Foreign Direct Investment, Corruption, and Carbon Emissions: Evidence from Developing Economies

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Abstract - **This article investigates the long-term relationship between foreign direct investment (FDI), corruption, and environmental quality measured by CO_2 emissions in 50 developing countries over the period 1996–2023. Using a panel Autoregressive Distributed Lag (ARDL) model, the study identifies strong evidence that FDI inflows, trade openness, public expenditure, and income per capita substantially increase CO_2 emissions in these economies. These findings validate the Pollution Haven Hypothesis (PHH), suggesting that developing countries with weak environmental governance tend to attract pollution-intensive investments. Corruption, measured through the control of corruption index, appears as a pivotal determinant: higher corruption correlates with greater environmental degradation, while effective corruption control reduces emissions. Short-term dynamics reveal limited immediate effects of FDI but significant influence of economic growth. Overall, the study underscores the need for targeted policies aimed at strengthening governance, promoting green investment, and enforcing environmental regulations in developing countries.**

Keywords— Developing countries, FDI, Corruption, CO_2 emissions, ARDL, Pollution Haven Hypothesis

I. INTRODUCTION

The rapid integration of developing economies into global markets has intensified inflows of foreign direct investment (FDI). While FDI is widely recognized for promoting economic growth, facilitating technology transfer, and improving industrial capacity, its environmental implications remain controversial. Many developing countries face a trade-off between attracting foreign capital and preserving environmental quality.

Weak governance, limited regulatory capacity, and high corruption levels can reduce environmental enforcement, making developing economies attractive destinations for pollution-intensive industries. These structural features raise the critical question: *Does FDI contribute to environmental degradation in developing countries?*

This article focuses exclusively on developing countries and examines how FDI, corruption, trade, public expenditure, and economic activity jointly influence CO_2 emissions over the period 1996–2023. The use of a panel ARDL model allows for the identification of both short- and long-term effects, even when variables show different integration orders.

II. THEORETICAL BACKGROUND

A. Pollution Haven Hypothesis (PHH)

The PHH suggests that multinational corporations relocate pollution-intensive production to countries with lax environmental regulations. Developing countries, often characterized by weak regulatory frameworks and high corruption, are more vulnerable to becoming pollution havens. Empirical evidence for developing economies often confirms positive links between FDI and environmental degradation—precisely the dynamic explored in this study.

B. Summary Table of Empirical Studies on FDI, Growth, Institutions, and CO_2 Emissions

TABLE 1
SUMMARY OF EMPIRICAL STUDIES

Study	Period / Countries	Methodology	Key Variables	Main Findings
Shahbaz et al. (2019)	1990–2015, MENA region	Dynamic panel models	Biomass energy, FDI, economic growth, CO_2	EKC validated; PHH supported; N-shaped FDI–CO_2 relationship; nonlinear technological effects.
Baek & Koo (2009)	China & India	ARDL	FDI, GDP per capita, CO_2	China: FDI increases emissions (PHH). India: short-run negative effect, weak long-run influence.
Baek (2015)	5 ASEAN countries, 1981–2010	Dynamic panel	FDI, income, energy use, CO_2	FDI raises emissions in low-income but reduces them in high-income countries; income & energy increase CO_2.
Omri et al. (2015)	12 MENA countries, 1990–2011	Simultaneous equations	CO_2, finance, trade, growth	EKC validated; bidirectional causality between growth and CO_2; strong variable interdependencies.
Tamat et al. (2015)	110 countries	GMM estimator	FDI, environmental regulation, corruption	Strict environmental rules reduce FDI; corruption increases inflows; institutions mediate environmental effects.
Lau et al. (2014)	Malaysia, 1984–2008	Cointegration	Institutional quality, CO_2, growth	Institutional improvement lowers CO_2 and boosts growth; virtuous governance–environment cycle.
Seker et al. (2015)	Turkey, 1974–2010	ARDL	FDI, energy use, growth, CO_2	FDI increases CO_2 long-term (modest magnitude); strong FDI-energy-growth relationships.
Costantini & Crespi (2008); Al-Mulali & Tang (2013)	International	Comparative analyses	Green technology, FDI, CO_2	Long-term competitiveness linked to sustainability; firms shift toward green innovation.
Umer et al. (2014)	12 Asian countries, 1995–2012	Panel analysis	Trade openness, corruption, CO_2	Corruption weakens regulation; good governance and consumer demand improve environmental quality.

