Environmental consequences of economic growth and foreign direct investment: evidence from panel data analysis

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Abstract

This paper is aimed at investigating non-linear relationship between foreign direct investment and environmental degradation using panel data of 110 developed and developing economies. The results indicated that environmental Kuznets curve exists and foreign direct investment increases environmental degradation.

Introduction

It is generally believed that Foreign Direct Investment (FDI) can have positive effect on host country's development efforts. In addition to being the main source of external capital, the inflow of foreign investment also helps in filling the resource gap between the targeted investment and locally mobilized savings as well as the gap between targeted foreign exchange requirements and those generated by net export earnings. Foreign direct investment also helps to develop managerial and specialized technological skills, innovations in the techniques of production, by means of training programmes and the process of learning by doing in the host country. Furthermore, FDI inflows also encourage the local enterprises to increase invest in the development projects and provides employment opportunities for both skilled and unskilled labor in the recipient country.

No doubt, FDI promotes economic growth but also impacts environment negatively (Xing and Kolstad 2002, He 2006). Environmental regulations are essential means of internalizing the external environmental cost of firms' economic activity. Therefore, in order to attract foreign investment, the governments of developing countries have a tendency to undermine environment concerns through relaxed or non-enforced regulation which is termed as *pollution haven hypothesis* in economic theory. As a result, companies like to shift their operations to these developing countries to take advantage of lower production cost which is known as *industrial flight hypothesis*. Both of these hypotheses lead to excessive pollution and degradation in environmental standard of the host countries. In contrast, it is also believed that foreign companies use better management practices and advanced technologies that result in clean environment in host countries (Zarsky 1999). This is known as *pollution haloes* hypothesis. This implies that trends in environmental damage due to foreign direct investment are unsustainable. The evidence from "pollution heaven" studies does not support general "industrial flight" hypothesis, but does argue that environmental regulations do influence some firms' locational decisions, particularly in resource and pollution intensive sectors. Empirical evidence also shows that in some sectors, particularly energy intensive and technology based, *pollution haloes* hypothesis is supported (Blackman and Wu 1998, BIAC 1999).

Economic growth through rapid industrialization and growing environmental consequences has generated a heated debate on how economic growth is linked with environment. The linkage of environmental quality with economic growth evoked much discussion in last decade. Empirical studies (e.g. Grossman and Krueger 1991, Selden and song 1994, Rothman 1998) supported an inverted U-shaped relationship between environmental degradation and economic growth. All of these studies supported the hypothesis that environmental degradation increases initially, reaches a maximum and after that declines as economy develops further. This systematic inverse U-shaped relationship has been termed as Environmental Kuznets Curve (EKC).

Table 1: Trends in FDIPC, GDPPC and CO_2PC of 110 Countries

Year	FDIPC (US $)	GDPPC (US $)	CO_2PC (metric tons)
1986-1990	75.58	4660.56	3.38
1991-1995	119.09	6025.87	3.53
1996-2000	259.64	6825.13	3.67
2000-2005	400.19	8307.06	3.82

Source: world development indicators (CD-ROM, 2010)

Since the beginning of economic reforms and opening up to the outside world in the early 1980s, FDI inflows and the resultant economic growth and carbon emission have increased very rapidly. For example, the average annual FDI per capita has reached to US$400.19 between 2000 and 2005, more than triple the amount for the period of 1991-1995 (see Table-1). As a result, the average annual GDP per capita has increased from US$6025.87 to US$8307.06 during the same time period. The unprecedented economic growth has been accompanied by the problem of environmental pollution. For example, the average annual CO_2 emissions per capita has increased from 3.38 metric tons in 1986 -1990 to 3.82 metric tons in 2000- 2005 (Table-1).

Therefore, the objective of our paper is to validate the relationship between FDI, environmental pollution and economic development. The contribution of present study is to model the environmental impacts of economic growth and foreign direct investment using time series data

of 110 developed and developing countries of the world by applying pooled regression, fixed effect and random effect models. Our results show that environmental Kuznets curve is validated in selected countries and foreign direct investment contributes to increase in environmental degradation.

