Income Heterogeneity and the Pollution Haven and Halo Hypotheses: Empirical Evidence from Developing Countries

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Abstract. Foreign direct investment (FDI) is commonly perceived as a catalyst for fostering economic growth in recipient nations. Nevertheless, new research findings indicate that multinational corporations may employ a specific approach to exporting pollution from nations with rigorous environmental regulations to emerging countries with less stringent legislation. This research investigates the influence of FDI on the environmental conditions of 80 developing nations from 2000 to 2019. The study employs the Least Squares Dummy Variable Corrected (LSDVC) methodology to analyse the data. The findings suggest that there exists a direct correlation between the influx of FDI and the occurrence of environmental contamination within developing nations. Nevertheless, it has been shown that there exists a noteworthy positive correlation between FDI and environmental deterioration, specifically in the case of nations classified as upper-middle-income nations. Furthermore, the findings substantiate a noteworthy correlation between the deterioration of the environment and the expansion of the economy, FDI, energy consumption, and population density. The findings of this study provide empirical support for the presence of both the Pollution Haven Hypothesis (PHH) and the Environmental Kuznets Curve (EKC) in middle-income nations. Additionally, this study offers recommendations aimed at assisting developing countries in their efforts to address environmental degradation.

1 Introduction

Many developing nations encounter a scarcity of financial resources in their pursuit of sustainable development objectives. It is not uncommon to encounter a situation where actual capital falls significantly below the required capital to achieve the objective of economic growth. As a result, numerous nations, particularly developing nations, rely on external financial sources to bridge the deficit, emphasizing the significance of foreign direct investment (FDI) in fostering economic progress. Undoubtedly, in response to this phenomenon, a majority of nations have undertaken measures to liberalise their capital, leading to a substantial surge in cross-border capital movements between countries. Consequently, the significance of inclusive growth for all nations has been emphasised by the global economy, rendering it a crucial element of the sustainable development goal (SDG). There has been a substantial rise in FDI globally, particularly within the past twenty years, since FDI enhance the economic development of host countries through the expansion of investment and competitiveness [1, 2]. However, the increase in FDI leads to concerns and potential implications for environmental sustainability. [3].

The significance of FDI cannot be overemphasised, considering the dual concerns of environmental preservation and economic development. Furthermore, there has been a proposition suggesting that FDI contributes to the transfer of knowledge to industrialised nations. In addition to several other purposes, FDI is a crucial tool in attaining both economic expansion and promoting environmental quality. Therefore, the impact of FDI on the environment remains a subject of contention. In light of their potential influence on emissions, the recent consideration of FDI as an additional determining factor of environmental sustainability has emerged [3, 4, 5, 6, 7]. There are two opposing views on the relationship between FDI and the environment.

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Environmental protection requires the integration of ecologically sustainable processes and technology into manufacturing operations. However, these inventions are associated with significant costs, making it difficult for most industrialised nations to afford their implementation. However, it is possible to transfer these advances to these countries through FDI, leading to the achievement of environmental sustainability. This provides evidence in favour of a negative correlation between FDI and environmental sustainability. Specifically, FDI is found to enhance environmental efficiency by reducing carbon dioxide (CO2) emissions. However, this phenomenon is commonly referred to as a "pollution halo." The Pollution Halo Hypothesis (PHH) places its emphasis on the environmental efficiency of multinational corporations in relation to their domestic counterparts, rather than their market position. It is posited that FDI originating from external corporations have the potential to enhance the environment within a host nation, primarily by means of facilitating the transfer of cleaner technology and the implementation of more effective environmental management systems [8].

In contrast, the Pollution Haven Hypothesis (PHVH) posits that FDI has detrimental effects on the environment. The underlying justification for this hypothesis posits that FDI in developing nations is characterised by exploitative tendencies and frequently fails to facilitate the transfer of environmentally sustainable technology. Conversely, individuals relocate to these nations as a means of circumventing the rigorous environmental rules prevalent in many developing countries. Consequently, they exacerbate the environmental challenges faced by developing nations [7]. Despite the theoretical assertions, several investigations aimed at assessing these two ideas have not yet produced conclusive results [5, 9].

Majority of the investigations pertaining to the factors influencing the environmental mostly focus on the impact of income, either in conjunction with or independent of energy consumption [10-14]. This literature review explores the hypothesis of the Environmental Kuznets Curve (EKC) in a comprehensive manner. The EKC hypothesis suggests the presence of a non-linear relationship between income and environmental pollution. Specifically, it proposes an inverted U-shaped link, wherein an increase in income initially leads to a rise in pollution levels until a certain threshold is reached, after which pollution levels begin to decline [15, 16].

