Int. Journal of Economics and Management 17 (3): 293-303 (2023)

IJEM
International Journal of Economics and Management
Journal homepage: http://www.ijem.upm.edu.my

Foreign Direct Investment and Its Impact on CO_2 Emissions at Various Levels of Economic Development

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ABSTRACT

Foreign direct investment (FDI) may have a negative impact on carbon dioxide (CO_2) emissions through imported technologies that cause air pollution. However, previous studies presented inconclusive results on the impact of FDI on CO_2 emissions. This indicates the possibility of other factors or different economic conditions that can explain the observed contradicting impacts of FDI on CO_2 emissions. This study examines the impact of FDI on CO_2 emissions at various levels of economic development. In a sample of 123 countries, results from the bias-corrected least-squares dummy variable (LSDVC) technique show that FDI asymmetrically affects CO_2 emissions. The presence of FDI lowers CO_2 emissions in countries with higher incomes and raises carbon emissions in countries with lower incomes. This finding also suggests that FDI inflows introduce greener technologies in high and middle-income countries. Meanwhile, dirty FDI flows into low-income countries and adversely affects the environment.

JEL Classification: F20, F23, Q53, Q56

Keywords: CO_2 Emissions; Economic Development; Foreign Direct Investment; Air Pollution; Bias-corrected Least Square Dummy Variable

Article history:
Received: 12 April 2023
Accepted: 4 December 2023

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DOI: http://doi.org/10.47836/ijeam.17.3.01

INTRODUCTION

CO_2 emissions can adversely affect the environmental quality and health of the population (Sabir et al., 2020). According to a report by the United Nations (2018), nine out of ten urban residents are exposed to polluted air. The financial costs sustained for respiratory diseases amounted to $610 billion, while 60,000 annual premature mortality were also linked to the impacts of pollution. As of 2015, pollution in China was believed to be the main cause of decreasing annual growth rates for forest biomass by 13 percent, rice by 8 percent, wheat by 6 percent, and total GDP by 7 percent. Feng et al. (2019) further noted annual losses in forest biomass, wheat, and rice to be approximated at $52 billion, $8 billion, and $11 billion, respectively.

Jalil and Mahmud (2009) argued that production-related activities are major contributors to CO_2 emissions. Sustaining positive economic growth requires a consistent increase in production. In most developing countries, there is limited availability of local funds to finance production. They may resort to foreign direct investment (FDI) as an effective and efficient source of funds. Previous findings argued that FDI supports economic growth via advanced technology transfer and employment (Azman-Saini et al., 2010; Burhan et al., 2018; Demena and van Bergeijk, 2019; Ibrahim et al., 2016; Moghadam et al., 2019; Shad et al., 2018). In global economies, the inflow of foreign investment increased substantially from approximately 550 billion dollars in 2003 to 2 trillion dollars in 2015 (UNCTAD, 2019).

Although many studies supported the importance of FDI to economic development (Ibrahim, 2009), FDI is believed to have a harmful effect on the environment (Feng et al., 2019). The Pollution Haven Hypothesis implies that industries with less green production avoid compliance by choosing countries that have less strict environmental laws. High CO_2 emissions from imported dirty technologies in these countries contribute to environmental degradation. On the other hand, the Pollution Halo Hypothesis argues that countries can benefit from clean technologies gained through FDI. FDI helps to enhance the sustainability of the environment in host countries that have strict environmental laws (Esty and Porter, 1998; Porter, 1991; Porter and Vander Linde, 1995). Less developed countries can also benefit from greener production methods promoted by environmentally friendly technology transfer from developed countries.

Following these theories, the study hypothesizes that different income levels amongst nations affect the outcome of FDI on the environment. The present paper argues that national economic and environmental agendas are determined based on individual income levels. Low-income nations prioritize economic growth even at the cost of environmental sustainability. On the contrary, developed or high-income countries emphasize sustainable growth and development while stressing the significance of environmental quality. Hence, FDI flowing to low and high-income countries bears different weights regarding environmental considerations.

Under the stated hypothesis, this study argues that compliance and enforcement are vital in achieving the targeted economic and environmental goals. Strong institutions in developed countries ensure compliance with sustainable economic growth and development. As developing low-income countries focus more on economic growth to cater to basic needs, institutions are less stringent in enforcing compliance and more willing to accommodate despite possible environmental risks. These arguments support that income level influences the relationship between FDI and environmental quality through institutions. Weak institutions are common in low-income countries, whereas quality institutions are more effective in developed high-income countries.

