2 \ln fdi_{it} + b_3 \ln dens_{it} + b_4 \ln agdp_{it} + \phi_i + \nu_{it}$$

In this equation, v_{it} is the error term. The technique effect as measured by pollutant emissions per each dollar of GDP depends on several variables:

Firstly, Total factor productivity, as a proxy variable reflecting the continuous technological progress, always striving to develop production techniques that are more energy-saving, more rational in using natural resources and that generate lower levels of pollutant emissions. This variable thus reveals to a great extent the efforts exerted by each country in view of reducing environmental pollution. Total factor productivity was chosen to replace the two indexes used by Bao, Chen and Song (2011): Research and development expenditure on pollution reduction and the number of employees in environmental protection agencies; due to the unavailability of these two indexes at the country level. Obviously, the coefficient b_1 is expected to be negative, since it reflects the efforts spent by host countries to mitigate pollution.

Secondly, Population density ($dens_{it}$) equals the number of inhabitants per square kilometer. Higher population density means that more people will be harmed by pollutant emissions and that greater efforts must be exerted to reduce pollution. Therefore, the coefficient b_3 is also expected to be negative.

Thirdly, GDP per capita ($agdp_{it}$) reveals the stage of economic development achieved by each country and influences the level of pollutant emissions per each dollar of GDP in two ways. Higher GDP per capita means that inhabitants will have a higher demand for a cleaner environment (assuming the environment is an ordinary good). Consequently, the government will be obliged to adopt stricter environmental regulations. Moreover, as a higher GDP per capita indicates a higher level of economic development, increasing resources can be allocated to environmental protection and pollution abatement. Therefore the coefficient b_4 is expected to be negative.

Finally, the last variable in this equation is Foreign Direct Investment *(fdi_{it}).* [2]

3.3. The composition effect

The composition effect of FDI on environmental performance is measured according to the following equation:

$$\ln comp_{it} = c_0 + c_1 lnfdi_{it} + c_2 \ln(\frac{k}{l})_{it} + c_3 \ln agdp_{it} + \psi_i + \upsilon_{it}$$

where v_{it} is the error term. This equation shows that the industrial composition, i.e. the ratio of the industrial output to GDP, is influenced by the following factors: Firstly, FDI *(fdi_{it})* and secondly, material capital per worker. A higher ratio of k/l reflects a higher ratio of industrial output/GDP, and the tendency to generate more pollution. Thirdly, GDP per capita ($agdp_{it}$) has a dual impact of the composition effect. Higher GDP per capita indicates a rapid industrialization process liable to generate more pollution. However, a higher GDP per capita leads to a higher demand for a cleaner environment and environment-friendly products. Thus the final outcome of these two influences is not obvious.

Two indexes used in the study of Bao, Chen and Song (2011) - Research and development expenditure, and the length of railways and roads - were excluded from the present study, due to the lack of data in many cases.

3.4. Determinants of FDI inflows

One of the problems facing the estimation of the econometric model applied in the present study is related to the homogeneity of foreign investment. In other words, FDI inflows may essentially depend on a number of internal factors prevailing in the host country; and these factors influence the expectations of foreign investors in a homogenous way.

[2] Two indexes used in the study of Bao, Chen and Song (2011) namely, the State budget for pollution abatement, and the budget of private funds for pollution abatement - were excluded from the present study due to the unavailability of data for those indexes or their substitutes.

Previous studies - for instance: Cheng and Kwan (2000); Sun et al. (2002); and Gao (2005) - designed the following model to investigate the determinants of FDI inflows.

$$\ln fdi_{it} = \gamma_0 + \gamma_1 \ln fdi_{i,t-1} + \gamma_2 \ln gdpg_{i,t-1} + \gamma_3 \ln ex_{it} + \gamma_4 \ln polu_{i,t-1} + \varpi_i + \eta_{it}$$

where $fdi_{i,t-1}$ refers to the one-year lagged value of Foreign Direct Investment while the coefficient γ_1 measures whether or not there is an influence of FDI self-accumulation. Other standard explanatory variables are also used in this model, as follows: Firstly, the rate of economic growth in the previous time period ($gdpg_{i,t-1}$) depicts the role of extended economic opportunities in attracting FDI to the host country. Secondly, the official exchange rate (ex_{it}) underscores the influence of investment costs on FDI inflows. Finally, this study explores the question: Does the level of pollutant emissions affect the decision of foreign investors concerning whether or not to invest in a particular developing country, as expounded by the Pollution Haven Hypothesis. Therefore, another explanatory variable is added, namely the level of pollutant emission in the previous year ($polu_{i,t-1}$) in order to measure the impact of environmental pollution feedback on the investment options available to foreign companies.