In this study, we examine the impact of FDI on carbon emissions in developing nations through the period spanning from 2000 to 2019. Despite the remarkable economic growth experienced by most developing nations over the past few decades, it is noteworthy that FDI and CO2 emissions have concurrently exhibited a steady upward trend in these countries. Consequently, it is imperative to examine the impact of FDI on environmental pollution in developing nations, given that a majority of existing research on FDI and emissions has neglected to consider a crucial determinant of emissions, namely energy consumption. Consequently, the objective of this analysis is to investigate the importance of FDI as a potential factor influencing environmental degradation. The investigation commences by providing a review of relevant literature pertaining to the relationship between FDI and environmental sustainability, with a particular focus on developing nations. Subsequently, these countries are categorised based on their respective income category, enabling an examination of the varying impact of FDI on environmental pollution across different income groups. The study used the bias-corrected least squares dummy variable (LSDVC) method given the nature of the data utilised in the analysis. In contrast to prior research, the present study enhances the body of knowledge by incorporating energy consumption into the relationship between FDI and the environment. Specifically, FDI is incorporated as an explanatory factor within the framework of the EKC model. The incorporation of these additional factors has the potential to mitigate the issues of misspecification and omitted variable bias that are evident in both the PHVH and EKC models. Furthermore, these additions have the capacity to significantly enhance the effectiveness of environmental policy. Existing research on FDI and its impact on the environment has yielded inconclusive findings about the relationship between FDI and the environment. The actual performance of the PH, PHH, or PHVH stand is significantly influenced by the prevailing local economic conditions. There is considerable variation in economic patterns across different countries. The phenomenon being discussed is commonly known as heterogeneity, which primarily encompasses factors such as economic growth, income levels, legal frameworks, intricate collaborations between the government and the market, environmental laws, the rise of non-state-owned economies, and the expansion of commodities markets, among other related aspects. These variables influence the stability and magnitudes of FDI, hence influencing the impact of FDI on the local environment and potentially resulting in inconclusive outcomes. [17-19]. However, research that considers the income heterogeneity of countries are rare. This study addresses these research gaps by categorising developing countries based on their income levels (high, middle and low-income countries).

The paper is organised as follows: in Section 1.2, related literature, an empirical review of relevant literature is provided. Section 2 discusses the methodology, which includes the data description and empirical model. The empirical results are discussed in Section 3, while the conclusion and policy recommendations are discussed in Section 4.

2 Materials and Methods

In order to examine the relationship between FDI and the environment, this study utilised a balanced panel dataset consisting of 80 developing nations across the time span from 2000 to 2019. The data utilised for this analysis was obtained from the World Development Indicators (WDI). Nonetheless, the selection of the scope is determined by the data accessibility pertaining to our dependent variable, namely CO_2 emissions, as obtained in the WDI. The association between FDI and pollution is represented by a mathematical function, where pollution is considered the outcome variable and FDI is regarded as the explanatory variable [20]. Given the context, we proceed to define our model as follows:

$$ED_{it} = \alpha + \Theta X_{it} + \mathcal{E}_{it} \quad (1)$$

In this context, the variable ED represents environmental degradation, specifically in relation to CO_2 emissions. The vector X denotes the set of factors that influence these emissions, while $\mathcal{E}$ represents the standard error. The individual countries and period are denoted by the variables *i* and *t*, respectively. In accordance with [20], we hereby present our functional model as follows:

$$ED_{it} = \alpha + \Theta_1 FDI_{it} + \Theta_2 EC_{it} + \Theta_3 GDPC_{it} + \Theta_4 GDPC_{it}^2 + \Theta_5 PD_{it} + \mathcal{E}_{it} \quad (2)$$

In this context, FDI refers to foreign direct investment, EC represents energy consumption, GDPC signifies economic growth, and GDP^2 represents the squared value of GDPC. Additionally, PD denotes population density, α represents the intercept, and $\Theta_1, \Theta_2, \Theta_3, \Theta_3, 4_4$, and Θ_5, are vectors of coefficients. The symbols ED, $\mathcal{E}$, and the subscripts i and t in equation (1) retain their respective definitions