Empirical results from previous studies on the impact of FDI on CO_2 emissions are inconclusive. Earlier studies showed that dirty FDI moves to less strict countries to avoid complying with environmental laws in their home countries (Beck and Koo, 2009; Lee, 2010; Zhang, 2008). Other findings supported that environmental degradation and CO_2 emissions in low-income economies increase when FDI increases (Hakimi and Hamdi, 2016; Seker et al., 2015). In contrast, other studies suggested that technology transfer and diffusion resulting from FDI enhance the environmental quality in the receiving countries (Abdouli and Hammami, 2017; Shahbaz et al., 2015).

The varying levels of economic development may have contributed to the inconclusive results. There was evidence to support the pollution haven hypothesis in developing or low-income countries (Hakimi and Hamdi, 2016; Kivyiro and Arminen, 2014), while evidence supporting the pollution halo hypothesis is found in developed or middle-income countries (Abdouli and Hammami, 2017). The mixed findings suggest that the impact of FDI is dependent on the income level and the rigidity of environmental laws in the host countries.

Priorities between environmental sustainability and economic growth may differ at various stages of economic development. Lower priority on environmental sustainability attracts dirty FDI in developing economies, whereas higher priority of environmental quality in developed countries means compliance with stricter environmental laws.

The study seeks to answer the following research questions. (i) Does FDI impact CO_2 emissions? (ii) Does income level influence the relationship between FDI and environmental quality? Our objective is to study the relationship between FDI and CO_2 emissions in different stages of economic development. This study adopts the bias-corrected least square dummy variable (LSDVC) method (Bruno, 2005) to estimate data from 123 countries from the year 2000 to 2019. Overall, FDI is found to enhance environmental quality by having an adverse impact on CO_2 emissions. There is also evidence that the impacts of FDI on the environment differ in countries with high and low incomes. FDI increases CO_2 emissions in countries with low incomes and supports the pollution haven hypothesis. Meanwhile, FDI lowers CO_2 emissions in countries with high incomes as proposed by the pollution halo hypothesis. In middle-income countries, results show an insignificant impact of FDI on CO_2 emissions. Common estimation issues found in dynamic panel methods, such as heterogeneity, consistency, and endogeneity are corrected using the LSDVC. This method generates consistent estimates and the least standard error compared to other asymptotically dynamic panel models.

This paper contributes to the existing literature in several ways. First, it adopts a more efficient and consistent methodology relative to most dynamic panel estimators. The employment of this method provides enhanced confidence in the results and findings. Second, the study hypothesized the role of income in determining the effect of FDI on environmental quality. This role explains how the Pollution Halo and Haven hypotheses hold in different countries. Third, the results of the paper provide direction for policy action. Policymakers can focus on improving income levels and institutional quality to mitigate environmental issues.

This paper is presented in five sections. Section 2 reviews related past literature. Section 3 describes the method of analysis. Section 4 presents the results. The findings are concluded in Section 5.

REVIEW OF LITERATURE

Previous studies on the technology gap theory argued that FDI affects the environment differently at various levels of compliance with environmental laws and different degrees of technology gaps. Environmental sustainability in host countries can be achieved when high-level compliance with strict environmental laws promotes the innovation of green technologies through FDI (Esty and Porter, 1998; Porter, 1991; Porter and Vander Linde, 1995). The pollution halo hypothesis recognizes that the acquired environmentally friendly technologies improve environmental quality. However, Palmer (1995) believed that cost-benefit analysis dictates the innovation of new green technologies to depend on motivating factors such as net gain and incentives. FDI yields positive externalities if the benefits exceed the costs but negative externalities with higher innovation costs. A pollution haven attracts highly polluting industries in countries with weak environmental laws and institutions. As a result, the pollution haven hypothesis argues that environmental degradation can be made worse through FDI. Findings from previous studies on these theories are inconclusive. For instance, Abdouli and Hammami (2017), Al-Mulali and Tan (2013), and Shahbaz et al. (2015) found evidence supporting the Pollution Halo hypothesis and reported that FDI promotes environmental sustainability by reducing CO_2 emissions. They believed that FDI enables the transfer and diffusion of green technologies to the host countries.

