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# The Dual Impact of FDI on Environmental Quality in Host Countries: A Study on the Heterogeneity of Effects in Developing and Developed Nations

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**Abstract.** This study examines the dual impact of Foreign Direct Investment (FDI) on environmental quality in host countries, differentiating between developing and developed nations. Linear regression analysis of income-segmented data reveals that FDI reduces greenhouse gas emissions globally but increases pollution in middle-income countries while reducing it in high-income countries. Robustness checks validate these findings. FDI's environmental impacts vary with the host country's regulatory environment and development status. Positive impacts include advanced technology transfer and improved resource efficiency, while negative impacts involve the "pollution haven" effect and resource over-exploitation by foreign investors. To maximize benefits and minimize drawbacks, host governments should provide incentives for environmentally friendly investments, promote knowledge exchange, and enforce robust environmental regulations with clear policies and self-reporting mechanisms. These strategies can help host countries harness FDI's advantages while mitigating its environmental risks.

**Keywords:** FDI, environmental quality, dual impact of FDI, developing and developed nations

## 1. Introduction

Foreign Direct Investment (FDI) refers to the act whereby a business entity from a home country invests in projects or local firms within a host country. With the rise of economic globalisation and increasing attention to environmental issues, it is crucial to assess the dual impact of Foreign Direct Investment on the environmental quality of host countries. As a controversial method of facilitating capital flow on an international scale, FDI exhibits a myriad of impacts of varying degrees on the environmental quality of host countries. Depending on the developmental status of the host nations, the effects induced by FDI reveal a complex and diverse nature. Hence, delving into the characteristics and specific manifestations of the impacts caused by FDI becomes particularly pivotal.

To evaluate the environmental repercussions of FDI in a more rational and dialectical manner, this essay employs empirical analysis to explore the nature of FDI's environmental impacts on host countries with different income and development levels, delineating both positive and negative aspects. Subsequently, adopting a logical deduction approach and integrating perspectives from previous literature with conclusions drawn from empirical analysis, this article elaborates in greater detail on the logical chain of effects, elucidating the positive and negative environmental impacts FDI engenders in host countries.

## 2. Methodology and Empirical Analysis

This section employs linear regression analysis for empirical investigation. Initially, a fundamental model based on linear regression is utilized to assess the impact of Foreign Direct Investment (FDI) on environmental indicators, with N2O emissions, a prevalent greenhouse gas, serving as the evaluative metric [1]. Moreover, the selected countries are categorized into two groups based on income levels, and linear regression analysis is conducted separately for each group to explore the correlation between FDI and environmental indicators. Consequently, the study concludes by delineating the nature of FDI's environmental impact on host nations across different income tiers [2].

 

## 2.1. Model Design and Variable Presentation

Assume the existing environmental indicator E, the inflow of FDI A, and various control variables X.

The regression model is as follows:

$$E=\beta 0+\beta 1A+\beta 2X+\varepsilon$$

where epsilon represents the error term.

Per the aforementioned model, variables are delineated as follows:

Explanatory variable: Foreign Direct Investment, net inflows (% of GDP), denoted as FDI.

Dependent variable: Nitrous Oxide emissions (kt of CO2 equivalent), denoted as N2O. Control variables: Annual freshwater withdrawal (billion cubic meters), denoted as FW; Gross National Income per capita, Atlas method (current US$), denoted as GNI; Renewable energy consumption (% of total final energy consumption), denoted as RE. To enhance data stability, natural logarithms (ln) are applied to all variables except FDI, due to the inclusion of negative values in FDI, for which original values are retained.

## 2.2. Descriptive Statistics

After grouping the countries by income level, the descriptive statistics for each variable are shown in Table 1, with the grouping based on the World Bank criteria [3].

**Table 1.** Descriptive statistics: N mean sd min max by income standard

Middle-income countries

| VARIABLES | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| FDI | 93 | 2.3350 | 1.5610 | -0.0601 | 5.9870 |
| N2O | 93 | 11.5660 | 1.2990 | 9.7870 | 13.2210 |
| GNIPC | 93 | 8.2380 | 0.8650 | 5.9910 | 9.4530 |
| FW | 93 | 4.3640 | 1.5150 | 2.5440 | 6.4040 |
| RE | 93 | 3.0860 | 0.6410 | 2.0440 | 3.9130 |

High-income countries

| VARIABLES | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| FDI | 93 | 1.6880 | 2.0720 | -.7250 | 12.7320 |
| N2O | 93 | 10.4840 | 0.3670 | 9.825 | 11.1150 |
| GNIPC | 93 | 10.4640 | 0.2870 | 9.935 | 10.8740 |
| FW | 93 | 3.9010 | 0.4170 | 3.196 | 4.5150 |
| RE | 93 | 2.1520 | 0.8280 | .6880 | 3.1720 |

