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Environment and Foreign Direct Investment: Policy Implications for Developing Countries

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Abstract

There is a two-way relationship between foreign direct investment (FDI) and environment that may have negative or positive effects on welfare. However, FDI-environment relationship is controversial and needs further investigation. To this end, the present research work uses a dynamic panel model to assess the effect of FDI inflows on pollution emissions in developing countries. Three equations are examined empirically. This is to assess the effect of FDI inflows in developing countries on carbon dioxide, energy use and biochemical oxygen demand (BOD) emissions level. A fixed effect panel data model with heterogonous slopes is used to account for differences within countries. The model is estimated using the error correction approach. In addition, the direction of the relationship between FDI flows and environment is studied using Granger causality test. The empirical results do not settle the FDI-environment debate and suggest focusing the analysis on individual county basis. Conclusions and policy implications for developing countries are also given. Policy implications highlight the importance of using effective policies to reduce pollution emissions and to regulate FDI-environment relationship.

Keywords*: Foreign direct investment; environment; dynamic panel data model; Granger causality test; developing countries.*

JEL classification: *C23, Q49, Q53*

1. Introduction

At the present time, there is a major threat to the earth's environment which is due to the increase in environmental damages as a result of accumulation of human made green house gases such as carbon dioxide, methane and nitrous oxide. In addition, the climate is changing and forests, scarce species as well as resources in general are depleting. Among others, foreign direct investment (FDI) is considered to be one of the major factors that may lead to this result. Thus, opposite to the old thoughts, FDI may have negative effects on welfare through its effect on the environment. This happens when developed countries direct their polluting FDI outflows to developing countries where there are loose environmental laws, causing more pollution in developing countries. On the other hand, FDI may have positive effects on welfare through the transfer of environmental friendly techniques of production to developing countries with FDI flows from developed countries. Thus, the interaction between FDI and the environment cannot be neglected or passed over.

The relationship between FDI and environment merits investigation. This is because of the controversy present in this issue. There is an ongoing debate on the nature and direction of the relationship between FDI and environment. In one hand, FDI plays an important role in stimulating growth in developing countries and increasing awareness about the importance of preserving the environment. On the other hand, FDI is accused of being one of the major factors that may contribute to environmental degradation and resource depletion, and hence to welfare losses. Meanwhile, raising environmental concerns affects FDI. This can be the case, for example, when stringent environmental laws, which reflect strong environmental awareness in a country, push polluting industries away from this country and direct them in the form of FDI to countries with lax environmental laws. Therefore, there is a two way relationship between FDI and environment.

Accordingly, the objective of this study is to examine the effect of FDI inflows in developing countries on pollution emissions. This is applied to a dynamic panel model. A fixed effect panel data model with heterogonous slopes is used to account for differences within countries. The model is estimated using the error correction approach (ECM). ECM is an appropriate modeling approach as it examines short run/long run relationship, minimizes spurious results and allows the use of general-to-specific technique. The empirical analysis is carried out for three model specifications to assess the effect of FDI inflows in developing countries on carbon dioxide, energy use and BOD emissions level. This can be viewed as robust checks on the results of the effect of FDI on pollution. The empirical investigation includes Granger causality test on the direction of the relationship between FDI flows and environment. Hence, this paper attempts to answer the following research question which is: What is the effect of FDI inflows on carbon dioxide emissions, emissions from energy use and BOD emissions in developing countries?

The rest of paper is organized as follows. Section 2 presents an overview of the theoretical and empirical debates on FDI-environment relationship. Section 3 deals with the econometric analysis of the FDI-environment relationship in developing countries. Section 4 presents the major findings and empirical results. Section 5 extends the analysis to include a Granger causality test on the direction of the relationship between FDI flows and environment. Section 6 contains conclusions and policy implications for developing countries.

2. Overview of the Debates on FDI-Environment Relationship

There is an ongoing debate on the nature and direction of the relationship between FDI and environment. This unsettled debate is present on both the theoretical and empirical levels. This is illustrated in the following subsections.

2.1 Overview of the Theoretical Debates on FDI-Environment Relationship

From the theoretical point of view, there are two different views governing the FDI-environment debate. One is rooted in the classical trade perspective of comparative advantage in the literature. This view treats environment as another factor of production in which stringent environmental laws increase the production costs. Following this logic, one can conclude that countries that have stringent environmental laws will have relatively high production costs. Consequently, these countries will not be able to have comparative advantage in the production of polluting goods and hence will not specialize in their production. On the other hand, countries with loose environmental laws will have relatively lower production costs and so they can specialize in polluting industries in which they have comparative advantage.

The other view is called the neo-technology trade perspective in which it questions whether stringent environmental laws led to the concentration of dirty industries in countries with loose environmental laws (Mihci et al. 2005). This view originates from the technology-gap approach. According to this view, it could be deduced that FDI may have positive effects on the environment through the transfer of environmental friendly techniques of production to developing countries with FDI flows from developed countries.

This neo-technology perspective was transmitted to FDI-environment relationship through Porter hypothesis. The hypothesis was originally formulated by Porter (1991) and later modified by Porter and Van der Linde (1995) and Esty and Porter (1998). "Porter hypothesis" as suggested by Mihci et al. (2005), states that stringent environmental laws push producers to innovate and create new technologies that are environmental friendly and to become net exporters of these new technologies. This idea comes from the concept of offsets whether in the form of product or process offsets. Although stringent environmental laws may increase compliance costs, the benefits incurred from innovation through the use of environmental friendly techniques can offset the cost of compliance. This happens because the net compliance cost may decrease with stringency and may even change into benefit.

However, Palmer et al. (1995) criticized Porter hypothesis for not considering cost-benefit analysis. They showed that only regulations will stimulate innovations if benefits from innovations exceed costs. Jaffe and Palmer (1997) showed that there are three versions for Porter hypothesis to be considered. The first one is the "narrow version" where there is no clear empirical implication of environmental regulations in stimulating innovations, while the "weak version" implies that these environmental regulations stimulate certain types of innovations. Finally, the "strong version" suggests that environmental regulations lead to innovations when benefits exceed costs making it now socially desirable.

This unsettled FDI-environment debate led to the rise of many hypotheses. Among them is the pollution havens hypothesis which states that the freer the trade and the movement of capital, the more is the shift of pollution intensive industry from countries of stringent environmental laws to countries with loose environmental regulations. This hypothesis has three dimensions according to Aliyu (2005). The first one is if one looks at this hypothesis from the comparative advantage perspective. In this situation, the developing countries impose relaxed environmental regulations to attract FDI and hence have a comparative advantage in polluting industries. The second dimension is the strong environmental laws in developed countries will result in damping hazardous wastes through FDI in developing countries. The third dimension is the massive depletion of the resources of developing countries especially non renewable ones as petroleum, timber and other forests resources by multinational corporations.

Accordingly, the pollution havens hypothesis has two empirical results. First, FDI outflows in developed countries have a positive relationship with the stringency of environmental laws in their countries. Second, pollution in developing countries is positively related to FDI Inflows.

Opposite to the pollution havens hypothesis, there is the pollution haloes hypothesis that states that FDI could have a positive effect on environment through the transfer of environmental friendly techniques of production from developed countries to developing countries that rely on environmental damaging techniques. According to OECD (2001), the transfer of environmental friendly techniques can take place through the transfer of better technologies that target higher environmental standards or even through management practices in large firms or multinational corporations. In addition, most of the firms that invest in non OECD countries are private firms. These firms usually have managerial efficiencies and are more accountable which in turn decreases waste and pollution (OECD 2001).

In the light of the theoretical background of the FDI-environment relationship and its counter argument, it becomes clear that empirical analysis would help in shedding light on what takes place in practice.

2.2 Overview of the Empirical Debates on FDI-Environment Relationship

Many empirical studies were carried out to study FDI-environment relationship. Levinson (1996) gives an empirical literature survey on how sensitive FDI to environmental regulations in US is at the international and domestic levels. He found out that after more than twenty years of empirical research, there is no strong evidence that stringent environmental laws push polluting FDI away from developed countries, or even to support the hypothesis that loose environmental laws attract FDI inflows. In line with this, Copeland and Taylor (2003) argue that strict environmental laws do not affect the direction of FDI but rather it is the kind of instruments used. They also added that there may be a pollution havens effect and not hypothesis.