On the contrary, Acharyya (2009), Beck and Koo (2009), Lee (2010), and Zhang (2008) found evidence to support the Pollution Haven theory, where FDI adversely affects the environment and increases CO_2 emissions through the relocation of dirty FDI. They argued that in avoiding compliance requirements in home countries, less environmentally friendly industries move to less developed countries where the institutions and environmental laws are less strict. Meanwhile, Hoffman et al. (2005), Kim and Beak (2012), and Shaari et al. (2014) found a weak technological gap that implies that FDI may drive technological advancement and diffusion. However, the technological gap does not significantly impact the environmental quality. There is also evidence to show that FDI does not significantly lower CO_2 emissions.

This study hypothesized that the relationship between FDI and environmental quality depends on countries' income levels. Following the hypothesis, enforcing environmental laws is a contingency economic priority. High-income countries may align their economic policy with environmental policy and have strong institutions to ensure compliance with necessary policy requirements. In contrast, the economic priority in low-income countries focuses on economic growth and development, addressing basic needs rather than life ecstatic. Weak institutions in these countries are inefficient in ensuring compliance with environmental laws. Production seldom involves crude methods with consequences on the environment.

Therefore, the effect of FDI on CO_2 emissions is not linear across counties and may depend on a certain income threshold. Many studies showed contradicting results when highlighting the economic growth-environment nexus. Some supported that economic growth adversely affects environmental quality (Nasreen et al., 2017; Robalino-Lopez et al., 2015), while others found that economic growth reduces CO_2 emissions (Mercan and Karakaya, 2015). Evidence of a non-linear relationship between economic growth and environmental sustainability can be found in Bento and Moutinho (2016) and Halicioglu and Ketenci (2016). Also, Dhrifi et al. (2020) found FDI to increase CO_2 emissions in a sample of 97 developing countries. Omri et al. (2014) and Pao and Tsai (2010) also reported a positive relationship between FDI and CO_2 emissions in 54 countries and BRICS member countries, respectively. Meanwhile, Omri et al. (2014) found that FDI increases CO_2 emissions in Latin America, the Caribbean, the Middle East, North Africa, and the sub-Sahara, but not in Europe and North Asia.

RESEARCH METHODOLOGY

This study specifies the functional relationship between FDI and environment quality based on the model from Hakimi and Hamdi (2016). The model can be expressed as follows:

$$CO2 = f(fdi, Xs) \tag{1}$$

where *CO2* represents CO_2 emissions (in metric tons). Environmental quality is measured using CO_2 emissions as a proxy. FDI is represented by *fdi* with two proxies: the ratio of FDI inflow to GDP and gross FDI inflow. *Xs* denotes the vector of control variables. Prior to estimation, all variables are transformed into logarithmic form as follows:

$$lCO2_{it} = \beta_0 + \beta_1 lCO2_{i,t-1} + \beta_2 ly_{it} + \beta_3 lfdi_{it} + \beta_4 lec_{it} + \varepsilon_{it} \tag{2}$$

where *lCO2* is the logarithm for CO_2, *ly* for economic growth, *lfdi* for FDI, and *lec* for energy consumption. Dummies are generated for different levels of income: low, lower-middle, upper-middle, and high, to be included to distinguish the varying impacts of FDI on the environment. The re-estimated model is given as:

$$lCO2_{it} = \beta_0 + \beta_1 lCO2_{i,t-1} + \beta_2 ly_{it} + \beta_3 d1lfdi_{it} + \beta_4 d2lfdi_{it} + \beta_5 d3lfdi_{it} + \beta_6 d4lfdi_{it} + \beta_7 lec_{it} + \varepsilon_{it} \tag{3}$$

where $d1, d2, d3, and\ d4$ denote dummies for four categories of income: low, lower-middle, upper-middle, and high. The categorization is as the classification published by the World Bank.