In this study, a sample comprising three nations was selected for the high-income country group, specifically Canada, Germany, and Japan. Similarly, the developing country group included data samples from three nations: South Africa, Brazil, and China. By contrasting the data from these groups, we can gain a macro-level understanding of the variations in the volume of FDI received by different income country groups and the corresponding values of various pollution indicators. Notably, the disparity in data indicators within the same group among different countries is marginal. Moreover, a comparison between the selected groups of countries with varying income levels reveals that, on average, the middle-income country group has received more FDI than the high-income group. Concurrently, the values of several environmental pollution indicators suggest that the level of pollutant emissions in middle-income countries is more severe than in high-income countries. This indicates that FDI inflows in middle-income countries may have on the whole, exerted a certain negative impact on the environmental front.

## 2.3. Multicollinearity Test

To identify multicollinearity, this study employs the Variance Inflation Factor (VIF), as demonstrated in Table 2. The application of VIF facilitates the effective detection of multicollinearity and assessment of model stability by quantifying the strength of linear relationships among explanatory variables.

**Table 2.** Variance Inflation Factor

| | Variance inflation factor | |
|---|---|---|
| VARIABLES | VIF | 1/VIF |
| RE | 1.6020 | .6244 |
| GNIPC | 1.5580 | .6419 |
| FW | 1.2830 | .7797 |
| FDI | 1.2360 | .8094 |
| Mean VIF | 1.4190 | . |

According to Table 2, VIF is 1.4190 < 10, which indicates that there is no severe multicollinearity among the variables, allowing for subsequent testing.

## 2.4. Fixed Effect Model Analysis

To ascertain the chosen effect model's relevance and the joint significance of all individual effects in the panel data for this empirical analysis, an F-test was conducted on the variables and the results are shown in Table 3.

**Table 3.** F-test results

| VARIABLES | Fixed-effects model |
|---|---|
| FDI | -0.0117** |
| | (0.0051) |
| FW | 0.3830*** |
| | (0.0845) |
| GNIPC | 0.0893*** |
| RE | -0.1320*** |
| | (0.0319) |
| Constant | 8.9780*** |
| | (0.4570) |
| Observations | 186 |
| Number of Code | 6 |
| R-squared | 0.6030 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

F-test that all u_i=θ:F(5,176)=667.72, Prob>F=0.0000. The F-test is passed which indicates that the fixed effects model significantly outperforms the model without fixed effects.

## 2.5. Stationarity Test

To ensure the stationarity of the data, the Harris-Tzavalis unit-root test (HT) and the Im-Pesaran-Shin unit-root test (IPS) are employed, with the results shown in Table 4. As indicated by the variables, the stationarity of the data has been tested, allowing for the subsequent regression analysis to proceed.

**Table 4.** Results of HT and IPS

| VARIABLES | HT | IPS |
|---|---|---|
| FDI | -0.2476*** | -7.9100*** |
| N2O | -0.1018*** | -7.6678*** |

**Table 4.** Continued

| | | |
|---|---|---|
| FW | 0.4030*** | -4.6401*** |
| RE | 0.2328*** | -5.1711*** |
| GNIPC | 0.6001*** | -2.7512*** |

*** p<0.01, ** p<0.05, * p<0.1

## 2.6. Regression Analysis

To more accurately analyze the impact of FDI on the overall environment of the selected countries and the separate effects of FDI on groups of countries with different income levels, this essay first conducts a fixed-effects linear regression on the overall data, with results presented in Table 5.

**Table 5.** Fixed-effects linear regression on the overall data

| | All Countries |
|---|---|
| VARIABLES | N2O |
| FDI | -0.0117** |
| | (0.0051) |
| FW | 0.3830*** |
| | (0.0845) |
| GNIPC | 0.0893*** |
| | (0.0142) |
| RE | -0.1320*** |
| | (0.0319) |
| VARIABLES | N2O |
| Constant | 8.4180*** |
| | (0.3350) |
| Observations | 186 |
| Number of Code | 6 |
| R-squared | 0.9920 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

At the level of all selected countries, the explanatory variable FDI is significantly correlated with the dependent variable N2O at a 95% confidence level. With a coefficient value of -0.0117, this indicates a negative correlation between FDI and the environmental indicator N2O at the level of all countries. In other words, for every additional unit of FDI, there will be a corresponding decrease of 0.0117 units in N2O emissions. The R-squared value of the model is 0.992, which suggests that the model fits the data quite well. In order to further explore the impact of FDI on the environment in host countries with different income levels, this essay opts for group-based regression analysis categorized by country. The regression results are presented in Table 6.