Another interesting finding was reached by the OECD (1997) which showed that most polluting industries in developed countries are directed as FDI to other developed and not developing countries. This is not the only result, but also the polluting FDI inflows directed to developing countries constituted a smaller proportion of total FDI receipts in 1992 than in 1972. Letchumanan and Kodama (2000) give another empirical support of this argument. They showed that there is “no existing correlation between FDI flows and pollution content of an industry … for developing countries” (Mihci et al. 2005). They also found out that there is a negative correlation for the cases of Singapore and Thailand which reflects that the FDI inflows were mainly in relatively clean industries. In contrast, US and Germany had more correlation with dirty industries compared to developing countries. They showed that FDI inflows to US are relatively more polluting than US FDI outflows. This finding is opposite to the case of Germany where FDI inflows to Germany are relatively in cleaner industries than its FDI outflows. As for Japan, FDI outflows were in less pollution intensive industries.

Furthermore, Eskeland and Harrison (1997) found that FDI reduces pollution in developing countries through their use of more environmental friendly techniques of production as they are "significantly more energy efficient and use cleaner types of energy than local firms"(Aliyu 2005). They disagree with the pollution havens hypothesis as free trade and FDI in Latin America was not accompanied by specialization in pollution intensive industries. In particular they concluded that the pollution havens hypothesis could be the case in closed economies. In free economies, however, FDI is always accompanied by cleaner environmental techniques that reduce pollution and depletion of resources.

Also, Acharyya (2009) examined the effects of FDI growth and the FDI-induced growth on carbon dioxide emissions in India. The results of this study indicated that the pollution havens hypothesis is incapable of explaining the increase in FDI in 1990s. Carbon dioxide emissions increased due to output growth. However, the results could be different if other pollutants are considered.

On the contrary, Kolstad and Xing (1998) carried out an empirical analysis to examine the relationship of the effect of stringency of the environmental laws in destination countries on the location of dirty industries FDI. They found out that there is statistically significant negative linear relationship between US FDI chemical industry outflows and the stringency of environmental laws of the foreign destination country. However, this relationship is not really obvious for less polluting FDI industries.

In general, there is strong evidence that loose environmental laws form a source of attraction to polluting FDI flows. This result was also reached by Co et al. (2004) through studying the US FDI outflows to developed and developing countries in two manufacturing industries in a panel data from 1982-1992. Their results assured that stringency of environmental laws affects investment decisions as there exists an inverse relationship between environmental standards and FDI flows for the average developing countries. However, there could be exception to this rule. In addition, Smarzynska and Wei (2001) showed that there could be a support for the pollution havens hypothesis when the environmental standards of a country were measured through its participation in international environmental agreements. They studied 543 major multinational corporations in 24 countries in Central/Eastern Europe and the former Soviet Republics by using firm level data rather than country/industry level data on investment.

In addition, Mihci et al. (2005) developed a model that was based on Dunning (1981; 1988) integrated approach to measure the FDI-environment relationship. Mihci specified several equations to evaluate the effects of various factors on FDI inflows and outflows.

Many samples were used to test the consistency of the explanatory variables such as FDI between developed and developing OECD countries, FDI in bilateral agreements between all OECD countries, total inflows to OECD countries. The most interesting finding was the influence of the environmental variable on FDI in most of the samples. The index of environmental sensitivity performance in the reporter country (IESP), which is a proxy of strict environmental laws in the reporter country, has a positive relationship with FDI outflows and is significant.

Also, Aliyu (2005) developed an econometric model for the period of 1990-2000 to assess the effect of environmental laws on FDI outflows in 11 developed OECD countries. Also, the study assessed the effects of FDI inflows on pollution emissions in 14 non OECD developing countries. These pollution emissions are mainly in the form of annual carbon dioxide total emissions, emissions of known particulate matters, rising temperature, and total energy use. Aliyu used a disaggregated FDI data in panel data regressions that yield the following results: 1) FDI outflows of polluting industries are positively correlated with environmental policies stringency in developed countries.2) FDI inflows in developing countries are not significant in affecting the pollution emissions and energy use except for carbon dioxide emissions where it was found significant and positive in the 14 developing countries studied.

Furthermore, Perkins and Neumayer (2009) showed in their study that neither transnational linkages via exports nor FDI inflows have an effect on local pollution efficiency. This was deduced when examining the effect on carbon dioxide and sulphur dioxide emissions in developing countries. However, Import links with more pollution efficient countries resulted in improvement in these pollutants emissions due to spillover effects.

Finally, Pao and Tsai (2011) examined the effect of FDI on Co_2 emissions using a panel cointegration technique for Russia, Brazil, India and China in the period that ranges from 1980-2007. Their results showed that there is a positive relationship between FDI and Co_2 emissions. This moves in line with the pollution havens hypothesis. In addition, they conducted a Granger causality test that showed that there is a two way relationship between FDI and Co_2 emissions.

From this review of empirical studies on FDI-environment relationship, one can conclude that this area of research is controversial and a hot debatable issue as always there are evidences with and others against the different hypotheses. This in turn emphasizes the need for further empirical research to have a clearer picture. As such, this research work constitutes another step forward to understand the nature of the FDI-environment relationship better.

3. The Empirical model

Many methods are used to study empirically FDI-environment relationship to provide answers for main theoretical debates. This includes computable general equilibrium (CGE) models (Hülber 2009), input output models (Jian and Rencheng 2007) and (Kakali 2006), welfare models (Grover 2005), profit maximization models (Di 2007) and econometric models (Aliyu 2005). The current research studies FDI-environment relationship using econometric methods.

3.1 Model Specification

This research uses a dynamic panel model that is based on the econometric work of Mihci et al. (2005), Aliyu (2005), and Merican et al. (2007). The model investigates the impact of FDI inflows received by developing countries on their pollution emissions level. For this purpose, the model uses a panel data set for developing countries to measure the effect of FDI inflows on pollution emissions over the period 1970-2005.[1] It is note worthy that while the time series dimension may differ slightly for the developing countries equations; it is still preferable to use all available data. The reason behind this is to obtain reliable statistical inference given that the sample is of moderate size. Using panel data increases the sample size for better estimation and improves the power of the test statistics. Also, it may indicate differences in the behavior of cross sections in the study for policy implications purposes. Heterogeneous slopes are used to account for individual differences within countries. Haque et al. (2000) showed that neglecting heterogeneity in panel data analysis leads to misleading statistical inference. Also, using group-wise slopes for block of countries by region, for example, may obscure heterogeneity within the block. Thus, consider the following fixed effect model:[2]

$$Co2_{i,t} = a_i + \psi_{1i} Co2_{i,t-1} + \psi_{2i} FDII_{i,t-1} + \psi_{3i} MANU_{i,t-1} + \psi_{4i} T_i + u_{1i,t} \quad (1)$$

[1] The list for developing countries includes Algeria, Bolivia, Cameroon, Chile, China, Columbia, Costa Rica, Ecuador, Egypt, Guatemala, Guyana, Honduras, India, Indonesia, Iran, Mexico, Morocco, Nepal, Pakistan, Philippines, South Africa, Sri Lanka, Tunisia, and Venezuela.

[2] Equation (1) is estimated for the period 1970-2005. Equation (2) is estimated for the period 1971-2005 for which data is available and Guyana is excluded from the sample due to lack of data. Equation (3) is estimated for the period 1980-2000 for which data is available. Also, Guyana, Nepal, Pakistan and Tunisia are excluded from the sample due to lack of data on BOD.

$$ENG_{i,t} = b_i + \alpha_{1i} ENG_{i,t-1} + \alpha_{2i} FDII_{i,t-1} + \alpha_{3i} MANU_{i,t-1} + \alpha_{4i} T_i + u_{2i,t} \quad (2)$$

$$BOD_{i,t} = c_i + \gamma_{1i} BOD_{i,t-1} + \gamma_{2i} FDII_{i,t-1} + \gamma_{3i} MANU_{i,t-1} + \gamma_{4i} T_i + u_{3i,t} \quad (3)$$

where for every country i at time t, Co_2 is carbon dioxide emissions, which is a measure of pollution and is measured as carbon dioxide emissions kg per US$ 2000 of GDP, ENG is the log of primary energy use measured in kilo tons (Kt) to reflect pollution, BOD is the log of biochemical or biological oxygen demand measured in Kg per day which is an indication of water pollution, FDII is foreign direct investment inflows in developing countries and is measured as net foreign direct investment inflows as a percentage of GDP, MANU is manufacturing value added in developing countries and is measured as manufacturing value added as a percentage of GDP, T is time trend to account for technological advances effect in developing countries, $u_{1,\dots,}u_3$ are error terms and Dummy variables $a_{i,\dots,}c_i$ are used to measure unobserved variables such as corruption and environmental awareness.