The Bias-Corrected Least Square Dummy Variable (LSDVC) method used was recommended and expanded in previous studies (Kiviet, 1995; Bun and Kiviet; 2003; Bruno, 2005; Judson and Owen; 1999; Kiviet; 1999). This method addresses the dynamic panel estimation problems, particularly relating to the asymptotic efficiency of estimates with endogeneity bias related to limited-time observations (Nickel, 1981). The degree of negative bias from dynamic panel estimations given by the AR(1) result is;

$$\underset{N\to\infty}{\text{plim}}(\rho - \rho) = -\frac{(1-\rho)}{T-1} \tag{4}$$

This supports the superiority of the LSDVC method compared to other dynamic panel estimators, as validated by Monte Carlo simulations (Dang et al., 2015). The smaller variance of the LSDVC is comparable to the GMM estimators and other mean squared error estimators. The LSDVC provides more accurate N and T estimates in any finite sample (Bun and Kiviet 2003; Judson and Owen, 1999; Kiviet, 1995). The bootstrapping procedure produces more accurate parameter estimates compared to the standard dynamic panel models, which are established from the asymptotic assumption of first-order AR models. Kiviet (1995) adopted bias correction to order 1, followed by bias correction to order 3 as found in Bun and Kiviet (2003). The estimation procedure is initialized by a dynamic panel estimator that is consistent and efficient for a viable bias correction. The consistency varies with undetermined population parameters. Thus, the bias correction model in this study is initialized following estimators used by Anderson and Hsaio (AH), Arellano and Bond (AB), and Blundell and Bond (BB).

Annual data from the period 2000 to 2019 are obtained for 123 countries. The sample comprises 12 countries with low incomes, 31 countries with lower-middle incomes, 35 countries with upper-middle incomes, and 45 countries with high incomes. Several countries are eliminated due to incomplete data and having less than a million population. We choose CO_2 emissions to represent environmental quality (Kivyiro and Arminen, 2014; Shahbaz et al., 2015). Real GDP per capita represents economic development, following Nasreen et al. (2017), while the electric power consumption per capita measures energy consumption, based on Mercan and Karakaya (2015). We use two measures as a proxy for FDI. The use of the gross FDI inflow (FDI 1) follows Abdouli and Hammami (2017), as this measure is believed to relate to output production and CO_2 emissions. To examine the comparative sizes of the economy and its impact, FDI 2 represents the ratio of FDI inflow, following Hakimi and Hamdi (2016). All data are obtained from two sources, namely Lane and Milesi-Ferretti (2017) and the World Development Indicator database.

RESULTS AND DISCUSSION

A significant variation in CO_2 emissions is observed among the sample countries (Table 1). The descriptive statistics show that CO_2 emissions have a mean value of 5.21 metric tons, with a wide gap ranging from 36.09 metric tons (maximum) to 0.02 metric tons (minimum). Other variables show similar observations. Table 2 indicates that the pairwise correlation with CO_2 emissions for all variables is statistically significant and positively correlated. There are moderately high coefficients of correlation between CO_2 emissions and electricity consumption (0.757), and GDP (0.611). However, the correlations of both FDI 1 (0.262) and FDI 2 (0.0508) with CO_2 emissions are statistically positive but weak.

Table 1 Descriptive Statistics

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
co2	2460	5.21	5.78	0.02	36.09
ec	2460	3,552.55	4,313.92	13.52	25,590.69
rgdpc	2460	13,327.18	17,244.61	170.58	91,617.28
fdi1	2459	1.41e+11	4.60e+11	0.00	6.23e+12
fdi2	2459	0.48	1.32	0.00	27.85

Note: co2 is CO_2 emissions per metric ton, ec is electricity consumption, rgdpc is real GDP per capita, fdi1is gross FDI inflow, fdi2 is the ratio of FDI flows to GDP.

Table 2 Correlation

	co2	*ec*	*rgdpc*	*fdi1*	*fdi2*
co2	1.000				
ec	0.757***	1.000			
rgdpc	0.611***	0.835***	1.000		
fdi1	0.262***	0.310***	0.426***	1.000	
fdi2	0.051**	0.066***	00.135***	0.199***	1.000

Note: co2 is CO_2 emissions per metric ton, ec is electricity consumption, rgdpc is real GDP per capita, fdi1is gross FDI inflow, fdi2 is the ratio of FDI flows to GDP. ** and *** show significance at 5% and 1%, respectively.

To estimate the impact of FDI on CO_2 emissions, this study employs the bias-corrected least square dummy variable method (LSDVC) based on the Blundell and Bond system generalized method of moments (GMM) and the Arellano and Bond difference GMM techniques. Table 3 presents the estimations for the FDI proxies: the gross inflow of FDI inflow (FDI 1) and the ratio of FDI to GDP (FDI 2). The results for FDI 1 indicate an insignificant relationship between FDI and CO_2 emissions, whereas FDI 2 shows a negative effect on CO_2 emissions. Previous studies, such as Hakimi and Hamdi (2016), believed that measuring FDI using FDI 2 gives a more accurate estimate than using FDI 1. They argued that measuring FDI using the ratio to GDP enables cross-country comparison and reflects both FDI inflows and outflows.