**Table 6.** Group-based regression analysis categorized by country

| | Middle-income countries | High-income countries |
|---|---|---|
| VARIABLES | N2O | N2O |
| FDI | 0.0158** | -0.0186*** |
| | (0.0067) | (0.0056) |
| FW | 0.0730 | 0.1420 |
| | (0.0815) | (0.1880) |

**Table 6.** Continued

| | | |
|---|---|---|
| GNIPC | 0.2410*** | 0.0371 |
| | (0.0188) | (0.0555) |
| RE | 0.2080*** | -0.2370*** |
| | (0.0437) | (0.0534) |
| Constant | 7.0930*** | 10.5400*** |
| | (0.3090) | (1.2850) |
| Observations | 93 | 93 |
| R-squared | 0.9970 | 0.9400 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In middle-income host countries, the explanatory variable FDI is significantly correlated with the dependent variable N2O at a 95% confidence level. A coefficient value of 0.0158 shows that for every additional unit of FDI, there is an increase of 0.0158 units in N2O emissions.

Meanwhile, in high-income host countries, the explanatory variable FDI is significantly correlated with the dependent variable N2O at a 99% confidence level. A coefficient value of -0.0186 indicates every additional unit of FDI is associated with a decrease of 0.0186 units in N2O emissions. For these two stratified regression analyses, the R-squared values are 0.997 and 0.940, respectively. These high R-squared values demonstrate that the model fits the data well in both groups of countries.

## 2.7. Robustness Check

To test the reliability and robustness of the research findings, this essay employs Windsorization techniques, eliminating outliers by setting thresholds at the 2.5% and 97.5% percentiles.

**Table 7.** Regression Results for Nitrous Oxide (N2O) Emissions with and without Outlier Removal Across Different Income Groups

| | | Outlier Removal | |
|---|---|---|---|
| | Total Countries | Middle-income countries | High-income countries |
| VARIABLES | N2O | N2O | N2O |
| FDI | -0.0145* | 0.0145* | -0.0216** |
| | (0.0078) | (0.0086) | (0.0101) |
| GNIPC | 0.0792*** | 0.2190*** | 0.0790 |
| | (0.0187) | (0.0225) | (0.0688) |
| FW | 0.5170*** | 0.1010 | 0.2760 |
| | (0.0975) | (0.1060) | (0.2330) |
| RE | -0.0774** | 0.1720*** | -0.1900** |
| | (0.0375) | (0.0498) | (0.0724) |
| Constant | 8.0150*** | 7.2980*** | 9.4670*** |
| | (0.3950) | (0.3410) | (1.6120) |
| Observations | 147 | 73 | 75 |
| R-squared | 0.9920 | 0.9970 | 0.9300 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results which are displayed in Table 7 indicate that the core explanatory variable FDI is significant and the direction of its relationship with the dependent variable remains consistent with the previous regression analysis. This essay considers these results to exhibit strong robustness.

### 2.8. Conclusion

In summary, the conclusions from the empirical analysis suggest that, at the level of all countries, FDI has a positive effect on the host country's environment. When examining the data by national income categories, in middle-income host countries, FDI's impact on the environment is observed to be negative. Conversely, in high-income host countries, FDI's impact on the environment is found to be positive.

## 3. Elucidation of Impacts and Logical Deduction

The empirical analysis indicates that the environmental effects of Foreign Direct Investment (FDI) on host countries vary according to their income levels, manifesting in both positive and negative impacts as detailed subsequently.

### 3.1. Positive Impacts

a. The application and dissemination of more environmentally friendly emission reduction technologies and energy-efficient practices directly alleviate the environmental burden on host countries. Predominantly originating from developed nations or emerging economies with robust economic and technological backgrounds, FDI often brings production methodologies that are more conducive to emission reduction and pollution treatment technologies that are both energy-efficient and effective. This directly and significantly curtails pollution generated during production processes, enhances resource utilization and production efficiency, and mitigates the environmental stress on host countries. As per Zarsky [4], within the global context, markets influence environmental performance through mechanisms that include the transfer of more environmentally friendly pollution treatment technologies and the promotion of "green consumerism." As a crucial market behavior within this broader context, FDI also facilitates the transfer and dissemination of advanced technologies to predominantly less developed host countries with inadequate technology, thereby promoting the eco-friendly evolution of production methodologies. The influx, application, and dissemination of these new technologies and concepts also generate a positive "halo effect," a phenomenon also referred to as the pollution haven hypothesis.

b. In the context of Foreign Direct Investment (FDI) predominantly from more developed economies to less developed host nations, the influx of advanced environmental management systems and concepts of corporate social responsibility often subtly exerts a positive influence on the ideological sphere of host societies. This influence catalyzes a contemplation of sustainable development among production entities and enhances the host society's recognition of corporate social responsibility, indirectly engendering a profound and lasting positive impact on the host country's environment. Such effects are supported by empirical evidence; for instance, according to Gallagher & Zarsky [5], the manufacturing and export processing zones of Mexico, known as 'Maquiladoras,' experienced a notable enhancement in environmental technological standards and sustainable operational management levels following substantial FDI inflows from North America.