3.5. The econometric methodology

An econometric model of six simultaneous equations was designed to simultaneously estimate the effects of FDI on the level of pollutant emissions in developing countries, as follows:

$$\ln polu_{it} = \ln gdp_{it} + \ln tech_{it} + \ln comp_{it} \quad (1)$$

$$\ln gdp_{it} = a_0 + a_1 \ln fdi_{it} + a_2 \ln k_{it} + a_3 \ln l_{it} + a_4 \ln polu_{it} + a_5 \ln h_{it} + \lambda_i + \varepsilon_{it} \quad (2)$$

$$\ln tech_{it} = b_0 + b_1 \ln tfp_{it} + b_2 \ln fdi_{it} + b_3 \ln dens_{it} + b_4 \ln agdp_{it} + \phi_i + \nu_{it} \quad (3)$$

$$\ln comp_{it} = c_0 + c_1 lnfdi_{it} + c_2 \ln(\frac{k}{l})_{it} + c_3 \ln agdp_{it} + \psi_i + \upsilon_{it} \quad (4)$$

$$\ln k_{it} = d_0 + d_1 \ln fdi_{it} + d_2 \ln(gdp_{i,t-1} - gdp_{i,t-2}) + \varphi_i + \mu_{it} \quad (5)$$

$$\ln fdi_{it} = \gamma_0 + \gamma_1 \ln fdi_{i,t-1} + \gamma_2 \ln gdpg_{i,t-1} + \gamma_3 \ln ex_{it} + \gamma_4 \ln polu_{i,t-1} + \varpi_i + \eta_{it} \quad (6)$$

Equation (1) is the baseline describing the decomposition of FDI impact into the three above-mentioned effects. Equations (2), (3), and (4) represent the scale effect, the technique effect and the composition effect respectively. Equation (5) shows the contribution of FDI to capital accumulation in developing countries. Equation (6) explores the determinants of FDI inflows to the developing countries in order to tackle the related issue of FDI internal homogeneity.

The above-mentioned model thus describes the mechanisms through which incoming foreign companies may affect the level of pollutant emissions in the host developing countries.

Firstly, FDI directly influences pollutant emissions through the three effects as measured by the coefficients a_1 , b_1 , and c_1 , respectively. Secondly, given that pollution intensity and industrial composition are also changing along with economic development, FDI has an indirect impact on pollutant emissions through its effect on the GDP per capita index. This indirect effect is determined using both a_1 and $b_4(c_3)$. Thirdly, FDI has another indirect impact on pollutant emissions through FDI influence on capital accumulation which in turn influences the scale and composition effects. Last, the influence of pollutant emissions feedback on economic growth is taken into account.

4. Empirical results

Since in this model Equation (1) represents the identity of the system, only the five other equations will be estimated, using the ordinary rank and order conditions. It is obvious that Equations (2) to (6) are over-identified. In order to estimate this model, the two-stages least squares (2SLS) method or the three-stages least squares (3SLS) method can be used. It is well known that the second method (3SLS) allows for the correlations between unobserved errors across the different equations and for the restrictions imposed on the coefficients of the different structural equations. Thus the 3SLS method produces a more efficient estimation of the simultaneous equations model by taking account of the correlations between the equations. See: Woodridge (2002).

Therefore, the 3SLS method was chosen for estimating this study model.

4.1. Estimation results on the scale effect

Table (1) displays the estimation results of the scale effect as follows:

Human capital, labor inputs and material capital are all important factors of economic growth; although the role of human capital is more critical than the other two factors. This result is compatible with the common belief that economic growth in developing countries is essentially driven by factor accumulation.