3.2 Model Estimation

Global warming is linked to the accumulation of several gases in the atmosphere such as carbon dioxide, methane, nitrous oxide and sulphur dioxide. These gases have the ability to trap infrared radiation (heat) that would normally escape into the earth atmosphere which increases the earth's temperature. Nevertheless, carbon dioxide is a valid proxy for pollution because it is the primary source for global warming. In addition, reliable data on carbon dioxide emissions are available which were used by several studies such as (Yaung 2001) and (Holtz-Eakin and Selden 1995). Finally, carbon dioxide is highly correlated with other pollutants.[4] Hence, there is sufficient evidence for the use of carbon dioxide as valid and reliable proxy for pollution. Energy use can be taken as a measure for pollution or a proxy measure for environmental degradation as well (Aliyu 2005). This is because primary energy sources are either renewable or non renewable sources. Renewable sources such as solar energy, wind energy or falling and tidal energy are usually considered clean energy sources. Contrary to non renewable energy sources such as oil, coal, natural gas and natural uranium which are always associated with polluting emissions such as carbon dioxide, nitrogen oxide, or sulphur oxides. Although the use of clean energy is increasing, still the fossil fuel

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[3] Linear interpolation is the method of finding out an unknown point that lies between two known points under the assumption that they are all on the same straight line.
[4] For example, the correlation coefficient of carbon dioxide with nitrous oxide and sulphur dioxide in 111 countries in 1990 are 0.9529 and 0.9536 respectively, see (Hoffmann et al., 2005).

consumption is the highest among all countries (US Energy Information Administration EIA, 2011). Accordingly, energy use could be used as a proxy measure for pollution. Perhaps, if patterns of energy use change in the future towards replacement of fossil fuels by clean energy sources, this argument will not be valid then.

To have a wider picture of the effect of FDI on environment in developing countries, water pollution should be also considered. One way to measure water pollution is through biochemical oxygen demand (BOD) which is commonly used by many researchers such as (Eskeland and Harrison 1997) and (Quiroga et al. 2009). According to the World Bank in the WDI, BOD is defined as the amount of oxygen needed by bacteria in water to break down wastes. High level of sewage in water, for example, reduces the amount of dissolved oxygen in natural water which will in return threaten the health of aquatic life and the ecosystem in general. Accordingly, high emissions of BOD reflect high levels of water pollution as it indicates that there is a shortage in the amount of oxygen needed in the water.

Lagged values of the independent variable Co_2, ENG and BOD are included to test whether there is persistence in pollution reflected by positive coefficients, or correction is happening towards lowering pollution, reflected by negative coefficients. The relation between FDI inflows and pollution emissions is ambiguous. This is because the neo-technology perspective expects that the coefficient of FDI inflows is negative (pollution halos hypothesis). However, the classical trade perspective of comparative advantage expects a positive coefficient of FDI (pollution havens hypothesis).

The reason for choosing manufacturing value added as a percentage of GDP as an explanatory variable in this research is that industrialization is a major contributor to the increase of pollution emissions worldwide (Merican et al. 2007). It is expected to have a positive coefficient of manufacturing reflecting a positive relationship between manufacturing value added and pollution emissions. In addition, a trend term is used to account for technological progress effect on pollution emissions.

To investigate the impact of FDI inflows, manufacturing value added and lagged pollution emissions variables on pollution emissions in a panel data model, several techniques could be used. Similar to time series analysis, cointegration and error correction model (ECM) specification are two modeling approaches that could be used in estimating panel data models. The choice between the two approaches depends largely on the unit-root test results since cointegration approach is only applicable if all variables are I(1). So stationarity of the variables are first examined. This can be carried out through the Augmented Dicky Fuller (ADF) and Phillips-Perron (PP) unit-root tests. Applying both tests to the model variables, the following results were reached: At 5 percent level of significance, not all variables are I(1). Accordingly, cointegration analysis will not be used in estimating this model. ADF and PP results are shown in the appendix.

An alternative modeling approach in this case is the ECM as proposed by Pesaran et al. (1999). They showed that a long run relationship still exists in case not all variables are I(1) under ECM specifications. ECM is an appropriate modeling approach as no information is ignored as a result of the inclusion of the disequilibrium term.[5] Also, ECM examines short run/long run relationship, minimizes spurious results and allows the use of general-to-specific technique. Following ECM approach, the long run relationship is estimated first to use its residual in estimating the short run relationship. In addition, ECM allows the use of OLS estimation which is another advantage of ECM.

Accordingly, to study the long run relationship, pollution emissions are regressed on FDI inflows, manufacturing value added and a time trend. A trend term is included to reflect technological advances which are vital for decreasing pollution. The lagged residual from the OLS estimation of the long run relation e_{it-1} is used in estimating the short run relationship. The coefficient of the lagged residual λ measures the speed of adjustment to long- run equilibrium, as the residual represents deviation from the long run relationship. To measure the short run relation, consider the following equation:

$$\Delta CO2_{i,t} = (T_i, lagged(\Delta CO2_{i,t-1}, \Delta FDII_{i,t}, \Delta MANU_{i,t})) - \lambda e_{i,t-1} + \in_{i,t} \quad (4)$$

$$\Delta ENG_{i,t} = (T_i, lagged(\Delta ENG_{i,t-1}, \Delta FDII_{i,t}, \Delta MANU_{i,t})) - \lambda e_{i,t-1} + \in_{i,t} \quad (5)$$

$$\Delta BOD_{i,t} = (T_i, lagged(\Delta BOD_{i,t-1}, \Delta FDII_{i,t}, \Delta MANU_{i,t})) - \lambda e_{i,t-1} + \in_{i,t} \quad (6)$$

where Ti is the trend term for country i, Co2 i,t-1 is carbon dioxide emissions at time t-1 for country i, ENGi,t-1 is log of energy use at time t-1 for country i, BODi,t-1 is the log of biochemical oxygen demand emissions at time t-1 for country i, FDII i,t is FDI inflows at time t for country i, MANUi,t manufacturing value added at time t for country i, λ is the coefficient of the disequilibrium error term, ei,t-1 is the lagged residual obtained from

[5] In a bivariate case, for example, ECM takes the following form:

$$\Delta y_{i,t} = b_{1i} \Delta x_{i,t} - \lambda_i (y_{i,t-1} - \beta_0 - \beta_{1i} x_{i,t-1}) + \in_{i,t}$$

where y is the dependent variable and x is the independent variable at time t for country i, ($y_{i,t-1} - \beta_0 - \beta_{1i} x_{i,t-1}$) is the disequilibrium error from period t-1, β_{1i} is long run elasticity of y with respect to x, and b_{1i} reflects the short-run effect of x on y (short-run elasticities or sensitivities). Hence, this equation states that for country i, the current change in y depends on the current change in x and the degree of disequilibrium in the previous period. The use of ECM approach allows for any disequilibrium in the x and y levels.

estimation of the long-run relationship and it represents the disequilibrium error term and Єit the error term for this OLS estimation at time t for country i. These equation states that for country i, the current change in pollution emissions depends on the change in pollution emissions in the previous period, the current change in both FDI inflows and manufacturing value added and the degree of disequilibrium in the previous period and a trend term. Given the moderate size of the sample data, the number of lags is chosen to be two to save degrees of freedom.[6] The interpretation of results is at 5 percent level of significance.

4. Empirical Results

The estimation results indicated that FDI inflows did not affect the environment in most of the cases. In addition, most of the countries suffered from lack of technological progress effect. Furthermore, the estimated results suggested the lack of an active policy to control pollution emissions in most of the countries.[7] However, there were exceptions to these main findings.

1. Some countries like Algeria, Cameroon, Iran, and Mexico showed evidence for the pollution havens hypothesis.
2. Other countries like Guyana, Indonesia, South Africa and Costa Rica showed evidence for the pollution haloes hypothesis.
3. Nine countries had a negative significant trend term which indicates that pollution is decreasing over time in these countries.[8]
4. Five countries showed evidence for persistence of emissions contrary to two countries only that showed evidence for emissions reduction.[9]
5. Some countries like Algeria, China, Iran and Mexico showed evidence for the effect of manufacturing techniques in polluting the environment. By contrast, countries like Guyana, and Morocco showed evidence for the use of environmental friendly techniques in manufacturing production.

Examining these results in depth is crucial for designing the appropriate policies. Doing so, the following conclusions on environment were reached. First, although FDI effect was insignificant in China, manufacturing value added had significantly positive effect as

[6] It is worthwhile to mention that saving degrees of freedom as a criteria for choice of the lag length is a procedure that is used before in the literature as mentioned by Greene (2003, chapter 19, p.604) and Hayashi (2000, chapter 10, p.662).
[7] See tables 7-15 in the appendix for more detailed results.
[8] These countries are Algeria, Bolivia, Cameroon, Colombia, Egypt, Guyana, Indonesia, Tunisia and Venezuela.
[9] Countries that showed persistence in emissions are China, Iran, Bolivia, Morocco and Philippines, while countries that showed reduction in emissions are Ecuador and Indonesia.

expected from one of the largest countries in industrial production and exports with potential increase in pollution and environmental degradation. Hence, manufacturing and not FDI inflows, is the active polluting factor in China. Also, little efforts are made to reduce pollution as there is persistence in carbon dioxide emissions as shown from the significantly positive coefficient of lagged carbon dioxide emissions.