### 3.2. Negative Impacts

a. The "Pollution Haven" Phenomenon and Concentration of Pollution due to Regulatory Relaxation

Certain developing nations may lower entry thresholds and regulatory standards to attract Foreign Direct Investment (FDI), thereby willingly accommodating the industrial transfer of highly pollutive sectors [6]. Over time, due to a lenient regulatory environment and lower costs of environmental degradation, foreign investors may tend to reduce expenditures on pollution control to enhance profits, leading to increasingly severe and concentrated pollution emissions and environmental damage within high-pollution industries of the host countries.

b. Short-sighted and Aggressive Exploitation by Some Foreign Investors Exacerbates Otherwise Manageable Ecological Damage

Given the volatility and unpredictability of FDI, particularly in resource-intensive industries such as mining and energy extraction in less developed countries, some foreign investors prioritize short-term gains over long-term environmental sustainability, potentially leading to improper treatment of pollutants and over-exploitation [7]. Moreover, due to foreign investors' lack of understanding or disregard for the host country's regulatory laws and socio-cultural context, they may adopt more aggressive and extensive approaches to development and production, significantly worsening environmental damage that would otherwise be within manageable limits [8]. Such instances are widely observed.

## 4. Feasibility Recommendations

To optimize the positive impacts and mitigate the negative effects of FDI, this essay proposes

a. Host country governments can adopt an open and win-win attitude towards foreign investors, attracting them with policy incentives and tax benefits for direct investment in the host country. Furthermore, fostering active experience exchange between domestic and foreign enterprises through forums and similar platforms can provide collaborative opportunities for businesses globally. This approach facilitates the widespread dissemination and promotion of positive experiences gleaned from certain

countries, where FDI has been instrumental in fostering economic vitality while preserving the ecological environment. It can stimulate the exchange of investment experiences and the sharing of investment opportunities among enterprises [9]. Furthermore, such interactions can propel environmentally friendly technological enhancements.

b. Host country governments should enhance the development and refinement of environmental protection and pollutant emission regulations within their supervisory and enforcement domains. Additionally, amplifying the dissemination of such regulations is crucial to ensure foreign investors are informed and compliant. Establishing transparent, self-reporting mechanisms for enterprises, mandating regular reports on environmental pollution and remediation measures, can enhance oversight through public opinion. This can curb the tendency of enterprises to undertake risky ventures that compromise the environment in pursuit of excessive profits and cost savings, while also enhancing their sense of corporate social responsibility.

## 5. Conclusion

### 5.1. Major Findings

This study has explored the dual impact of Foreign Direct Investment (FDI) on the environmental quality of host countries, with a specific focus on the differing effects observed in developing and developed nations. Through linear regression analysis of data categorized by income levels, significant variations were identified in how FDI influences environmental indicators, particularly nitrous oxide (N2O) emissions. The results indicate that while FDI generally helps reduce greenhouse gas emissions globally, its effects differ substantially between middle-income and high-income countries. In middle-income countries, FDI tends to increase pollution levels, whereas in high-income countries, FDI contributes to a reduction in pollution. Robustness checks confirm the consistency of these findings, underscoring the validity of the empirical analysis.

### 5.2. Analysis of Impacts

The empirical evidence reveals both positive and negative impacts of FDI on environmental quality, shaped largely by the regulatory environment and development status of the host country. On the positive side, FDI often brings advanced technologies and practices from developed nations, leading to significant emission reductions and enhanced resource efficiency. Additionally, FDI introduces higher standards of environmental management and corporate social responsibility (CSR), fostering sustainable development in host countries. On the negative side, the "pollution haven" phenomenon occurs when developing countries relax environmental regulations to attract FDI, resulting in increased local pollution. Moreover, in resource-intensive industries, foreign investors may prioritize short-term profits over long-term sustainability, leading to over-exploitation and severe environmental damage.

### 5.3. Recommendations

To maximize the positive impacts and mitigate the negative effects of FDI on environmental quality, host country governments should adopt a strategic approach [10]. First, policy incentives and platforms for experience sharing should be established to attract environmentally friendly investments and promote knowledge exchange between domestic and foreign enterprises. This can enhance the dissemination of best practices and foster collaborative opportunities that benefit the environment. Second, strengthening the development and enforcement of environmental regulations is crucial. Clear and transparent policies, along with self-reporting mechanisms for enterprises, can ensure compliance and accountability, encouraging corporate social responsibility and reducing environmental risks. By implementing these strategies, host countries can harness the benefits of FDI while minimizing its adverse environmental impacts, thereby promoting sustainable development and environmental protection.

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