Typically, while modelling dynamic panel data, it is necessary to include the lagged dependent variable as an explanatory variable. In addition, the estimation of a dynamic panel model using a finite time series frequently yields imprecise asymptotic estimates and may potentially lead to type 1 error [21]. However, in their study, researchers [22-25] proposed the LSDVC estimator as a solution to this problem. This estimator is more effective than other instrumental and least squares estimators, such as GMMs, which have been found to be inefficient when dealing with a relatively small sample size [26]. In accordance with [27], equation (2) is extended to incorporate a dynamic panel model that exhibits first-order stationarity (AR1).

$$ED_{it} = \alpha + \Theta_1 ED_{it-1} + \Theta_2 FDI_{it} + \Theta_3 EC_{it} + \Theta_4 GDPC_{it} + \Theta_5 GDPC_{it}^2 + \Theta_6 PD_{it} + \mu_{it} + \mathcal{E}_{it} \quad (3)$$

The regression analysis examines the relationship between pollution and the lagged value of our dependent variable (EVD_{it-1}), as well as other factors that influence pollution. Furthermore, the error term is partitioned into a country-specific effect denoted as η_i and an error term ε_{it} with a variance of δ_ε^2. The variances of the LSDVC estimator are reported to be smaller than those of other estimators of the mean due to the utilisation of the bootstrapping technique, as opposed to the asymptotically effective GMM estimator. This is especially true in the context of a finite sample, where the LSDVC estimator offers more dependable estimates [23, 28, 29].

3 Empirical results and discussion

3.1 Empirical results

This research assesses the effects of FDI on the environment in developing nations from 2000 to 2019, utilising the LSDVC approach, as introduced by the Blundell and Bond estimator. The findings regarding the influence of FDI on environmental degradation in developing nations are presented in Table 1. The first result column presents the findings of the linear environmental model initiated by Blundell and Bond, while the second column presents the linear model initiated by Anderson and Hsiao. The justification for including the result from two separate estimators is to provide a robustness check for the main estimator (Blundell and Bond) in order to see the reliability or consistency of our result. However, further results are provided in Table 2 in order to test for the possible existence of the EKC hypothesis in developing countries. The findings presented in Table 1 demonstrate that FDI, population density and energy consumption exhibit statistical significance in both models. The coefficients of GDPC, FDI, energy consumption, and population density exhibit a positive correlation, indicating a favourable influence on environmental degradation within developing nations.

In addition, the favourable impact of FDI provides support for the PHVH in the context of developing nations. The coefficient associated with FDI demonstrates that a marginal increase of 1% in FDI is projected to result in an approximate 0.021% rise in CO2 emissions. This outcome aligns with prior empirical investigations such as [6, 9, 30]. The coefficient of energy consumption implies that a 1% increase in energy consumption will result in a 0.10% increase in CO2 emissions. While the results indicate that an increase in GDPC and population density will lead to a rise in CO2 emissions of about 0.3%, Generally, the results in the Blundell and Bond model and the Anderson and Hsiao model are similar in terms of both significance level and magnitude of effect.

Table 2 illustrates the effects of FDI on the environment, specifically by categorising emerging nations into different income groups. The columns labelled "BB" across all income groups present the results obtained from the Blundell & Bond estimator, while the columns labelled "AH" represent results that are obtained from the Anderson and Hsiao estimator. The findings indicate that environmental pollution is significantly influenced by factors such as energy consumption, GDP, and population density. FDI does not emerge as a substantial factor influencing environmental degradation in high-income nations. In contrast, FDI exhibits a significant influence on environmental degradation within middle-income nations, as well as low-income countries. The relationship between energy consumption and pollution is positive across all socioeconomic category, indicating that environmental pollution levels rise in tandem with increased energy consumption in these nations. The GDPC exhibits a favourable influence on pollution levels across various income categories within emerging nations. This observation implies that GDPC plays a crucial role in mitigating environmental degradation within these countries. This implies that the level of pollution in developing countries will increase as economic growth increases. In addition, population density has a negative coefficient across all income categories. It is interesting that this finding is only significant in high-income countries. This suggests that the spatial distribution of the people in urban areas within high-income nations plays a significant role in mitigating environmental degradation.