Second, Algeria, Cameroon and Iran had positive significant FDI inflows and manufacturing effect on carbon dioxide emissions suggesting that more efforts are needed to reduce pollution in these countries as there are two forces working together to increase it, namely, FDI and manufacturing activity. Hence, the results showed evidence for the pollution havens hypothesis. Accordingly, loose environmental laws in these countries gave them comparative advantage in polluting industries. Thus, it pulled polluting FDI from developed countries into these countries.

Third, FDI in Algeria and Iran are using environmental friendly techniques as indicated by the energy use equation results when the petroleum production sector is excluded. But when FDI in oil production is included through measuring emissions from gas flaring in oil production in the carbon dioxide equation, the relation becomes positive. This suggests that FDI use polluting techniques in oil production. This is magnified when considering the huge amount of oil production in Algeria and Iran, added to other emissions evolving from transportation sector.

Fourth, Indonesia had a negative significant effect with respect to technological advances reflected by the trend term, FDI inflows and manufacturing value added. This indicates that pollution is decreasing over time; FDI inflows reduce pollution and the use of environmental friendly technology in industrial activity. The results point out that Indonesia appears to be adopting a comprehensive environmental policy to reduce water pollution. This is also shown through the reduction in emissions as indicated by the significant negative coefficient of lagged BOD.

Fifth, Mexico had a positive significant FDI inflows and manufacturing effect on BOD emissions suggesting that more efforts are needed to reduce water pollution in this country as both FDI and manufacturing activities contribute to it.

Sixth, both Morocco and Philippines showed persistence in BOD emissions reflected by the positive significant coefficient of lagged BOD. FDI coefficient does not contribute to this as it was insignificant in both countries. But in Philippines, manufacturing value added was significantly positive. This suggests that manufacturing activity increases and contributes to the persistence in BOD emissions. However, in Morocco, the coefficient of manufacturing value added was significantly negative so that manufacturing activity decreases BOD emissions. Hence, neither FDI nor manufacturing activity contributed to this persistence of BOD in Morocco which suggests that it could be due to agricultural activities or sewage discharges for example.

The coefficient of manufacturing value added in Philippines was negative in the energy use equation and positive in the BOD equation. A possible explanation for that is that the production techniques used in Philippines pollutes water through the discharge of factories industrial wastes in water. However, they do not result in air pollution.

Finally, the empirical results indicated that FDI inflows in Egypt did not affect the environment. In addition, Egypt suffered from lack of technological progress effect except for the case of emissions from energy use. A possible explanation for this discrepancy in results is similar to the case of Algeria and Iran discussed earlier. The inclusion or exclusion of emissions from the oil production and emissions from transportation are likely factors.[10] The coefficient of the trend term in the energy use equation was significantly negative for the case of Egypt which indicates a reduction in the levels of pollution over time. Furthermore, the estimated results suggested the lack of an active policy to control pollution emissions.

5. Granger Causality Test

Some studies in environmental economics used Granger causality test to measure the direction of the relationship between two or more variables such as Hoffmann et al. (2005) and Lee (2009). Granger (1969) measures causality between two variables X and Y through examining how much of the current values of Y are explained by previous values of Y and if the inclusion of lagged values of X improves the explanation.[11] The F-statistic is examined to test for the joint hypothesis that the regression coefficients $\beta_1 = \beta_2 = \beta_3 \ldots = \beta_k = 0$. Accordingly, the null hypothesis of X does not Granger-cause Y is examined. Granger causality test is usually used to examine a two way relationship between two variables in two separate regressions. This is to test whether X Granger-cause Y in the first regression and Y Granger-cause X in the second regression.

[10] According to the US Energy Information Administration (EIA) Egypt ranks 27 among the countries of the world in oil production with 680, 46 thousand barrels per day in 2009. Furthermore, the transportation sector and manufacturing and construction sector in Egypt accounts for 17 percent and 29 percent of carbon dioxide emissions respectively. In addition, cement manufacturing releases 9 percent of carbon dioxide emissions in 1998.

[11] X is said to Granger-cause Y if the forecast for Y is improved when lagged values of X are taken into account. i.e. the coefficients of lagged values of X are statistically significant. However, this does not imply that X is the cause of Y in the conventional sense as Granger causality measures only the effect of X in predicting or forecasting Y.

5.1 Granger Causality Test Using ECM

Several researches studied Granger causality tests using ECM approach such as Marrocu et al. (2000), Zhang and Felmingham (2001) and Lee (2009). To test for Granger causality within an ECM framework, stationarity of the variables is examined first. The second step is to formulate an ECM in both directions to test for the existence of a short run adjustment towards long run equilibrium in one or two directions. The stationarity test is done through ADF or PP tests. However, the causality test includes two ECMs as follows.

$$\Delta Y_{i,t} = lagged(\Delta Y_{i,t-1}, \Delta X_{i,t-1}) - \lambda_1 e_{1i,t-1} + \in_{1i,t} \quad (7)$$

$$\Delta X_{i,t} = lagged(\Delta X_{i,t-1}, \Delta Y_{i,t-1}) - \lambda_2 e_{2i,t-1} + \in_{2i,t} \quad (8)$$

In equations (7) and (8), λ is the coefficient of the disequilibrium error term, $e_{i,t-1}$ is the lagged residual obtained from estimation of the long-run relationship and it represents the disequilibrium error term. There are two channels that may lead to Granger Causality within an ECM.[12] The first channel is related to the adjustment of the variables to the long run equilibrium represented by λ, while the second channel is related to the short run response of one variable. Granger Causality tests are misspecified if the first channel is not considered. There is a two way relationship between X and Y if λ_1 and λ_2 are significant. However, if only one of them is significant, there is one way relationship. Finally, if both λ_1 and λ_2 are insignificant, the first channel of Granger causality is excluded. Nevertheless, Granger causality may still exist from the second channel even if it was not apparent in the first channel. This reflects short run interaction between the two variables. If this is the case, then standard Granger causality tests are used (Ibrahim 2000).

5.2 Granger Causality Test between FDI and Environment

Hoffmann et al. (2005) studied Granger causality between FDI and environment using VAR technique in a panel data model. They concluded that in low-income countries carbon dioxide emissions Granger-cause FDI inflows while in middle income countries, FDI inflows Granger-cause carbon dioxide emissions. In addition, there was no evidence for Granger causality in high income countries.

Lee (2009) examined Granger causality between FDI, pollution and economic growth in Malaysia in the period 1970-2000 using ECM. He concluded that in the short run FDI and carbon dioxide Granger-cause GDP, while FDI only Granger-cause carbon dioxide. However, the results showed that GDP Granger-cause FDI in the long run. Using ECM approach in testing for Granger causality is appropriate for the current study since it was the adopted

[12] See Zhang et al. (2001) and Marrocu et al.(2000).

estimation technique through out the research. Accordingly, Granger causality test using ECM is applied for developing countries.

5.3 Granger Causality Test between FDI and Environment Using ECM for Developing Countries

To test for Granger causality between FDI and environment, consider a fixed effect panel data model with heterogeneous slopes. Following the test procedures discussed in section 5.1, stationarity of the variables is examined first. ADF and PP unit-root tests results for carbon dioxide emissions and FDI inflows in developing countries showed that both variables are I(0). The next step is to run two ECM estimations. The causality test related to FDI and environment relationship for developing countries includes two ECMs as follows.

$$\Delta FDII_{i,t} = (T_i, lagged(\Delta FDII_{i,t-1}, \Delta Co2_{i,t-1})) - \lambda_1 e_{1i,t-1} + \in_{1i,t} \quad (9)$$

$$\Delta Co2_{i,t} = (T_i, lagged(\Delta Co2_{i,t-1}, \Delta FDII_{i,t-1})) - \lambda_2 e_{2i,t-1} + \in_{2i,t} \quad (10)$$

where FDII is foreign direct investment inflows in developing countries, Co_2 is carbon dioxide emissions which is a measure of pollution in developing countries, T is the trend term to account for technical progress effect, λ is the coefficient of the disequilibrium error term, $e_{i,t-1}$ is the lagged residual obtained from estimation of the long-run relationship and it represents the disequilibrium error term and ϵ_{it} the error term for this OLS estimation at time t for country i. This is to test whether carbon dioxide emissions Granger-cause FDI in the first regression and FDI Granger-cause carbon dioxide emissions in the second regression for developing countries.