II. Literature Review

Numerous studies have provided a theoretical rational for the impact of foreign direct investment on economic growth (e.g., Lucas 1988, Rebelo 1991, Romer 1986 and 1993). For instance, Romer (1993) pointed out that foreign direct investment can be an important source for transferring technological and business know-how to host countries and the transfer of technology through foreign direct investment may have substantial positive spillover effects for the overall economy. On the other hand, some theories predict that foreign direct investment in the presence of existing liberalization; deregulation and privatization policies will hurt resource allocations which in turn will slower the rate of economic growth (Boyd and Smith 1992). Theoretical literature also points out that the economic success of the countries has been achieved at the expense of their environment degradation. Grossman and Krueger (1995) have shown that economic growth leads to environmental degradation until GDP per capita of a country is less than US$ 8000 (1985). In this context, some researchers have investigated a relationship between economic growth and CO2 emissions termed as environmental Kuznets curve (EKC) which implies that economic growth deteriorates environment and improves it after certain level of per capita income during economic development process. Stern (2004) also provided the empirical support to EKC with the evidence that initially environmental degradation is increased and then falls with an increase in per capita income.

Many studies pointed out that foreign investors prefer to invest in those developing countries where environmental regulations are relatively relaxed (Smarzynska and Wei, 2001 and, Copeland and Taylor 2003). Thus, consistent increase in foreign direct investment in developing countries deteriorates environmental quality. On the contrary, Porter and van der Linde (1995) argued that environmental quality is a normal good, as economic growth improves with foreign inflows, developing countries tend to adopt more strict environmental regulations that saves the environment from deterioration.

Various studies have investigated the relationship between foreign direct investment and economic growth, foreign direct investment and environment, economic growth and environment and also foreign direct investment, economic growth and environment using cross-country and time-series data. Various models including non-linear and linear parametric models, semi parametric and non-parametric have been developed to investigate these relationships. However, empirical evidence is inconclusive. For instance, Alfaro (2003) examined the effect of foreign direct investment on economic growth of primary, manufacturing and services sector using cross- country data. The study could not support any clear relationship between foreign direct investment and economic growth. Author finds that foreign direct investment in primary sector has negative impact on growth; in manufacturing sector effect is positive while in services sector foreign direct investment has ambiguous impact on growth. Herzer et al. (2008) probed FDI–led growth hypothesis for 28 developing countries by applying Engle-Granger cointegration and error correction model for short run dynamics. They found neither long run nor short run relationship between foreign direct investment and economic growth in most countries. Moreover, Causality analysis could not provide clear evidence on direction of causality between foreign direct investment and economic growth.

Perman and Stern (2003) tried to validate the environmental Kuznets curve by using panel data approach to cointegration and confirmed the long run equilibrium stable relation between sulfur emissions and economic growth but failed to support the existence of the EKC. Similarly, Asici and Atil (2011) investigated causal relationship between economic growth and environmental degradation for the low, middle and high income countries. They applied fixed effect and fixed effect instrumental variables regression and concluded that positive effect of income on environment degradation is stronger in middle income countries as compared to low and high income economies. Moreover, in high income countries, the effect is not only negative but also statistically insignificant. Thus, the results do not provide support for EKC hypothesis.

Peter and Jeffrey (2003) argued that heavy dependence on foreign direct investment contributes to the growth of carbon dioxide emissions in less developed economies of the globe. However, domestic investment has no significant effect on CO2 emissions. Furthermore, study also suggested that foreign direct investment is more concentrated in industries which require more energy and as a result, energy emissions are increased and therefore, foreign investors prefer to invest in these industries in those countries where environmental laws are relatively flexible. Haffmann (2005) tested the direction of causality between foreign direct investment and environmental pollution in low, middle and high income countries of the globe. The study used Hurlin and Venet (2001) panel causality test to test the relationship between foreign direct investment and CO2 emissions. The results of panel causality test indicated that unidirectional causality is found running from foreign direct investment to energy emissions in middle income countries while CO2 emissions Granger cause foreign direct investment in low income economies and neutral hypothesis exists between both the variables in high income countries which imply the rejection of pollution heaven hypothesis in high income countries.