The impact of pollutant emissions feedback on economic growth: Table (1) indicates a positive pollution coefficient of carbon dioxide emissions, their entailed damage and methane emissions; and a negative coefficient of nitrous emissions and deep-buried gases. This is due to the fact that carbon dioxide emissions are related to the expansion of the industrial and the means of transport and communication sectors, while nitrous emissions are related to the expansion of the agricultural sector. Moreover, these first two sectors usually represent the main pillars of economic growth. On the other hand, nitrous emissions and deep-buried gases emissions are generated by natural earth processes or specific industrial processes that are not influential at the macro-economic level. In addition, technological progress has succeeded in alleviating the damage of such industrial processes to a great extent. Concerning pollutant emissions as other inputs, similar to capital and labor -

See: Copeland and Taylor (2003) - empirical results show that the flexibility of pollutant emissions ranges between -0.001 and 0.43

Table (1): Estimation results on the scale effect

	CO_2	CO_2 damage	Nitrous	Methane	greenhouse gases
a_0	15.721 (42.14)***	15.804 (50.31)***	14.587 (30.15)***	14.207 (29.25)***	14.978 (23.24)***
$\ln fdi_{it}$	0.1498 (27.94)***	0.0993 (20.66)***	0.1532 (25.48)***	0.1607 (26.79)***	0.2659 (30.85)***
$\ln k_{it}$	0.1621 (8.172)***	0.0638 (3.593)***	0.2704 (10.90)***	0.2629 (10.49)***	0.1292 (4.695)***
$\ln l_{it}$	0.0107 (0.357)	-0.0868 (-3.38)***	0.2651 (7.501)***	0.2305 (6.454)***	0.2055 (4.538)***
$\ln polu_{it}$	0.3783 (21.91)***	0.4289 (33.35)***	-0.0439 (-3.14)***	0.0439 (2.177)**	-0.0012 (-0.39)***
$\ln h_{it}$	0.3642 (5.272)***	-0.4002 (-6.61)***	0.5642 (5.670)***	0.4846 (4.823)***	0.2435 (2.186)**
Adjusted R^2	%99.1	%99.5	%99.1	%99.1	%98.5
Obs.	1534	1534	1295	1295	993

Note: *Dependent variable is* $\boldsymbol{ln\ gdp_{it}}$. *, **, *** indicate significance at 1%, 5% and 10% respectively.

From Table (1) we further deduce that foreign investment is another engine of economic growth besides the inputs of local factors, as expressed by the large positive value of the coefficient a_1 in the five equations (2) – (6). The elasticity of FDI output ranges from 0.10 to 0.27, thus scoring a lower level than the elasticity of human capital, labor inputs, and material capital, as expected. However, the role of FDI in increasing economic growth in developing countries seems more important when we take account of FDI impact on domestic capital accumulation in the developing countries.

Table (2) shows that the coefficients resulting from the estimation of FDI impact on the stock of capital are ranging from 0.21 to 0.27 which means that an increase of 1% in FDI leads to an increase of 0.21 to 0.27% in the stock of capital. Finally, the direct and indirect impacts of FDI on economic growth are added to obtain the total effect of FDI on economic growth in developing countries as measured by the parameter: $a_1 + d_1 a_2$. So if we take carbon dioxide emissions as an example, FDI total effect on the economy scale will be equal to approximately: 0.1498 + 0.2473 x 0.1621 = 0.1899.

Table (2): Estimation results on the capital accumulation effect

Dependent variable: $\ln k_{it}$

	CO_2	CO_2 damage	Nitrous	Methane	greenhouse gases
a_0	9.1896 (60.65)***	9.4277 (62.03)***	9.9993 (75.13)***	9.9893 (75.27)***	8.6283 (51.57)***
$\ln fdi_{it}$	0.2473 (38.44)***	0.2367 (36.66)***	0.2094 (37.00)***	0.2098 (37.19)***	0.2707 (37.36)***
$\ln(gdp_{i,t-1} - gdp_{i,t-2})$	-1.2211 (-10.9)***	-1.2047 (-10.6)***	-1.0162 (-10.9)***	-1.0180 (-11.0)***	-1.1966 (-10.8)***
Adjusted R^2	%97.6	%97.7	%98.3	%98.3	%98.1
Obs.	1534	1534	1295	1295	993

Note; - *, **, *** indicate significance at 1%, 5% and 10% respectively

4.2. Estimation results on the technique effect

Table (3) shows the estimation results on the technique effect in respect of the five pollutants.

Taking total factor productivity (TFP) as a proxy of technological advancement, all TFP coefficients are found negative indicating that research and development expenditure on pollution reduction, clean technology, and modernizing production techniques and equipment effectively contributes to mitigating pollutant emissions. The population density coefficient is revealed positive and statistically significant for the five pollutants. This finding is compatible with the theoretical assumption advanced by Copeland and Taylor (2003) stating that growing population density increases the marginal damage caused by pollution. Consequently local governments impose stricter environmental regulations.