Table 1. Results for the Impact of FDI on Environment

	Developing Countries	
	Blundell & Bond	Anderson & Hsiao
	Model 1	Model 2
L.emission	0.753^{***}	0.686^{***}
	(0.000)	(0.000)
FDI (inflows)	0.021^{***}	0.018^{***}
	(0.001)	(0.000)
Energy consumption	0.102^{***}	0.135^{***}
	(0.008)	(0.000)
GDPC	0.031^{**}	0.062^{**}
	(0.023)	(0.024)
Population density	0.027^{***}	0.029^{***}
	(0.000)	(0.000)
Observations	720	720
Number of countries	80	80

Note: the values in parentheses are *p*-values, where, ** $p < 0.05$, *** $p < 0.01$.

The quadratic form of the EKC hypothesis is utilised in Table 3 to illustrate the effects of FDI on the environment. The relevant variables in this model are GDPC and $GDPC^2$, which are used to assess the validity of the EKC hypothesis for different income groups. The results indicate that GDPC is consistently positive across all income groups, while $GDPC^2$ is negative and significant in the high and upper middle income categories. This suggests that the level of pollution in high- and upper middle-income countries decreases after reaching a certain threshold, as their incomes continue to increase. A negative coefficient of $GDPC^2$ suggests a decline in pollution in these countries once a certain threshold is reached. Therefore, the results support the validity of the EKC hypothesis in high- and upper middle-income countries. Nevertheless, the findings did not provide empirical support for the validity of the EKC in low- and middle-income nations.

3.2 Discussion of findings

The present study investigated the influence of FDI on the environment from 2000 to 2019. The countries are subdivided into various groups in order to analyse the potential variations in income levels within the context of the interaction between FDI and the environment. The findings suggest a strong relationship between FDI and pollution levels. However, upon examination of the income levels of these nations, the findings indicate that FDI has a detrimental effect on environment in upper middle-income countries. Conversely, FDI has no substantial impact on the environment in high-, and lower middle-income and low-income countries. This suggests that some developing countries have seen positive effects from FDI, without transferring pollution to these nations.

The obtained result demonstrates the soundness of the PHVH, hence implying a positive relationship between FDI and emissions. This suggests that developed countries export pollution to underdeveloped countries due to their laxer environmental regulations. This result provides empirical evidence to previous studies [20, 31-33]. However, divergent results were observed when the countries were classified into different income levels. The validation of the PHVH has been observed only in upper middle-income nations given the positive impact of emissions. This finding is interesting, although it is peculiar to high-income developing countries where there are stringent environmental laws and huge investments in public transport systems such as the train system and other commuter services. This helps them reduce emissions even amidst high population density.

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Table 2. Results for the Impact of FDI on Environment by Income Groups

	High Income		Upper Middle Income		Low- and Lower Middle Income	
	BB	AH	BB	AH	BB	AH
L.emissions	1.231***	1.191***	0.930***	1.0540***	0.783***	1.802***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FDI	0.013	0.162	0.025***	0.156***	0.024**	0.601**
	(0.172)	(0.639)	(0.006)	(0.000)	(0.021)	(0.019)
Energy Consumption	0.068***	0.089***	0.735***	0.509***	0.473***	0.338***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GDPC	0.061***	0.004***	0.090**	0.006**	0.073**	0.058***
	(0.000)	(0.000)	(0.023)	(0.048)	(0.052)	(0.004)
Population Density	-0.073***	-0.018***	-0.020	-0.011	-0.021	-0.018
	(0.004)	(0.000)	(0.236)	(0.190)	(0.767)	(0.531)
Observations.	378	378	522	522	540	540
Countries	21	21	29	29	30	30

Note: BB and AH represent Blundell & Bond and Anderson & Hsiao estimators, respectively, values in parentheses are *p*-values, where, ** $p < 0.05$, *** $p < 0.01$.

Table 3. Results for the Impact of FDI on Environment in a Quadratic Form

	High Income		Upper Middle Income		Lower-Middle and Low Income	
	BB	AH	BB	AH	BB	AH
L.emissions	1.371***	0.981***	0.802***	1.212***	0.887***	1.773***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FDI	0.005	0.090	0.015***	0.172***	0.017	0.004
	(0.457)	(0.293)	(0.008)	(0.000)	(0.195)	(0.188)
Energy Consumption	0.064***	0.039***	0.285***	0.160***	0.228***	0.301***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GDPC	0.112**	0.100***	0.280**	0.122***	0.752***	0.635***
	(0.042)	(0.001)	(0.016)	(0.002)	(0.000)	(0.000)
$GDPC^2$	-0.050***	-0.008***	-0.030**	-0.104**	0.028	0.141
	(0.000)	(0.000)	(0.042)	(0.015)	(0.288)	(0.725)
Population Density	-0.073***	-0.042***	-0.020	-0.001	-0.001	-0.090
	(0.001)	(0.000)	(0.638)	(0.193)	(0.996)	(0.754)
Obs.	378	378	522	522	540	540
Countries	21	21	29	29	30	30

Note: BB and AH represent Blundell & Bond and Anderson & Hsiao estimators, respectively, values in parentheses are *p*-values, where, ** $p < 0.05$, *** $p < 0.01$.