Beak and Koo (2009) investigated the interrelationship between foreign direct investment, economic growth and energy emissions in China and India. They found that foreign direct investment has positive and significant impact on energy consumption in China. In India, foreign direct investment deteriorates environment in the short-run while negative and insignificant effect of foreign direct investment on energy emissions is found in the long-run. Moreover, empirical evidence showed positive impact of economic growth on CO_2 emission indicating that economic growth worsens the environmental quality. Beak et al. (2009) attempted to investigate the relationship between economic growth and environment by incorporating trade openness. Their results showed adverse relationship of economic growth and trade openness on CO_2 emissions in developed countries and opposite inference can be drawn in developing countries. Lee (2010) investigated the link between economic growth, foreign direct investment and energy pollutants in case of Malaysia. The results indicated long run relationship between the variables when foreign direct investment is treated as dependent variable. The causality analysis showed unidirectional Granger causality running from foreign direct investment to economic growth, energy emissions to economic growth, foreign direct investment to energy pollutants in the

short run and economic growth granger causes foreign direct investment in the long run. Pao and Tsai (2011) conducted a study to address the effect of economic growth and foreign direct investment on environmental degradation using data of BRIC countries by applying panel cointegration. Their results confirmed long run relationship between the variables and provided support for the existence of environmental Kuznets curve (EKC). Moreover, causality analysis indicated bidirectional causal relationship between foreign direct investment and energy pollutants and economic growth granger causes foreign direct investment. This confirms the existence of pollution heaven and both halo and scale effects. Kim and Beak (2011) tested the environmental consequences of economic growth using ARDL bounds testing approach. Their results indicated that economic growth lowers the growth of energy emissions in developed world but the environmental quality is deteriorated during economic growth process in developing economies. Moreover, a rising demand for energy is major contributor to energy emissions and FDI has minimal effect on CO_2 emissions.

Only a few empirical studies have analyzed the relationship between foreign direct investment, economic growth and energy pollutants. In this study, we provide empirical evidence for the relationship between foreign direct investments, economic growth and energy emissions using non-linear model by applying pooled, fixed effect and random effect regressions. Moreover, we use data of 110 countries to test the hypothesis whether a consistent rise in foreign direct investment would improve environmental quality or not. The study intends to provide new insights for policy makers by focusing on the interrelationships between foreign direct investment, economic growth and environmental degradation. Our findings confirm the existence of EKC and foreign direct investment contributes to increase energy emissions.

The rest of the paper is organized as follows: Section-II details econometric methodology; Section-III interprets empirical findings and conclusion and policy implications are drawn in Section-IV.

2. Econometric Methodology

This empirical investigation probes the relationship between economic growth, foreign direct investment and energy emissions using panel data approach for 110 developed and developing

economies of the globe over the period 1985-2006. The data source of the variables is "World Development Indicators" (CD-ROM, 2010) by World Bank. The review of relevant literature allows constructing an algebraic model given below for empirical investigation:

$$\ln C_{it} = \alpha_1 + \alpha_2 \ln Y_{it} + \alpha_3 Y_{it}^2 + \alpha_4 \ln F_{it} + \mu_i \qquad (1)$$

To investigate the monotonic effect of foreign direct investment on carbon emissions, the following model will be used for empirical investigation:

$$\ln C_{it} = \beta_1 + \beta_4 \ln F_{it} + \beta_5 \ln F_{it}^2 + \mu_i \qquad (2)$$

We have used carbon dioxide emission per capita (in metric tons) as an indicator of environmental degradation (C_{it}). Carbon emission is the main gas which is responsible for generating greenhouse effect and global warming. The linear and non-linear terms of GDP per capita (Y_{it} & Y_{it}^2) have included in the model to validate the existence of Environmental Kuznets curve (EKC). EKC implies that environmental degradation increases with economic growth and environmental quality starts to improve after certain level of income. The theoretical expectation is that the coefficients which represent that these variables should be positive and negative with significance i.e. $\partial Y_{it} / \partial C_{it} > 0$ and $\partial Y_{it}^2 / \partial C_{it} < 0$. The other explanatory variable is foreign direct investment per capita (F_{it}) and the justification for the inclusion of this variable is that as the flow of foreign direct investment increases, environmental degradation also increases particularly in developing countries in equation (1). We have included squared term of foreign direct investment per capita (F_{it}^2) to examine monotonic effect of foreign direct investment on environmental degradation in equation (2). The economic theory reveals that initially, an increase in foreign direct investment is linked with a rise in energy emissions in developing or host countries, after reaching a certain level, foreign direct investment lowers CO_2 emissions as MNCs adopt new technology to enhance output with less emissions. The expected signs should be $\partial F_{it} / \partial C_{it} > 0$ and $\partial F_{it}^2 / \partial C_{it} < 0$. The expected signs would be $\partial F_{it} / \partial C_{it} > 0$

and $\partial F_{it}^2 / \partial C_{it} > 0$, if MNCs find relax regarding environmental law then they enhance their production at the cost of environment.