The coefficient of GDP per capita is largely negative, denoting that the group of developing countries herein examined lies beyond the turning point of the environmental Kuznets curve (EKC).

The technique effect of FDI: All the coefficients of the *fdi* variable are found largely negative ranging from -0.04 to -0.4. This means that an increase of 1% in FDI leads to the reduction of pollutant emissions intensity by a ratio ranging from 0.04% to 0.4 %. This is probably due to the fact that foreign companies adopt environment-friendly techniques or in general, more advanced techniques than those used by local companies, thus contributing to pollution reduction. This result confirms the conclusion reached by Wang and Jin (2002). In addition, foreign companies indirectly influence local companies via incentivizing them to adopt more modern and cleaner production techniques, and to use more efficiently their energy sources and other resources. Such endeavors tend to reduce the intensity of pollutant emissions generated during production

Table (3): Estimation results on the technique effect

Dependent variable: $\ln tech_{it}$

	CO_2	CO_2 damage	Nitrous	Methane	greenhouse gases
b_0	0.6831 (3.023)***	1.0971 (4.888)***	0.9126 (3.244)***	0.6124 (2.176)**	1.4074 (4.418)***
$\ln tfp_{it}$	-0.0614 (-8.34)***	-0.0411 (-5.62)***	-0.0209 (-2.75)***	-0.0345 (-4.52)***	-0.0074 (-0.59)
$\ln fdi_{it}$	-0.0739 (-1.97)**	-0.0387 (-1.05)	-0.3963 (-8.94)***	-0.3872 (-8.73)***	-0.3417 (-6.76)***
$\ln dens_{it}$	0.2433 (6.589)***	0.1758 (4.793)***	0.1239 (2.859)***	0.1648 (3.802)***	0.2184 (3.503)***
$\ln agdp_{it}$	-0.0786 (-2.32)**	-0.1549 (-4.63)***	-0.1684 (-4.14)***	-0.1135 (-2.79)***	-0.2840 (-5.75)***
Adjusted R^2	%94.2	%94.5	%95.8	%95.7	%98.9
Obs.	1534	1534	1295	1295	993

Note; - *, **, *** indicate significance at 1%, 5% and 10% respectively.

4.3. Estimation results on the composition effect

Table (4) displays the estimation results on the composition effect in relation to the five pollutants.

Factor inputs, herein represented by the capital/labor (k/l) ratio, are an important determinant of the industrial composition. The negative coefficient of the k/l variable indicates that a rising k/l ratio decreases the ratio of industrial output to GDP. This unexpected finding may be explained by the fact that industrial sectors in developing countries are generally labor intensive, and consequently they generate lower pollution levels. See: Antweiler et al. (2001).

The impact of GDP per capita is found largely positive. This means that along with the climbing per capita income, the industrial composition evolves towards developing cleaner goods and services or higher value added products.

FDI composition effect is clearly negative. This is another unexpected result. An increase of 1% in FDI leads the reduction of the industrial output share in GDP by a ratio ranging from 0.015 to 0.023%. This finding shows that most FDI companies operate in non-industrial sectors. Hence the contribution of FDI to the promotion of industrial production in developing countries remains an ambiguous issue.

In order to estimate more accurately the impact of FDI on industrial composition, the present study highlights the indirect impact of FDI on industrial composition through FDI effects on the capital to labor ratio and on economic growth. The combined FDI environmental effects are discussed in the following section.

Table (4): Estimation results on the composition effect

Dependent variable: $\boldsymbol{ln\,comp_{it}}$

	CO_2	CO_2 damage	Nitrous	Methane	greenhouse gases
c_0	3.3688 (15.09)***	3.4155 (15.31)***	3.6516 (13.57)***	3.5906 (13.33)***	3.5123 (11.09)***
$ln\,fdi_{it}$	-0.0211 (-3.56)***	-0.0166 (-2.81)***	-0.0199 (-3.42)***	-0.0230 (-3.95)***	-0.0145 (-1.63)
$ln(k/l)_{it}$	-0.0559 (-2.25)**	-0.0497 (-1.99)**	-0.1112 (-3.93)***	-0.1165 (-4.12)***	-0.0619 (-1.77)*
$ln\,agdp_{it}$	0.1154 (3.781)***	0.0911 (2.984)***	0.1567 (4.774)***	0.1779 (5.424)***	0.0940 (2.026)**
Adjusted R^2	%85.1	%85.2	%85.6	%85.6	%84.4
Obs.	1475	1475	1236	1236	956

Note; - *, **, *** indicate significance at 1%, 5% and 10% respectively.