Table 3 The Impact of FDI on CO_2 Emissions LSDVC Results (Based on The System and Difference GMM)

	Model 1 *Blundell & Bond System GMM*	**Model 2** *Arellano & Bond Difference GMM*	**Model 3** *Blundell & Bond System GMM*	**Model 4** *Arellano & Bond Difference GMM*
l.lco2	0.879***	0.809***	0.879***	0.809***
	(0.013)	(0.016)	(0.012)	(0.015)
lec	0.080***	0.104***	0.078***	0.101***
	(0.014)	(0.015)	(0.015)	(0.014)
lrgdp	0.057***	0.055***	0.050***	0.055***
	(0.019)	(0.019)	(0.017)	(0.015)
lfdi1	-0.007*	-0.005		
	(0.004)	(0.004)		
lfdi2			-0.012**	-0.009**
			(0.005)	(0.004)
Observations	2335	2335	2335	2335

Note: l.lco2 is log of lag of CO_2 emissions, lec is log of electricity consumption, lfdi1is log of gross FDI inflow, lfdi2 is log of the ratio of FDI flow to GDP, ly is log of real GDP per capita. Models 1 and 3 are initialized based on Blundell and Bond System GMM. Models 2 and 4 are initialized based on Arellano and Bond Difference GMM. Standard errors are given in parentheses. *, **, and *** denote significance at 10%, 5% and 1%, respectively.

Results from the system GMM and difference GMM estimations show that FDI2 has a negative coefficient. The negative relationship implies that when FDI increases, CO_2 emissions decrease. A one percent increase in the ratio of FDI to GDP would result in about 0.01 percent decrease in CO_2 emissions. Thus, this supports the argument that FDI promotes environmental sustainability in the host country, which is consistent with the findings of Al-Mulali and Tan (2013) and Shahbaz et al. (2015). The estimation results for electricity consumption and economic growth variables indicate positive coefficients, implying that an increase in both factors produces more CO_2 emissions, causing further environmental degradation. Based on Models 1 to 4, a one percent increase in the ratio of FDI to GDP would lead to about 0.1 percent increase in electricity consumption. Also, a one percent increase in FDI leads to about 0.06 percent increase in per capita real GDP. All models generate consistent findings that support Nasreen et al. (2017).

The model is extended to examine whether the relationship between FDI and CO_2 emissions changes given different levels of income. Different countries may respond differently to FDI based on their existing economic condition and available infrastructure. For instance, countries with high incomes may have better facilities and human capital to gain from FDI. Countries with lower incomes, inadequate resources, and inferior human capital are not able to fully gain from foreign investment. Instead, their weak institutions and desperate need for foreign investment could attract dirty FDI with technologies that are harmful to the environment. This study uses dummies to distinguish countries with different levels of income. Dummies *d1* to *d4* are introduced to denote countries with low, lower-middle, upper-middle, and high incomes. Categories represent their income level following the World Bank classification. Table 4 presents the results showing a significant impact of the level of income on the relationship between FDI and CO_2 emissions. Negative coefficients in countries with high incomes imply an adverse relationship between FDI and CO_2 emissions, supporting that countries with higher incomes gain from greener technologies through FDI that lead to lower CO_2 emissions and better environmental quality. Meanwhile, positive coefficients in lower-income countries indicate a positive relationship between FDI and CO_2 emissions. As lower-income countries receive more foreign investment, less efficient technologies or imported dirty industries increase CO_2 emissions and further increase environmental degradation. FDI does not significantly impact CO_2 emissions in countries with lower-middle incomes but supports the pollution halo hypothesis in countries with upper-middle incomes.

The results validate the hypothesis of the study. The study postulates that income level influences the relationship between FDI and CO_2 emissions. It further argues that as income level rises, economic priorities focus more on environmental quality. High-income countries usually have quality institutions to ensure enforcement and compliance with environmental laws. FDI to these countries is mandated to comply with ex-ante laws. Since FDI embodies environmentally friendly technologies, technological diffusion would ensure reduced CO_2 emissions.