In relevant economic literature, different approaches are used to analyze dynamic relationship between economic growth, foreign direct investment and environment. These approaches are: (i) pooled ordinary least square (POLS), (ii) one-way fixed effects (OEF). It should be noted that fixed effects approach is better in case of unobservable country-effects and unobservable time-effects and (iii) one way random effects is also used (Baltagi 2001). Johnston and Dinardo (1997) considered that panel data model is useful because it handles problem of relevant omitted variables. Moreover, panel data model accommodates the special heterogeneity which is indicated by region specific, non-observable and time invariant intercepts. This implies that panel data controls for non-observable effects by means of two different models: a fixed effect model and a random effect model.

In this study, we prefer the fixed effect approach since the random effect estimation requires that omitted variables must be uncorrelated with the included right hand side variables for the same country which seems unrealistic in the context of our selected models. Moreover, fixed effect model is a suitable approach that assumed the slope of the equation is the same for all individuals, but there are specific intercepts for each of them that it would be correlated or uncorrelated with explanatory variables. In order to distinguish between fixed effect and random effect models, we apply Hausman test to test whether explanatory variables and individual effect are uncorrelated or not. The fixed effect estimates are consistent with both null and alternative hypotheses, whereas random effect estimates are only compatible with null hypothesis. Therefore, random effect model is preferred when null hypothesis holds otherwise fixed effect method can be applicable.

3. Empirical Results

Results of regression analysis of pooled OLS models are presented in Table-1.For the pooled regression, all estimated results reveal that linear and non-linear terms of income per capita i.e. $Y_{it} \& Y_{it}^2$ have positive and negative effect respectively on energy emissions confirming the existence of inverted U-shaped relationship between economic growth and environmental

degradation. This relationship between income per capita and energy emissions is termed as environmental Kuznets curve (EKC) which implies that environmental quality improves with an increase in per capita income after certain level of income has been reached in developing economies of the world. The effect of foreign direct investment on energy emissions is positive but is statistically insignificant. The coefficient of determination is 0.8135 which indicates that Carbon dioxide emission is 81% explained by economic growth and foreign direct investment and very minimal is by other factors. The F-test is also significant indicating the best fit of the estimated model.

Table-1: Pooled OLS

Variables	**Dependent Variable =** $\ln C_{it}$		
	Coefficient	**T-statistic**	**P-value**
$\ln Y_{it}$	2.5288*	25.5692	0.0000
$\ln Y_{it}^2$	-0.1029*	-16.5967	0.0000
$\ln F_{it}$	0.0099	1.3943	0.1660
R^2	0.8135		
$Adj-R^2$	0.8132		
F-Statistic	3511.85*		
Variables	**Dependent Variable =** $\ln C_{it}$		
	Coefficient	**T-statistic**	**P-value**
$\ln F_{it}$	0.0488*	2.8016	0.0051
$\ln F_{it}^2$	0.2043*	21.5948	0.0000
R^2	0.4832		
$Adj-R^2$	0.4828		
F-Statistic	1126.786*		

Note: * indicates significant at 1% level.

In second pooled regressions, both linear and non-linear terms of foreign direct investment have positive and statistically significant effect on CO_2 emissions which implies that an increase in foreign direct investment is a major contributor to environmental degradation. The value of R^2 is 0.4832 which is slightly good. The F-statistic measures the overall goodness of fit of the model and it is statistically significant.

Table 2: Fixed and Random Effect Models

Dependent Variable = $\ln C_{it}$						
Variables	**Fixed Effect Model**			**Random Effect Model**		
	Coefficient	**T-statistic**	**P-value**	**Coefficient**	**T-statistic**	**P-value**
$\ln Y_{it}$	0.9868*	9.8091	0.0000	1.1360*	11.2142	0.0000
$\ln Y_{it}^2$	-0.0387*	-6.0468	0.0000	-0.0409*	-6.3906	0.0000
$\ln F_{it}$	0.0092**	2.6285	0.0096	0.0073**	2.0277	0.0456
R^2	0.8131			0.8121		
F-Statistic	157.98*			282.457*		
Hausman Test	198.42*					
Dependent Variable = $\ln C_{it}$						
Variables	**Fixed Effect Model**			**Random Effect Model**		
	Coefficient	**T-statistic**	**P-value**	**Coefficient**	**T-statistic**	**P-value**
$\ln F_{it}$	0.0138*	2.8726	0.0041	0.0147*	3.0547	0.0023
$\ln F_{it}^2$	0.0147*	4.6964	0.0000	0.0180*	5.7607	0.0000
R^2	0.4765			0.4782		
F-Statistic	41.061*			105.26*		
Hausman Test	118.114*					

Note: * and ** indicates significant at 1% and 5% level respectively.