4.4. Estimation results on the determinants of FDI

Table (5) presents the estimation results on the determinants of FDI in developing countries. Generally speaking, the results of the present study agree with the findings of Cheng and Kwan (2000); Sun et al. (2005); and Gao (2005).

Table (5) reveals a self-cumulative FDI effect since the coefficient fdi_{t-1} adopts a remarkable positive value showing that higher FDI values in previous years tend to attract increasing FDI inflows to the developing countries, perhaps due to the influence of geographic concentration of related industries and associated institutions. The positive coefficients of economic growth in the previous time period and of the exchange rate reflect the important role of these two factors in attracting FDI.

Table (5): Estimation results on the determinants of FDI

Dependent variable: $\ln fdi_{it}$

	CO_2	CO_2 damage	Nitrous	Methane	greenhouse gases
γ_0	-5.4172 (-7.95)***	-10.069 (-14.6)***	8.2395 (8.339)***	-1.6187 (-1.33	12.061 (24.67)***
$lnfdi_{i,t-1}$	0.3986 (24.86)***	0.2794 (17.07)***	0.5967 (35.49)***	0.5486 (32.17)***	0.4267 (21.44)***
$\ln gdpg_{i,t-}$	1.5752 (25.35)***	1.1943 (33.14)***	0.0669 (0.800)	1.0116 (9.387)***	0.0725 (4.088)***
$\ln ex_{it}$	0.0291 (8.529)***	0.0304 (9.017)***	0.0290 (7.528)***	0.0311 (8.217)***	0.0144 (3.145)***
$\ln polu_{i,t-}$	0.0557 (3.732)***	0.0280 (2.007)**	0.0804 (4.229)***	0.0969 (5.399)***	0.0900 (4.793)***
Adjusted R^2	%82.9	%83.2	%83.4	%83.5	%83.2
Obs.	1534	1534	1295	1295	993

Note; - **, **, *** indicate significance at 1%, 5% and 10% respectively.*

This analysis is further pursued to investigate whether or not there is a feedback effect of pollutant emissions on FDI, while adopting the Pollution Haven Hypothesis. Developing countries enjoy a comparative advantage in polluting sectors due to their relatively low environmental standards. In the case of most polluting industries, such as cement manufacturing plants, companies in developed countries strive to move their operations to the developing countries where a higher level of pollutant emissions is allowed and where lower pollution tax rates are levied in comparison to the developed countries. In this way, the foreign companies can avoid the need to install

expensive filters or to adopt costly environment friendly production processes, as required in their own countries.
The estimation results of this study support the Pollution Haven Hypothesis to some extent. The lagged coefficients of the four pollutant emissions are found positive and statistically significant. This result confirms the assumption that environmental regulations allowing for much higher levels of pollutant emissions than those imposed in the developed countries effectively incentivize increasing amounts of FDI inflows to move from the developed countries to the developing countries in view of benefitting from lower production costs.
The case of the group of developing countries herein examined arouses an interesting research question as to how important the quality of environment can be for attracting FDI inflows.

4.5. The combined environmental effects of FDI

The estimation results displayed in Tables (1) to (5) are aggregated to measure the combined environmental effects of FDI. Specifically, by simultaneously solving the above-mentioned 6-equations model, the scale effect, the technique effect, the composition effect and the total effect of FDI on pollutant emissions can be obtained as below described:

Total effect: $\frac{\partial \ln polu_{it}}{\partial \ln fdi} = \frac{(b_2+c_1+c_2d_1)+(1+b_4+c_3)(a_1+a_2d_1)}{1-(1+b_4+c_3)a_4}$

Scale effect: $\frac{\partial \ln gdp_{it}}{\partial \ln fdi} = \frac{(b_2+c_1+c_2d_1)a_4+(a_1+a_2d_1)}{1-(1+b_4+c_3)a_4}$

Technique effect: $\frac{\partial \ln tech_{it}}{\partial \ln fdi} = b_2 + \frac{(b_2+c_1+c_2d_1)a_4+(a_1+a_2d_1)}{1-(1+b_4+c_3)a_4} b_4$

Composition effect: $\frac{\partial \ln comp_{it}}{\partial \ln fdi} = \frac{(c_1+c_2d_1)(1+a_4+a_4b_4)+c_3(a_1+a_2d_1)+b_2a_4c_2}{1-(1+b_4+c_3)a_4}$