On the contrary, the hypothesis states that FDI may exacerbate CO_2 emissions in low-income countries. The economic priority in low-income nations stresses economic development and may welcome dirty FDI as long as it promotes growth despite the environmental risks. Moreover, weak institutional quality in these countries may not enforce compliance with environmental standards. Cost-benefit analysis in low-income countries shows noncompliance nor adoption of technologies that promote environmental sustainability. Environmentally friendly technologies are costly, and rational investors would choose inexpensive technologies in low-income countries due to weak institutions. The economic priority only emphasizes survival or growth, even at a very high cost to health and the environment.

Table 4 The Impact of FDI on CO_2 Emissions (LSDVC Results with Dummies for Levels of Economic Development)

	Model 5 *Blundell & Bond System GMM*	**Model 6** *Arellano & Bond Difference GMM*	**Model 7** *Blundell & Bond System GMM*	**Model 8** *Arellano & Bond Difference GMM*
l.lco2	0.775***	0.720***	0.783***	0.764***
	(0.015)	(0.027)	(0.015)	(0.023)
lec	0.109***	0.204***	0.108***	0.223***
	(0.015)	(0.036)	(0.014)	(0.030)
lrgdpc	0.059***	0.103***	0.056***	0.076***
	(0.019)	(0.027)	(0.015)	(0.021)
d1fdi1	0.033***	0.023**		
	(0.008)	(0.010)		
d2fdi1	0.004	-0.010		
	(0.006)	(0.010)		
d3fdi1	-0.006	-0.016**		
	(0.005)	(0.007)		
d4fdi1	-0.023***	-0.035***		
	(0.005)	(0.007)		
d1fdi2			0.048***	0.022
			(0.012)	(0.015)
d2fdi2			0.006	-0.023**
			(0.009)	(0.012)
d3fdi2			-0.011	-0.027***
			(0.006)	(0.008)
d4fdi2			-0.035***	-0.050***
			(0.007)	(0.009)
Observations	2335	2335	2335	2335

Note: l.lco2 is log of lag of CO_2emissions, lec is log of electricity consumption, lfdi1is log of gross FDI inflow, lfdi2is log of the ratio of FDI inflow to GDP, lrgdpc is log of real GDP per capita, d1, d2, d3, and d4 represent dummies for four groups of income levels: low, lower-middle, upper-middle and high, respectively. Models 5 and 7 are initialized based on Blundell and Bond System GMM. Models 6 and 8 are initialized based on Arellano and Bond Difference GMM. Standard errors are given in parentheses. *, **, and *** denote significance at 10%, 5% and 1%, respectively.

Estimation based on the full sample supports the pollution halo hypothesis, where FDI decreases CO_2 emissions and improves environmental sustainability. Through FDI, transferred environmentally friendly technologies and innovative production methods contribute to improving environmental quality by reducing greenhouse gas emissions. This part of the finding shows a negative relationship between FDI and CO_2 emissions, which agrees with Abdouli and Hammami (2017). The negative relationship holds only in countries with high and upper-middle incomes, whereas evidence shows a positive relationship between FDI and CO_2 emissions in countries with low incomes. Based on our findings, the pollution halo hypothesis predominates in countries with high and upper-middle incomes, while the pollution haven hypothesis is evident in countries with low incomes. Meanwhile, estimates for lower-middle-income countries show that FDI is found to be insignificant and has no impact on CO_2 emissions. This evidence of the insignificant impact of FDI is consistent with Kim and Beak (2012).

The levels of income and economic development may influence how countries prioritize their need for FDI and strive for environmental quality. High-income countries implement strict environmental laws and offer incentives such as tax relief to foreign companies that are environmentally friendly. A high level of compliance is expected from foreign producers to operate in these countries. In low-income countries, job creation and economic growth take priority over environmental quality. At the expense of the environment, dirty FDI is expected to create jobs in low-income countries that are high in poverty and unemployment. Foreign firms that operate in less environmentally friendly manners take advantage of the less strict environmental laws in these countries and reexport the output. Weak institutions, poor enforcement, and high corruption further allow higher CO_2 emissions that continue to pollute the environment.

Environmentally conscious high-income countries expect foreign firms to engage in research and development (R&D) to improve production methods and innovations to promote a healthy environment. Not many firms are willing to spend on high costs of green R&D and may choose countries that are more focused on output than protecting the environment. The motivation for R&D and innovation also depends on its cost-benefit analysis (Palmer, 1995; Chee-Lip et al., 2015). Low-income countries may offer little incentive and incur higher R&D costs with less efficient research infrastructure and facilities. Less rigid countries offer a haven for firms operating with dirty technologies that are harmful to the environment, where an increase in FDI increases CO_2 emissions. Our findings that show FDI contributes to environmental degradation in low-income countries are consistent with Acharyya (2009) and Lee (2010).