5.4 Sample and Data Measurement for Developing Countries

It is important to point out that the developing countries sample is similar to the sample used in carbon dioxide estimation in section 3.[13] Also, the years studied are the same which is from 1970-2005. Co_2 is measured as carbon dioxide emissions kg per US$ 2000 of GDP and FDII is measured as net foreign direct investment inflows as a percentage of GDP. All data for this equation are collected from WDI database of the World Bank. Missing data were calculated through the use of linear interpolation.[14] Given the moderate size of the sample data, the number of lags is chosen to be two to save degrees of freedom. The interpretation of results is at 5 percent level of significance.

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[13] The list for developing countries includes Algeria, Bolivia, Cameroon, Chile, China, Columbia, Costa Rica, Ecuador, Egypt, Guatemala, Guyana, Honduras, India, Indonesia, Iran, Mexico, Morocco, Nepal, Pakistan, Philippines, South Africa, Sri Lanka, Tunisia, and Venezuela.

[14] There are missing data for FDI inflows in Iran in the years 1991 and 1992.

5.5 Empirical Results for Developing Countries

The estimated results of equations (9) and (10) indicate that there is no long run effect between FDI and environment in most of the countries. This is because λ is mutually significant in 3 countries only: Bolivia, Guyana and Venezuela. This indicates that there is a two way relationship between FDI and environment in these 3 countries. Nevertheless, when testing for the existence of no effect of the explanatory variable on the dependent variable in the long run and short run jointly, the results showed that there is Granger causality between FDI and environment that runs in both directions. A possible explanation for the different conclusion reached when testing for Granger causality (no long run effect) and for the long run and short jointly is the heterogeneity within countries or short run interaction between the two variables.

Looking at the Granger causality results of equations (9) and (10) in details, the coefficient of the lagged error term of short–run disequilibrium is examined to reflect the first channel of Granger causality. It had the expected negative sign in all countries, but was significantly negative in 7 countries in equation (9), and in 8 countries in equation (10).[15] This shows that Carbon dioxide Granger-cause FDI in 7 countries, whereas FDI Granger-cause carbon dioxide in 8 countries. Among these countries only Bolivia, Guyana and Venezuela showed evidence for a two way relationship between FDI and Environment as λ was significant in both equations for these countries. Table (1) summarizes the results for Granger causality from the first channel.

Table (1) Granger Causality Test Results for Developing Countries (No Long Run Effect)

H_0: $\lambda_i = 0$

Results	Number of Countries
Co_2 Granger- cause FDI inflows	7
FDI inflows Granger- cause Co_2	8
Co_2 Granger- cause FDI inflows and FDI inflows Granger- cause Co_2	3
No long run effect	17 in eq. (9), 16 in eq. (10)

Based on the F test results, the null hypothesis of whether the lagged changes of the explanatory variables and the coefficient of disequilibrium error term λ are jointly equal to zero (no Granger causality between the variables) is rejected. This shows that that there is

[15] These countries are Bolivia, Chile, Egypt, Guyana, South Africa, Tunisia and Venezuela for equation (9) and Algeria, Bolivia, Cameroon, China, Ecuador, Guyana, Iran and Venezuela for equation (10).

Granger causality between FDI and environment that runs in both directions when considering the short run and long run together. Table (2) shows summary of the results.

Table (2) Granger Causality Test Results for Developing Countries*

Null Hypothesis	F-Statistic	Probability	Decision
Co_2 does not Granger- cause FDI inflows	2.288545	0.00000	Reject Null
FDI inflows does not Granger-cause Co_2	3.820795	0.00000	Reject Null

* The results are for all coefficients jointly to test for Granger Causality in the short and long run in the case of a two period lags.

6. Conclusion and Policy Implications

The model studied examined the effect of FDI inflows on pollution emissions in a dynamic panel data model with heterogeneous slopes over the period 1970-2005. ECM was the chosen estimation technique. The estimation results indicated that FDI inflows did not affect the environment in most of the cases. In addition, most of the countries suffered from lack of technological progress effect. Furthermore, the estimated results suggested the lack of an active policy to control pollution emissions in most of the countries. However, there were exceptions to these main findings. In addition Granger causality test was conducted and it showed that there was no long run effect between FDI and environment in most of the countries. Only three countries showed evidence for a two way relationship. Nevertheless, when testing for the existence of no effect of the explanatory variable on the dependent variable in the long run and short run jointly, the results showed that there is Granger causality between FDI and environment that runs in both directions.

After reviewing the empirical results and deriving important connections for individual countries as shown in section 4, the following policy implications are suggested in two levels. The first level is a general one, while the second level is for specific countries.

6.1 General Policies

To take the outmost of the FDI-environment relationship and to control pollution, there are policies that have to be applied in developing countries in general. However, these policies for developing countries rest on 2 main pillars.

1. Design policies to reduce pollution emissions and ensure their enforcement and compliance.
2. Regulate FDI-environment relationship.

Concerning the first pillar, there are three different approaches of environmental regulations to reduce emissions: Command-and-control approach, economic incentive approach and non mandatory approach. In command-and-control approach, the government decides on standards for each pollutant emissions and the most suitable technology to be used in production that ensures that these standards are met. On the other hand, in the economic incentive approach producers are free to choose their appropriate methods of production or technologies as long as pollution levels are within the legal standards. Not only this, but also producers are financially rewarded for reducing pollution further below the legal levels. Finally, non mandatory approach relies on voluntary actions of firms to upgrade their environmental performance. Environmental self regulation by firms assumes that self interest is the reason behind firms' adoption of voluntary action to reduce pollution.

Any country is free to choose between these three approaches. However, developing countries that lack technical, political and financial capabilities required to calculate the correct fees, allocate permits, check emissions, charge polluters and record permits trade should not rely heavily on economic incentive approach. At the same time, command-and-control approach is also costly and proved to be inefficient. One possible option here is to carry out a policy mix between both approaches. That is to use command-and-control approach with economic incentive approach in environmental regulations. Accordingly, command-and-control approach and economic incentive approach will be viewed then as complements and not as substitutes. This policy mix is adopted now in many countries in Europe and in the US.

Another policy option is to rely on non mandatory approach to reduce emissions in developing countries. However, ensuring transparency and information availability, increasing consumers' awareness of the effects of pollution and environmental degradation, penalties costs and market pressures, and finally eliminating corruption are all precondition for the success of the non mandatory approach. Unfortunately, most of developing countries suffer from lack of transparency. Public pressure with respect to preserving the environment is still modest, and corruption is widespread that makes it difficult to enforce regulations or ensure compliance. Accordingly, relying solely on non mandatory approach in developing countries is not particularly useful under the current conditions. However, it could be used in a later stage. For the time being, what seems more appropriate is to do three things: First, guarantee all the factors needed as a precondition for a successful non mandatory approach. Second, use a policy mix between command-and-control approach and non mandatory approach. Finally, try non mandatory approach in a small scale in certain industries or certain sectors and once proven successful, this can be applied to a wider scale.

In addition to reducing emissions, regulating FDI is the second pillar to adjust FDI-environment relationship. There are many factors that could be used to regulate FDI-environment relationship as recommended by international organizations like OECD, WB or the UN. Among them is:

- To have an integration of the environmental and investment goals.
- To encourage the private business to innovate to reach "the best environmental practice".
- Make all the necessary arrangements such as putting in place the appropriate policies, institutions and capacities for a market economy to function in a stable and fair system to attract FDI in developing countries.
- Use environmental friendly techniques in management and production not only in subsidiaries but also in the local firms in developing countries.
- Ensure transparency.
- Stress on the role of multinational corporations' entrepreneurs in spreading environmental awareness among their employees and the public.

Most of the international organizations are departing from complete reliance on the rigid and proven inefficient command-and-control approach. Innovations by firms to reach best practice which is the most cost effective are greatly recommended by these international organizations. But this takes us back to the argument of the inability of developing countries to meet economic incentives approach or non mandatory approach conditions solely. Accordingly, a policy mix is recommended as stated before.

Few points are left to be covered under the FDI-environment regulation to avoid environmental degradation and to make sure that FDI and preserving the environment are moving in line together in practice. These points are the role of corruption in encouraging polluting FDI in developing countries, public awareness and loose environmental laws. Corruption is a very crucial issue when tackling FDI effect on the environment. Also, loose environmental laws may encourage polluting FDI in developing countries. As a result, the policy implications with respect to FDI-environment relationship in developing countries are:

- To fight corruption through increasing penalties and strong monitoring.
- To spread public awareness through the media about methods of preserving the environment and the effect of hazardous substances on threatening our lives.
- To apply stringent environmental laws and ensure its enforcement.