The total environmental effect of FDI ($\partial \ln polu / \partial \ln fdi$) *can be decomposed as follows:*
The coefficients a_1 , b_2 , *and* c_1 *,measure FDI direct scale, technique and composition effects, respectively. Estimation results show that the scale effect is positive while the technique*

effect and the composition effect are both negative. No doubt foreign investments are expected to have a negative effect on the pollution level through bringing to the developing countries more advanced technologies that save on resource consumption and generate less pollutant emissions. They also probably induce local companies to adopt similar techniques to be able to compete with foreign companies. Moreover, foreign investments entail structural changes in the economies of developing countries through expanding the scale of non-polluting sectors such as the services sectors and especially tourism. This may explain why the composition effect of FDI reduces the pollution level.

On the other hand, growing FDI inflows increase the scale of the economy in developing countries, through expanding production and raising income levels thus leading to higher pollution levels.

FDI capital accumulation effect: Capital accumulation at the domestic level is considered one of the essential determinants of economic growth and industrial composition. FDI has an indirect effect on environmental pollution based on how FDI influences capital accumulation (d_1) and how capital accumulation in turn influences economic growth (a_2) and industrial composition (c_2). Therefore, the indirect impact of FDI on pollution can be obtained by calculating $d_1 (a_2 + c_2)$. Estimation results reveal that an increase of 1% in FDI inflows entails an increase ranging from 0.21 to 0.27% in the stock of capital.

An increase in the stock of capital increases the scale of the economy – Table (1) and reduces the ratio of industrial output to GDP – Table (4). This means that the indirect effect of FDI on environmental pollution is positive through the scale effect and negative through the composition effect. In other words, FDI increases pollutant emissions through increasing capital accumulation while it reduces pollutant emissions through changing the economic structure of the host country.

4.6. Economic growth impact on the composition effect and the technique effect

Rapid economic growth has two opposing impacts on pollutant emissions. On one hand, growing industrialization is liable to increase the pollution level. On the other hand, rising income levels lead to an increasing demand for a cleaner environment and to higher expenditures on pollution mitigation.

According to the estimation results of this study, economic growth tends to reduce pollution intensity in the industrial output (b_4) probably due to the continuous technological progress. Moreover, the ratio of industrial output to GDP tends to decline with the growing scale of the economy and the rising average income levels (c_3), thus reflecting the evolution of the economy structure accompanying the industrialization process. It is well known that growing industrialization and rising income levels entail structural changes in the economy. Hence the relative importance of the contribution of the industrial sector to GDP declines while the relative importance of the services sector rises, producing what is known today as the services economy.

These results are in line with the inverted curve that illustrates Kuznets' Pollution Haven Hypothesis concerning the relationship between economic growth and the level of pollutant emissions. Specifically, increasing FDI inflows increase the pollution level at the beginning of the industrialization process, while driving up capital accumulation and the economic growth rate. However with rapid industrialization and rising income levels, citizens become better aware of environmental issues and more money is spent on reducing pollution levels. This is exactly what Kuznets' PHH implies.

To sum up, while investments are considered the engine of economic growth, they entail higher pollution levels at the beginning of industrialization. However with the continuing economic growth process, the pollution performance of the economy improves.

4.7. Pollution feedbacks on economic growth

Table (1) indicates that pollutant emissions have a positive impact on the scale of production (a_4) which in turn influences the composition and the technique effects ($b_4 + c_3$). The feedbacks of pollutant emissions on economic growth are then measured by: $a_4 (1 + b_4 + c_3)$. This index shows that if pollution feedbacks are disregarded, i.e., if $a_4 = 0$, the total impact of FDI would be simply equal to the aggregation of the three FDI effects, possibly leading to biased results.

Based on the estimated parameters of the study model the environmental effects of FDI in the host developing countries were calculated as displayed in Table (6). The standard errors of the aggregated values of the various FDI environmental effects were computed using the usual Delta method. See: Woodridge (2002).