We have also applied fixed effect and random effect models to test the robustness of estimated results. To compare the fixed effect model (FEM) with random effect model (REM), Hausman test is applied. The value of Hausman test is significant which indicates that fixed effect model (FEM) is a better choice for the analysis as compared to random effect model (REM). The results of fixed effect and random effect models are consistent with pooled OLS results which corroborates the existence of environmental Kuznets curve (EKC). Furthermore, positive relationship is found between foreign direct investment and environmental degradation represented both by linear and non-linear terms of FDI in 110 countries of the globe. This positive effect of foreign direct investment provides support for the *halo effect* and *scale effect* among the selected 110 developed and developing countries. These findings are contrary to those Kim and Beck (2011) who reported that foreign direct investment has minimal effect on environmental quality.

4. Concluding Remarks

The objective of present study is to test the economic growth-environment and foreign direct investment-environment nexuses. Although, numerous studies have investigated the said issues using time series and cross-sectional data sets separately. This study attempted to examine environmental consequence of economic growth and foreign direct investment using data of 110 developing and developed nations of the world by applying pooled regression along with fixed and random effect models.

Our results by pooled regression, fixed and random effects model validates an inverted U-shaped and significant relation between environmental degradation and economic growth termed as environmental Kuznets curve (EKC) in selected 110 developed and developing economies. Furthermore, our empirical evidence shows that a consistent rise in foreign direct investment is contributing to CO_2 emissions.

Our estimated results contain four practical interpretations. First, by developing economies may use slack regulations regarding environment to participate in race of FDI competition in the absence of FDI-attracting factors such as infrastructure and skilled labor force etc. Secondly, developing countries are unable to afford high cost of executing and monitoring the environmental rules and regulations to minimize environment deterioration due to the existence of innocent pollution heaven hypothesis. Thirdly, multinationals should pay attention to use advanced and efficient i.e. greener technology to enhance their output which not only improves environmental quality but also lowers per unit cost. Finally, multinationals should play their role to save environment from degradation by improving the industrial capacity in host countries. Moreover, developing economies of the world should set tariff regulations to duck environmental degradation. Emerging and transitional economies must enthusiastically encourage environmental protection by technological transmission and know-how from developed countries to save the environmental quality and natural resources consumption.

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APPENDIX

High Income Countries	Middle Income Countries	Low Income Countries
Antigua and Barbuda	Bulgaria	Burkina Faso
Australia	Cameroon	Burundi
Austria	Cape Verde	Benin
Finland	Botswana	Congo Dem Rep
Italy	Grenada	Cote d'Ivoire
Malta	Dominica	Ethiopia
Bahamas The	Equator	Mali
Bahrain	Fiji	Kenya
Barbados	Gabon	Central African Republic
Belgium	Jamaica	Chad
Canada	Jordan	Comoros
Cyprus	Belize	Gambia The
Denmark	Bolivia	Ghana
Singapore	Costa Rica	Guinea
Switzerland	Congo Rep	Guinea Bissau
Trinidad and Togo	Honduras	Mozambique
Ireland	Guatemala	Leo P.D.R.
Greece	Iran	Liberia
Neither land The	Guyana	Madagascar
New Zealand	Namibia	Malawi
Portugal	Nicaragua	Sri Lanka
Saudi Arabia	Panama	Bangladesh
Norway	Lebanon	Papua New Guinea
Spain	Libya	Yemen Rep
Sweden	Maldives	Nepal
United States	Oman	Niger
United Kingdom	Rwanda	Nigeria
Japan	Senegal	Pakistan
Iceland	Sierra Leona	Solomon Islands
France	St Kitts Nevis	India
	St Lucia	
	Seychelles	
	Togo	
	Tunisia	
	Mauritius	

	Paraguay	
	Samoa	
	Surinam	
	Swaziland	
	Sudan	
	Vanuatu	
	Tanzania	
	Venezuela RB de	
	Vietnam	
	Zimbabwe	
	Uruguay	
	Mauritania	
	Uganda	
	Tonga	
	Zambia	