Hence, designing policies to reduce pollution emissions and ensure their enforcement and compliance and regulating FDI-environment relationship are among the general policies that should be implemented in all developing countries. However, the empirical results of the current study discussed in section 4 necessitate recommending specific policies to some developing countries which are discussed in the appendix in table (15).

All in all, three main things are essential for developing countries to solve this matter: Getting rid of corruption, strong enforcement of law and raising public and firms' awareness of the importance of preserving environment. However, the debate on FDI-environment relationship still exists and more research is needed on individual country level. For further research, it is preferred to study case by case due to the heterogeneity factor across countries. Also, it would be interesting for future research work to study FDI-environment relationship at industry level for deeper analysis. Finally, it is crucial to have available data on emissions for long time series to be able to reach reliable results. Accordingly, governments and research centers in developing countries should give more attention to such important issue.

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APPENDIX

Unit Root Tests of CO_2 Equation

Table 1. A Results of the Augmented Dicky Fuller Unit Root Tests in Heterogeneous Panel
Augmented Dicky Fuller-Fisher Chi-Square Test With Trend

	Level		First Difference	
	Statistic	Prob.	Statistic	Prob.
Co2	101.714	0	611.335	0
FDI Inflow	168.105	0	724.638	0
Manufacturing	55.6139	0.2099	438.445	0

Table 1.B Results of the Augmented Dicky Fuller Unit Root Tests in Heterogeneous Panel
Augmented Dicky Fuller Choi Z-stat Test With Trend

	Level		First Difference	
	Statistic	Prob.	Statistic	Prob.
Co2	-2.05994	0.0197	-21.2972	0
FDI Inflow	-8.12281	0	-22.3896	0
Manufacturing	-0.51891	0.3019	-17.6331	0

Table 2. A Results of the Phillips-Perron Unit Root Tests in Heterogeneous Panel
PP-Fisher Chi-Square Test With Trend

	Level		First Difference	
	Statistic	Prob.	Statistic	Prob.
Co2	102.849	0	1663.20	0
FDI Inflow	155.112	0	3080.16	0
Manufacturing	54.9291	0.2287	1201.01	0

Table 2. B Results of the Phillips-Perron Unit Root Tests in Heterogeneous Panel
PP-Choi Z-stat Test With Trend

	Level		First Difference	
	Statistic	Prob.	Statistic	Prob.
Co2	-2.09320	0.0182	-33.7027	0
FDI Inflow	-6.80723	0	-46.9270	0
Manufacturing	-0.66864	0.2519	-25.8769	0

Unit Root Tests of Energy Use Equation

Table 3. A Results of the Augmented Dicky Fuller Unit Root Tests in Heterogeneous Panel
Augmented Dicky Fuller-Fisher Chi-Square Test With Trend

	Level		First Difference	
	Statistic	Prob.	Statistic	Prob.
Energy Use	54.9950	0.1707	392.014	0
FDI Inflow	161.803	0	651.337	0
Manufacturing	48.4559	0.3741	422.678	0

Table 3. B Results of the Augmented Dicky Fuller Unit Root Tests in Heterogeneous Panel
Augmented Dicky Fuller Choi Z-stat Test With Trend

	Level		First Difference	
	Statistic	Prob.	Statistic	Prob.
Energy Use	0.04592	0.5183	-15.7725	0
FDI Inflow	-7.90929	0	-21.1188	0
Manufacturing	0.12524	0.5498	-17.3322	0

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Table 4. A Results of the Phillips-Perron Unit Root Tests in Heterogeneous Panel
PP-Fisher Chi-Square Test With Trend

	Level		First Difference	
	Statistic	Prob.	Statistic	Prob.
Energy Use	40.4667	0.7025	466.895	0
FDI Inflow	161.287	0	2847.73	0
Manufacturing	46.9131	0.4349	920.575	0

Table 4. B Results of the Phillips-Perron Unit Root Tests in Heterogeneous Panel
PP-Choi Z-stat Test With Trend

	Level		First Difference	
	Statistic	Prob.	Statistic	Prob.
Energy Use	1.21571	0.8880	-17.8833	0
FDI Inflow	-7.04567	0	-44.3533	0
Manufacturing	-0.02452	0.4902	-22.6514	0

Unit Root Tests of BOD Equation

Table 5. A Results of the Augmented Dicky Fuller Unit Root Tests in Heterogeneous Panel
Augmented Dicky Fuller-Fisher Chi-Square Test With Trend

	Level		First Difference	
	Statistic	Prob.	Statistic	Prob.
BOD	53.3650	0.0768	176.716	0
FDI Inflow	73.5136	0.0010	176.641	0
Manufacturing	78.5379	0.0003	195.183	0

Table 5. B Results of the Augmented Dicky Fuller Unit Root Tests in Heterogeneous Panel
Augmented Dicky Fuller Choi Z-stat Test With Trend

	Level		First Difference	
	Statistic	Prob.	Statistic	Prob.
BOD	0.81807	0.7933	-9.30110	0
FDI Inflow	-1.94952	0.0256	-7.87651	0
Manufacturing	-2.58625	0.0049	-10.1357	0

Table 6.A Results of the Phillips-Perron Unit Root Tests in Heterogeneous Panel
PP-Fisher Chi-Square Test With Trend

	Level		First Difference	
	Statistic	Prob.	Statistic	Prob.
BOD	54.0781	0.0678	200.729	0
FDI Inflow	84.7473	0	321.554	0
Manufacturing	63.0121	0.0116	209.318	0

Table 6. B Results of the Phillips-Perron Unit Root Tests in Heterogeneous Panel
PP-Choi Z-stat Test With Trend

	Level		First Difference	
	Statistic	Prob.	Statistic	Prob.
BOD	1.29214	0.9018	-10.0862	0
FDI Inflow	-3.47788	0.0003	-14.2929	0
Manufacturing	-1.91323	0.0279	-10.5433	0

Error Correction Model Results of Co_2 Equation

Table 7 Error Correction Model Results for Heterogeneous Panel with Trend
Dependent Variable Co_2 (Sample Period Adjusted: 1973-2005)
Cross-sections 24
Total pool (balanced) observations:792

	Countries					
	Algeria	Cameroon	China	Ecuador	Guyana	Iran
Variables						
	0.101974	0.013874	**0.993515**	-0.073768	0.183984	**0.409057**
$Co_2(-1)$	(0.710395)*	(0.105168)	**(8.724599)**	(-0.65805)	(1.143794)	**(2.617662)**
	0.148699	-0.085093	-0.235960	**-0.225015**	-0.163789	0.084744
$Co_2(-2)$	(1.392009)	(-0.718655)	(-1.58901)	**(-2.31449)**	(-1.48557)	(0.615853)
	0.108530	**0.036913**	-0.002112	-0.014058	**-0.006522**	**0.097549**
FDI	**(2.556942)**	**(2.580059)**	(-0.06476)	(-0.63700)	**(-2.05183)**	**(2.172487)**
	0.050001	**0.039200**	0.057395	0.023940	0.000999	**0.213347**
FDI (-1)	(1.129710)	**(2.137295)**	(1.592130)	(1.429928)	(0.253255)	**(3.647741)**
	0.016999	**0.042200**	0.068564	0.001040	-0.000594	0.060696
FDI (-2)	(0.473237)	**(2.871950)**	(1.834370)	(0.074504)	(-0.19518)	(1.121417)
	0.042396	0.009682	**0.121755**	-0.004751	**-0.073846**	**0.128488**
Manu	**(2.772602)**	(0.692802)	**(4.579662)**	(-0.36450)	**(-4.65111)**	**(5.349039)**
	0.010092	0.019623	-0.060905	**0.043633**	**-0.068098**	-0.036926
Manu(-1)	(0.603168)	(1.412084)	(-1.74392)	**(3.465217)**	**(-3.77132)**	(-1.744858)
	0.013946	**0.033472**	-0.004978	**-0.048491**	**-0.101837**	-9.78E-05
Manu(-2)	(0.885353)	**(2.364803)**	(-0.16676)	**(-3.55979)**	**(-5.31862)**	(-0.005199)
	-0.003807	-0.002334	-0.001285	-0.004368	**-0.006606**	-0.000691
Trend	(-1.798920)	(-1.163452)	(-0.61117)	(-1.79297)	**(-3.16206)**	(-0.343641)
	-0.923565	**-0.611269**	**-0.569481**	**-0.330785**	**-1.486607**	**-0.989236**
Λ	**(-5.395431)**	**(-4.380293)**	**(-4.72706)**	**(-2.97073)**	**(-6.39556)**	**(-4.786687)**
R-squared	0.639997					

*t-statistics are in brackets.