Table (6): Various effects of FDI on pollution

	CO_2	CO_2 damage	Nitrous	Methane	greenhouse gases
Total effect $\partial polu/\partial fdi$	0.1111 (9.109)***	0.0354 (32.31)***	-0.2158 (-13.1)***	-0.2078 (-3.33)***	-0.1235 (-9.09)***
Scale effect $\partial gdp/\partial fdi$	0.2447 (2.561)***	0.1431 (5.51)***	0.2194 (2.56)***	0.2066 (3.537)***	0.3010 (3.591)***
Technique effect $\partial tech/\partial fdi$	-0.0931 (-5.25)***	-0.0609 (-7.25)***	-0.4332 (-4.25)***	-0.4107 (-4.25)***	-0.4272 (-3.29)***
Compostion effect $\partial comp/\partial fdi$	-0.0404 (-7.81)***	-0.0468 (-3.81)***	-0.0019 (-6.71)***	-0.0038 (-6.21)***	0.0027 (8.193)***

Note; - **, **, *** indicate significance at 1%, 5% and 10% respectively.*

The results in Table (6) indicate that FDI scale effect has a positive influence on the four pollutants, ranging between 0.143 and 0.301. This means that an increase of 1% in FDI leads to an *increase of approximately 0.2% in the scale of the economy, which in turn entails higher pollution levels. This is quite understandable since an increase in the scale of the economy implies an increase in the number and scale of industrial plants, agricultural projects, means of transport and other facilities that all contribute to increasing pollution levels. This finding is in agreement with the deductions reached by other studies such as: Copeland and Taylor (2003); and Bao, Chen and Song (2011).*

The present analysis goes further by taking account of both FDI direct and indirect scale effects. FDI indirect scale effect is examined from two perspectives: Firstly, the indirect effect of FDI on the economy scale through FDI impact on capital accumulation (a_2 d_1); and secondly, through the pollution feedbacks on the economy scale represented by (b_2 +c_1 + c_2 d_1). FDI total indirect scale effect is calculated as follows:

$(a_2 d_1) + (b_2 + c_1 + c_2 d_1)\, a_4$

The importance of the role of foreign companies in speeding up the economic development process of the host countries can then be undermined if FDI indirect scale effect is omitted from the assessment of economic growth factors. As speeding up economic growth and increasing the economy scale are accompanied by higher levels of pollutant emissions, then a choice should be made between FDI effect on economic growth and FDI effect on the quality of environment; unless the negative impacts of FDI on environmental performance via the scale and the composition effects are clearly outweighed by the technique effect.

FDI technique effect on the four pollutants is negative and ranges between -0.061 and -0.433. This technique effect can be decomposed into direct and indirect effects. The FDI direct technique effect is measured by the estimated coefficient b_2 as shown in Table (2).

FDI indirect technique effect is determined by:

$\frac{\partial gdp}{\partial fd}$ *and* b_4 .

For example, FDI direct technique effect on carbon dioxide emissions equals about -0.074. To determine FDI indirect technique effect on CO_2 emissions, two factors must be considered: How economic development affects pollution intensity as measured by b_4; and how FDI influences economic development as measured by FDI scale effect. Therefore, FDI total indirect technique effect can be estimated by:

$$[a_1 + a_2 d_1 + (b_2 + c_1 + c_2 d_1)\ a_4] b_4$$

Applying simple mathematics, FDI indirect technique effect on carbon dioxide emissions is found equal to -0.0117. FDI total direct and indirect technique effect on carbon dioxide emissions therefore equals:

- (0.074 + 0.0117) = - 0.0857.

FDI composition effect can be determined in the same way. Firstly, FDI direct composition effect is measured by c_1 as mentioned in Table (4). Secondly, FDI indirect composition effect reflects the extent of FDI influence on the capital/labor ratio and on GDP per capita. FDI direct composition effect is found largely negative - See Table (4). FDI indirect composition effect is also negative - See Table (7).

By aggregating the scale, composition and technique effects, FDI total effect on the environmental performance of the developing countries can be assessed. The results presented in Table (6) show that, generally speaking, foreign companies operating in developing countries contribute to the reduction of pollutant emissions with the exception of carbon dioxide emissions.

FDI effect in mitigating pollution is the largest with respect to nitrous oxide emissions (-0.2158), followed by methane gas emissions (-0.2078) and last by deep-buried gases emissions (-0.1235).