The results of the study also indicate a substantial relationship between energy usage and emissions. The results presented in this study align with other empirical investigations, as evidenced by [3, 34]. Furthermore, the empirical findings demonstrate the existence of the EKC in developing nations when examining the complete panel. This suggests that pollution initially rises with income growth, but subsequently declines after surpassing a certain threshold due to a rapid increase in income, leading to efforts to mitigate pollution. This provides empirical evidence for [35, 36]. Nevertheless, our findings yielded a combination of outcomes when we classified the countries according to their respective income category. The findings of this study do not offer empirical evidence to substantiate the presence of the EKC in low-income nations. This suggests that the subsequent pollution levels in these countries have not yet reached a critical point. In this scenario, it is anticipated that these nations, will prioritise economic growth over environmental quality, with the intention of subsequently addressing and enhancing environmental conditions as their economies progress. Nevertheless, it has been observed that the EKC is evident in high- and upper-middle-income countries, indicating that these nations have reached their peak pollution levels. This observation aligns with the findings of [37], which indicate the existence of the EKC in upper-middle-income nations.

Finally, the results of our study indicate that there is a positive relationship between population density and increased consumption of energy-intensive commodities [35]. The findings of the study indicate that in high-income nations, the pollution is negatively affected by population density and urbanisation. This conclusion is drawn after conducting a detailed analysis of the countries, taking into account their income groups. The growth of populations in developed nations would result in the proliferation of natural monopoly industries and subsequently lead to a decrease in unit costs for public transport. This reduction in costs would likely encourage greater utilisation of public transport systems, so contributing to the mitigation of pollutants and the enhancement of environmental conditions. The notion that pollution cannot be solely attributed to a larger population level might be inferred [38].

4 Conclusion and policy recommendations

The primary objective of this study is to analyse the influence of FDI on the environment in developing nations from 2000 to 2019, utilising the LSDVC approach. The findings demonstrate the existence of a positive relationship between FDI and pollution in emerging nations. Nevertheless, it is worth noting that the estimates indicate a significant positive relationship between FDI and pollution, but only for upper middle-income countries.

Furthermore, the findings substantiate a notable relationship between the pollution and economic development, energy consumption, FDI, and population density. The findings of this study provide empirical support for the presence of both the PHVH and the EKC hypotheses in developing nations. However, these results do not offer evidence to substantiate the existence of these hypotheses in low-income countries. In a similar vein, it has been observed that there is a positive relationship between FDI and pollution in upper-middle-income countries. However, research findings indicate that the impact of FDI on the environment is not statistically significant in high-income and low-income countries. This suggests that pollution levels in these countries do not experience a significant change in response to an increase in net inflow of FDI. In contrast, the findings of our study indicate a positive relationship between population density and pollution.

The conclusions serve as the foundation for a range of policy suggestions concerning environmental legislation in emerging nations. The endeavour to safeguard the environment can be sustained, as empirical data has demonstrated a curvilinear association between pollution and economic growth, following an inverted U-shaped pattern. The data reveals a clear relationship between the rise in CO2 emissions in emerging nations throughout the past ten years and the potential implementation of a more cautious environmental strategy alongside sustained economic expansion. These nations will persist in their efforts to mitigate pollution while simultaneously fostering economic growth. The achievement of this objective can be facilitated by embracing manufacturing practises that are environmentally friendly, including green energy sources like bioenergy and thermal energy, and employing energy-efficient equipment to mitigate emissions and pollutants. Furthermore, given the substantial impact of energy usage, it is imperative for these nations to adopt energy-efficient and low-carbon measures in order to alleviate the environmental consequences of their energy consumption. It is not advisable or required to implement predatory FDI policies in developing countries. These nations stand to gain significant economic growth from foreign capital, while the environmental impact of FDI is generally minimal.

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