Error Correction Model Results of Energy Use Equation

Table 8 Error Correction Model Results for Heterogeneous Panel with Trend
Dependent Variable Energy Use (Sample Period Adjusted: 1974-2005)
Cross-sections 23, total pool (balanced) observations:736

	Countries					
	Algeria	Bolivia	Chile	China	Costa Rica	Ecuador
Variables						
	0.201466	**0.244877**	0.350468	**0.732975**	0.030640	0.135813
ENG(-1)	(1.553726)*	**(2.002443)**	(1.809546)	**(2.722768)**	(0.198520)	(0.999813)
ENG(-2)	It	Was	found	insignificant	in all	Countries
	-0.045201	0.001205	**0.015380**	0.010891	-0.018556	-0.009403
FDI	**(-2.911306)**	(0.268705)	**(3.391023)**	(0.934030)	(-1.51704)	(-1.021919)
	0.016104	0.001537	0.002694	6.48E-08	**-0.032336**	**-0.017101**
FDI (-1)	(0.871193)	(0.360056)	(0.512529)	(5.58E-06)	**(-2.20068)**	**(-2.048031)**
	0.021859	0.002517	-0.004646	0.015513	**-0.035554**	0.003457
FDI (-2)	(1.492448)	(0.596408)	(-0.97981)	(1.393116)	**(-2.71906)**	(0.478875)
	0.012309	-0.000438	**0.013730**	0.014218	-0.005898	0.005336
Manu	**(2.200583)**	(-0.10565)	**(3.703204)**	(1.759683)	(-0.99062)	(1.098274)
Manu(-1)	It	Was	Found	insignificant	in all	Countries
Manu(-2)	It	Was	Found	insignificant	in all	Countries
	-0.005234	-0.001177	0.001197	-7.61E-05	**0.001753**	-0.001609
Trend	**(-4.675356)**	(-1.30834)	(1.320892)	(-0.092286)	**(2.090939)**	(-1.658661)
	-0.271771	**-0.303692**	**-0.238649**	**-0.750581**	**-0.565956**	**-0.292119**
Λ	**(-3.693607)**	**(-4.25091)**	**(-2.0044)**	**(-2.843445)**	**(-3.39676)**	**(-2.652485)**

* t-statistics are in brackets

Table 8 (cont.) Error Correction Model Results for Heterogeneous Panel with Trend
Dependent Variable Energy Use (Sample Period Adjusted: 1974-2005)
Cross-sections 23, total pool (balanced) observations: 736

	Countries					
	Egypt	Indonesia	Iran	Philippines	South Africa	Venezuela
Variables						
ENG(-1)	0.036370 (0.219007)	0.166653 (0.755354)	0.005959 (0.039945)	-0.026070 (-0.119581)	0.097486 (0.444690)	-0.242145 (-1.47103)
ENG(-2)	It	Was	Found	Insignificant	in all	Countries
FDI	0.000896 (0.172287)	-0.000342 (-0.051300)	**-0.072489** **(-2.89797)**	-0.004872 (-0.478478)	-0.006818 (-1.209963)	0.002445 (0.413011)
FDI(-1)	-0.007479 (-1.230224)	-0.002187 (-0.296161)	-0.027710 (-1.06902)	0.000840 (0.062627)	**-0.018316** **(-2.529250)**	0.008348 (1.280654)
FDI(-2)	-0.003608 (-0.593780)	0.002777 (0.384933)	-0.004001 (-0.20514)	0.014996 (1.374935)	-0.008761 (-1.283326)	-0.001374 (-0.24581)
Manu	0.002515 (0.275187)	**0.016468** **(2.215448)**	-0.014407 (-1.85846)	**-0.031473** **(-2.03065)**	**0.020667** **(2.167590)**	-0.002988 (-0.67445)
Manu(-1)	It	Was	Found	Insignificant	in all	Countries
Manu(-2)	It	Was	Found	Insignificant	in all	Countries
Trend	**-0.002127** **(-2.475582)**	-0.000548 (-0.649435)	-0.001072 (-1.20431)	0.000235 (0.298359)	-0.000633 (-0.749046)	**-0.002944** **(-2.84869)**
Λ	**-0.281653** **(-2.952793)**	-0.271019 (-1.696544)	**-0.703780** **(-3.61626)**	-0.316565 (-1.532401)	-0.273673 (-1.812924)	**-0.232063** **(-2.56347)**
R-squared	0.511032					

*t-statistics are in brackets.

Table 9 Error Correction Model Results for Heterogeneous Panel with Trend
Dependent Variable Energy Use (Sample Period Adjusted: 1974-2005)
Cross-sections 23 (General-to-specific)
Total pool (balanced) observations: 736

	Countries					
	Algeria	Bolivia	Chile	China	Colombia	Costa Rica
Variables						
ENG(-1)	0.184825 (1.470726)*	**0.335073** **(3.010961)**	0.258873 (1.615085)	**0.652401** **(3.041272)**	-0.257286 (-0.921965)	0.106626 (0.807969)
FDI	**-0.043894** **(-2.967131)**	0.003851 (0.952907)	**0.015233** **(3.662386)**	0.007757 (0.698696)	0.001437 (0.190179)	-0.018529 (-1.638755)
FDI (-1)	-0.003124 (-0.200633)	0.003020 (0.748113)	0.004215 (0.889030)	-0.004607 (-0.421145)	0.011460 (1.398934)	-0.024726 (-1.878390)
FDI (-2)	0.011084 (0.961813)	0.002374 (0.583701)	-0.004315 (-0.97101)	0.013411 (1.245873)	-0.001120 (-0.109100)	**-0.028138** **(-2.497785)**
Manu	0.009108 (1.740212)	-0.003298 (-1.005238)	**0.014007** **(4.808600)**	0.015035 (1.952168)	-0.002397 (-0.332619)	-0.003400 (-0.595958)
Trend	**-0.003948** **(-4.150315)**	**-0.001671** **(-2.120308)**	0.001284 (1.486563)	0.000180 (0.233227)	**-0.001921** **(-2.160347)**	0.001586 (1.996888)
Λ	**-0.210893** **(-3.363322)**	**-0.280473** **(-4.224543)**	-0.215588 (-1.93160)	**-0.465252** **(-2.397327)**	-0.065884 (-0.647624)	**-0.606623** **(-4.309680)**

* t-statistics are in brackets.

Table 9 (cont.) Error Correction Model Results for Heterogeneous Panel with Trend
Dependent Variable Energy Use (Sample Period Adjusted: 1974-2005)
Cross-sections 23 (General-to-specific))
Total pool (balanced) observations: 736

	Countries						
	Egypt	Indonesia	Iran	Philippines	South Africa	Tunisia	Venezuela
Variables							
ENG(-1)	0.003313 (0.021165)*	0.061934 (0.312206)	-0.016960 (-0.1320)	-0.094630 (-0.513220)	0.069847 (0.355946)	-0.297941 (-1.54487)	-0.252420 (-1.786697)
FDI	-0.000303 (-0.065475)	-0.000245 (-0.03906)	**-0.060351** **(-2.7117)**	-0.006415 (-0.664045)	-0.005142 (-0.97408)	0.002605 (0.374465)	0.005806 (1.139064)
FDI (-1)	-0.007272 (-1.231242)	-0.002351 (-0.34186)	-0.020505 (-0.9140)	0.003368 (0.264654)	**-0.017547** **(-2.55160)**	-0.001680 (-0.25902)	0.010409 (1.997000)
FDI (-2)	-0.003159 (-0.551811)	0.006059 (0.895739)	-0.005475 (-0.3258)	0.017623 (1.706640)	-0.007587 (-1.30304)	-0.000287 (-0.04536)	-0.002232 (-0.470407)
Manu	0.002307 (0.274131)	**0.014928** **(2.120635)**	-0.013944 (-1.8901)	**-0.030136** **(-2.046721)**	**0.020776** **(2.244419)**	0.016599 (1.651534)	-0.004325 (-1.116491)
Trend	**-0.002034** **(-2.568956)**	-0.000692 (-0.87923)	-0.001140 (-1.3281)	0.000282 (0.370351)	-0.000684 (-0.87239)	**-0.001866** **(-2.27866)**	**-0.002854** **(-3.332323)**
Λ	**-0.236265** **(-3.041921)**	-0.231215 (-1.64362)	**-0.667532** **(-3.8150)**	-0.262167 (-1.419752)	-0.202906 (-1.56286)	**-0.328684** **(-2.10038)**	**-0.241899** **(-2.853407)**
R-squared	0.465675						

* t-statistics are in brackets.