Robustness Test

We test the robustness of our estimations using a sensitivity analysis. We employ the Anderson and Hsiao instrumental variable method to re-estimate our model. Table 5 shows consistent results with results presented in Table 3 and Table 4. In general, FDI shows an asymmetry effect on CO_2 emissions when considering income levels. The impact of FDI on CO_2 emissions is negative and supports the pollution halo hypothesis in countries with high and upper-middle incomes. In contrast, higher CO_2 emissions in low-income countries following an increase in FDI strongly support the pollution haven hypothesis. Finally, FDI does not significantly impact CO_2 emissions in countries with lower-middle incomes.

Table 5 The Impact of FDI on CO_2 Emissions (LSDVC Results with Anderson and Hsiao Instrumental Variable)

	Model 9	Model 10	Model 11	Model 12
l.lco2	.759***	0.782***	0.869***	0.863***
	(0.023)	(0.025)	(0.014)	(0.012)
lec	0.220***	0.221***	0.070***	0.077***
	(0.030)	(0.030)	(0.015)	(0.015)
lrgdpc	0.106***	0.071***	0.060***	0.059***
	(0.028)	(0.022)	(0.021)	0.017)
lfdi 1	-0.020***			
	(0.005)			
lfdi 2		-0.0029***		
		(0.006)		
d1fdi 1			0.027***	
			(0.008)	
d2fdi1			0.003	
			(0.007)	
d3fdi1			-0.006	
			(0.005)	
d4fdi 1			-0.019***	
			(0.005)	
d1fdi 2				0.041***
				(0.013)
d2fdi 2				0.001
				(0.009)
d3fdi 2				-0.014**
				(0.007)
d4fdi 2				-0.032***
				(0.008)
Observations	2355	2355	2355	2355

Note: l.lco2 is log of lag of CO_2 emissions, lec is log of electricity consumption, lrgdpc is log of real GDP per capita, fdi 1 is log of gross FDI inflow, fdi 2 is log of the ratio of FDI inflow to GDP, d1, d2, d3, and d4 represent dummies for four groups of income levels: low, lower-middle, upper-middle and high, respectively. Standard errors given in parentheses represent * $p< 0.1$, ** $p< 0.05$, *** $p< 0.001$.

CONCLUSION

In a sample of 123 countries, data from 2000-2019 is used to examine the impact of FDI on CO_2 emissions. The study contributes to the existing literature by providing a new perspective on the FDI-environmental quality nexus by hypothesizing that the relationship is income-dependent. The findings support that income levels define economic and policy priorities and the degree of environmental law enforcement. The robust technique employed in this study addresses most dynamic panel problems and is superior to most dynamic panel estimators. Using the LSDVC method, the results show that CO_2 emissions decrease and environmental quality increases with an increase in FDI. FDI and CO_2 emissions have an asymmetrical relationship that varies with income levels. FDI lowers CO_2 emissions in countries with high and upper-middle incomes, whereas CO_2 emissions increase in countries with low incomes. The Pollution Halo Hypothesis holds in high and middle-income countries, while the Pollution Haven Hypothesis prevails in low-income countries. The heterogeneous impact of FDI on CO_2 emissions is supported by lower CO_2 emissions in countries with higher and upper-middle incomes compared to countries with low incomes.

The implications of the results reveal that the absorptive capacity of FDI inflows is more evident in high-income countries. The level of economic development in individual countries may influence environmental policies and subsequently affect environmental quality. Economic sustenance is more important in low-income countries than environmental quality, where institutions are less effective in environmental law enforcement. Low-income countries should promote better human capital, financial development, and quality institutions to attract environmentally friendly and greener technologies through FDI. However, the paper's limitation includes its inability to determine the turning point of income levels at which economic and policy priorities on environmental quality change in different countries. The paper also does not consider the possible interactive effect of institutional quality on the relationship between FDI and environmental quality. Future studies should focus on the threshold of income and institutions on the FDI-environmental quality relationship. Also, there is a need to explore the indirect relationship between FDI and the environment through interaction models.

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