These results can be explained by the fact that foreign direct investments in developing countries tend to be concentrated in the industrial sector which is the largest source of carbon dioxide emissions. In other words, FDI (positive) scale effect (increasing industrial plants and means of transportation) *exceeds FDI (negative) composition and technique effects and the final outcome is FDI (positive) total effect on carbon dioxide emissions. Conversely, the three other pollutants are more related to the agricultural sector that does not generally attract FDI (low FDI scale effect) while it is more influenced by FDI indirect composition and technique effects, via the application of more advanced production techniques and benefitting from structural changes. According to another calculation, the total negative effect of FDI on pollutant emissions, with the exception of carbon emissions, is mostly attributable to FDI technique effect.*

According to the present study, FDI scale effect on the four pollutant emissions is found positive and FDI composition and technique effects are revealed negative. Thus the effective contribution of foreign companies operating in developing countries to improving environment quality essentially depends on the relative magnitude of these three effects, i.e., whether the positive scale effect exceeds the sum of the negative composition and the technique effects or vice versa. Taking carbon dioxide emissions as an example, FDI scale, technique and composition effects are estimated at 0.2447, - 0.0857 and - 0.0404 respectively. The final outcome is a positive FDI effect on carbon dioxide emissions amounting to 0.1112. On the other hand, FDI total effect on nitrous gas emissions is found negative, since the negative value of the technique effect (-0.4332)largely exceeds the positive value of the scale effect.

Table (7): The decomposition of the three environment effects

	CO_2	CO_2 damage	Nitrous	Methane	greenhouse gases
Scale effect	***0.2447***	***0.1431***	***0.2194***	***0.2066***	***0.3010***
Direct scale effect	*0.1498*	*0.0993*	*0.1532*	*0.1607*	*0.2659*
Indirect scale effect	*-0.0011*	*-0.0137*	*0.0755*	*0.0365*	*0.0354*
Technique effect	***-0.0931***	***-0.0609***	***-0.4332***	***-0.4107***	***-0.4272***
Direct technique	*-0.0739*	*-0.0387*	*-0.3963*	*-0.3872*	*-0.3417*

effect					
Indirect technique effect	*-0.0117*	*-0.0133*	*-0.0385*	*-0.0224*	*-0.0856*
Compostion effect	***-0.0404***	***-0.0468***	***-0.0019***	***-0.0038***	***0.0027***
Direct compostion effect	*-0.0211*	*-0.0166*	*-0.0199*	*-0.0230*	*-0.0145*
Indirect compostion effect	*-0.0193*	*-0.0302*	*0.0180*	*0.0192*	*0.0118*

The further decomposition of the three FDI environmental effects into direct and indirect effects provides a deeper insight into the mechanisms through which FDI influences the level of pollutant emissions. It is noteworthy that the total FDI impact on pollution would be largely biased if only the direct effects are included in the estimation.

5. Conclusion

The present study investigated the relationship between Foreign Direct Investment and environmental pollution in developing countries. A model of six simultaneous equations was designed and applied using the three-stage least squares (3SLS) method. FDI environmental impact was decomposed into three effects: The scale, composition and technique effects.

The study concluded that FDI scale effect positively influenced pollution in two ways: First directly through its impact on economic growth and second, indirectly through its impact on capital accumulation. For instance, FDI total scale effect on carbon dioxide emissions was estimated at 0.1899. On the other hand, FDI technique effect was found negative, reflecting the impact of such factors as research and development expenditure on pollution mitigation, adopting clean technologies, and modernizing production techniques and equipment on reducing pollutant emissions. The composition effect also proved to be negative. This unexpected finding may be explained by the growing importance of the services sector. The total impact of

FDI on environmental performance in developing countries was obtained by aggregating the three effects.

Generally speaking, foreign investment companies contribute to the mitigation of pollutant emissions with the exception of carbon dioxide emissions. Actually FDI effect on reducing pollution was the largest in the case of nitrous emissions, followed by methane gas emissions, then buried gases emissions.

These results can be readily explained as foreign direct investments tend to be concentrated in the industrial sector, i.e., the sector generating the highest level of carbon emissions. Therefore, in the case of carbon emissions, FDI positive scale effect (expanding the industrial and transportation sectors) outweighs its negative composition and technique effects. The final outcome is a positive relationship between FDI and carbon dioxide emissions.

Conversely, the other pollutants are more related to the agricultural sector that does not usually attract FDI inflows but benefits from FDI indirect effects, such as promoting new technologies and bringing about structural economic changes. The final outcome is a negative relationship between FDI and the other three pollutant emissions.

Developing countries, particularly in their early stages of economic development, should assess their needs of FDI inflows on a sector basis. Moreover, the adverse FDI scale effect on environmental performance can be alleviated through imposing stricter environmental protection regulations while providing foreign companies, especially those operating in the industrial sector, with financial incentives – such as tax reductions – and other incentives – such as less bureaucratic procedures and available utilities – in order to compensate them for higher production costs.

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