Error Correction Model Results of BOD Equation

Table 10 Error Correction Model Results for Heterogeneous Panel with Trend
Dependent Variable BOD (Sample Period Adjusted: 1983-2000)
Cross-sections 20
Total pool (balanced) observations: 360

	Countries				
	Cameroon	Indonesia	Mexico	Morocco	Philippines
Variables					
BOD(-1)	-0.435494 (-0.86747)	**-1.337075** **(-3.254363)**	0.932713 (1.672406)	**0.797896** **(2.057820)**	**0.486722** **(2.242182)**
BOD(-2)	-0.414933 (-1.14737)	**-0.925245** **(-3.148584)**	0.483418 (1.498688)	0.264238 (0.853059)	0.133487 (0.485856)
FDI	0.011421 (0.533972)	0.119553 (1.799942)	**0.184330** **(3.721018)**	0.020584 (0.343539)	-0.020717 (-0.767225)
FDI (-1)	It was	Found	Insignificant	in all	Countries**
FDI (-2)	0.013953 (0.632471)	**-0.340060** **(-4.51732)**	-0.073624 (-1.147084)	-0.071750 (-1.02871)	-0.001308 (-0.045326)
Manu	0.005762 (0.373822)	**-0.063802** **(-2.006637)**	**0.081536** **(3.218261)**	**-0.090773** **(-2.02855)**	**0.114393** **(2.089819)**
Manu(-1)	-0.003818 (-0.27389)	**0.072846** **(2.022818)**	-0.031054 (-0.932266)	-0.068342 (-1.05210)	-0.070530 (-1.165424)
Manu(-2)	-0.004635 (-0.36360)	**0.105164** **(3.554588)**	-0.004863 (-0.224029)	-0.030280 (-0.68971)	0.050416 (0.609645)
Trend	**-0.012790** **(-2.17306)**	**-0.018741** **(-2.549564)**	8.15E-06 (0.001926)	3.57E-05 (0.006742)	0.009256 (1.784775)
Λ	-0.735532 (-1.29140)	0.308283 (0.590787)	**-2.603244** **(-3.753754)**	**-1.672424** **(-3.13489)**	**-0.667156** **(-2.507206)**
R-squared	0.788738				

* t-statistics are in brackets
** General-to-specific approach is not applied here because the estimation results were not meaningful after omitting the insignificant terms suggesting that we have an omitted variable problem.

Table 11: Summary of Results of CO_2 Equation

Variable	Total Number of Countries with Significant Coefficient	No. of Countries with –ve Significant Coefficient	No. of Countries with +ve Significant Coefficient
Trend	1	1	-
Lagged CO_2	3	1	2
FDII	4	1	3
MANU	7	2	5
Lagged Residual	8	8	-

Table 12: Summary of Results of Energy Use Equation *

Variable	Total Number of Countries with Significant Coefficient	No. of Countries with -ve Significant Coefficient	No. of Countries with +ve Significant Coefficient
Trend	4	3	1
Lagged ENG	2	-	2
FDII	6	5	1
MANU	5	1	4
Lagged Residual	10	10	-

*The results are before omitting insignificant variables.

Table 13: Summary of Results of Energy Use Equation *

Variable	Total Number of Countries with Significant Coefficient	No. of Countries with –ve Significant Coefficient	No. of Countries with +ve Significant Coefficient
Trend	6	6	-
Lagged ENG	2	-	2
FDII	5	4	1
MANU	4	1	3
Lagged Residual	10	10	-

* The results are after omitting the insignificant variables.

Table 14: Summary of Results of BOD Equation

Variable	Total Number of Countries with Significant Coefficient	No. of Countries with - ve Significant Coefficient	No. of Countries with +ve Significant Coefficient
Trend	2	2	-
Lagged BOD	3	1	2
FDI	2	1	1
MANU	4	2	2
Lagged Residual	5	5	-

TABLE 15: SUMMARY OF RESULTS & POLICY IMPLICATIONS

Countries	Results	Policy Implications
Algeria, Cameroon, Iran, and Mexico	1. FDI increases pollution (pollution havens hypothesis). 2. Manufacturing techniques are polluting the environment. 3. Granger causality results showed that FDI Granger-cause carbon dioxide in Algeria, Cameroon and Iran. 4. The empirical results suggest that FDI use polluting techniques in oil production in Algeria and Iran.	1. More efforts are needed to reduce pollution in these countries as there are two forces working together to increase it, namely, FDI and manufacturing activity. 2. Enforce stringent environmental laws and the use of environmental friendly techniques of production as stated in section 6.1. 3. These countries should consider the incentive compatibility approach to ensure regulations enforcement and compliance. 4. Spread through the mass media environmental awareness, teach children at schools about the importance of preserving the environment and do whatever needed to reduce pollution even if this entails changing consumption and production patterns. 5. One thing is left concerning Algeria and Iran which is to find means of controlling pollution from oil production such as to find other energy alternatives to oil so as to reduce its production. 6. Decisions should be made after weighing these costs with the benefits of preserving the environment and to look at long run effects and not only on the short run ones.
Guyana, Indonesia, South Africa and Costa Rica	FDI reduces pollution (pollution haloes hypothesis)	Analyze their FDI-environment policies to generalize it to other developing countries if possible.
Nine countries	pollution is decreasing over time	Analyze their policies promoting technical progress effect to assess their applicability to other developing countries.
Iran, Bolivia and Morocco	1. Persistence of emissions. 2. In Morocco, there is persistence in BOD emissions reflected by the positive significant coefficient of lagged BOD. FDI coefficient does not contribute to this as it was insignificant in Morocco. In addition, the coefficient of manufacturing value added was significantly negative; accordingly, manufacturing activity decreases BOD emissions. Hence, neither FDI nor manufacturing activity contributed to this persistence of BOD in Morocco which suggests that it could be related to such factors as agricultural activities or sewage discharges.	1. Carry out a policy mix between both approaches. That is to use command-and-control approach with economic incentive approach in environmental regulations. 2. Guarantee all the factors needed as a precondition for a successful non mandatory approach. 3. Use a policy mix between command-and-control approach and non mandatory approach. 4. Try non mandatory approach in a small scale in certain industries or certain sectors and once proven successful, this can be applied to a wider scale. 5. It is preferred then for Morocco to search for the real cause of persistence of BOD emissions and do the needed R&D to solve this problem.
Ecuador and Indonesia	emissions reduction	Analyze their emissions reduction policies to generalize it to other developing countries if possible.

China and Philippines	1. In both countries manufacturing and not FDI inflows, is the active polluting factor. 2. Nevertheless, this should not lead to ignore the effects of FDI in China because Granger causality results showed that FDI Granger-cause carbon dioxide emissions in China. 3. Little efforts are made to reduce pollution as there is persistence in the emissions as shown from the significantly positive coefficient of the lagged emissions. 4. As for Philippines, coefficient of manufacturing value added was negative in the energy use equation and positive in the BOD equation. A possible explanation for that is that the production techniques used in Philippines pollutes water through the discharge of factories industrial wastes in water. However, they do not result in air pollution.	1. Focus on how to encourage firms to use environmental friendly techniques in production. 2. Policies discussed earlier on reducing pollution emissions in section 6.1 should be encouraged as well. 3. Philippines should focus more on fighting water pollution. This could be through good monitoring of industrial discharges in water with continuous measurement of the BOD emissions and imposing penalties on the polluting firms.
Guyana, and Morocco	Environmental friendly techniques are used in manufacturing production.	Study their manufacturing techniques to be taken as a role model to other developing countries.
Egypt	1. FDI inflows in Egypt did not affect the environment. 2. Granger causality results showed that carbon dioxide Granger-cause FDI in Egypt. 3. Egypt suffered from lack of technological progress effect except for the case of emissions from energy use. 4. The coefficient of the trend term in the energy use equation was significantly negative for the case of Egypt which indicates a reduction in the levels of pollution over time. 5. The lack of an active policy to control pollution emissions.	1. Enforce stringent environmental laws 2. Avoid vague statements in the law and provided needed specifications. 3. Avoid individualistic decisions and adopt objective criteria to fight corruption. 4. Increase public awareness of methods of preserving the environment, hazardous wastes effects and polluting firms. This is to form a public pressure such as what happened in Agrium crisis. 5. Stop giving license to polluting industries such as cement, gypsum firms and foundries. 6. Give more incentives to polluting firms to encourage them to abide by the legal emissions standards and to incorporate the economic factor with the environmental factor in their decisions. 7. One possible option here is to use a policy mix between command-and-control regulatory approach and economic incentives approach. 8. Use environmental assessment to firms that are carried on annual basis. 9. Impose on new investment projects the inclusion of the social costs of environmental degradation among their total costs in their feasibility studies. 10. Always be updated with the new environmental techniques used in developed countries.