Source: by the au author

III. DATA OVERVIEW FOR DEVELOPING COUNTRIES

The sample consists of **50 developing countries** over **1996–2023**. The descriptive statistics provide important insights into the structural and institutional context of the sampled developing countries, which in turn shape the mechanisms through which FDI affects environmental outcomes. Average CO_2 emissions stand at 0.83 tons per capita, a level dramatically lower than that observed in high-income economies (7.41 tons). This substantial gap reflects not only limited industrialization but also the predominance of less energy-intensive sectors and constrained productive capacity. Similarly, average FDI inflows—representing 3.35% of GDP—display relatively low dispersion, suggesting that most countries in the sample attract foreign capital at comparably modest levels, often concentrated in specific sectors such as natural resources or low-cost manufacturing.

Trade openness, averaging 67.51%, points to a moderate but uneven degree of integration into global markets, which may facilitate technology transfer but also expose economies to environmental pressures linked to export-oriented activities. The control of corruption index (–0.72) signals persistent institutional fragility, reflecting weak enforcement mechanisms, limited regulatory oversight, and vulnerabilities to rent-seeking behavior. Such institutional constraints can undermine the ability of governments to impose or monitor environmental standards, thereby altering the ecological implications of foreign investment.

Finally, the log of GDP per capita (5.02) confirms the relatively low level of economic development, which often correlates with inadequate environmental infrastructure, limited green technological adoption, and prioritization of short-term economic gains over long-term sustainability goals.

IV. METHODOLOGY

The study applies a **panel ARDL model**, appropriate for variables integrated at I(0) and I(1). The key advantages include:
- Ability to estimate short- and long-term relationships
- Robustness to mixed integration orders
- Inclusion of country-specific fixed effects

The variables selected and their sources are shown in Table 2

TABLE 2
DEFINITIONS AND SOURCES OF DATA

Variable	Definition	Source
CO_2	Total annual emissions of carbon dioxide (CO_2); (t CO_2e/capita).	WDI
FDI	Foreign Direct Investment, net inflows (% of GDP).	
Trade	Sum of exports and imports of goods and services (% of GDP).	
CC	Control of Corruption.	
Lgdp	GDP per capita, constant price, in logarithm.	
G	General government final consumption expenditure (% of GDP).	
Inf	Inflation, GDP deflator (annual %).	

Stationarity tests indicate that CO_2 is I(1), while all other variables are I(0). Pedroni cointegration tests confirm the existence of long-term relationships among variables.

The estimated equation is:

$$CO_{2it} = \alpha_0 + \alpha_1 FDI_{it} + \alpha_2 Trade_{it} + \alpha_3 CC_{it} + \alpha_4 Lgdp_{it} + \alpha_5 G_{it} + \alpha_6 Inf_{it} + \varepsilon_{it}$$

- The subscript "t" represents the year of observation and "i" designates the country
- Toda–Yamamoto causality tests (with lag = 8 for developing countries) are used to examine directionality.

V. EMPIRICAL RESULTS: FOCUS ON DEVELOPING COUNTRIES

A. Long-Term Effects

The long-run ARDL estimates highlight how structural, economic, and institutional factors jointly determine CO_2 emissions in developing countries. The positive and significant effect of FDI on environmental degradation indicates that foreign investment tends to be directed toward pollution-intensive and resource-dependent sectors. This supports the **Pollution Haven Hypothesis**, which posits that multinational firms relocate environmentally harmful activities to countries with weaker regulations (Pizzuto, 1997; Cole et al., 2006; Baek & Koo, 2009). The results therefore suggest that developing

economies may lack the regulatory and technological capacity to attract cleaner, efficiency-enhancing investment (Javorcik, 2004).

Trade openness also increases emissions, indicating that integration into global markets reinforces specialization in environmentally harmful industries. This aligns with the **scale effect** and the **structural effect** of trade described in the environmental economics literature, where higher production, transportation, and resource extraction raise emissions (Antweiler et al., 2001; Copeland & Taylor, 2004). Many developing countries continue to rely on carbon-intensive export sectors, which limits their ability to benefit from the potential "technique effect" associated with cleaner technologies.

TABLE 3
ESTIMATION RESULTS OF ARDL MODEL

	Developing	
	Long run coefficients	
	Coef	**Pro**
FDI	0.0027	0.00
Trade	0.0008	0.00
CC	-0.0287	0.02
Lgdp	0.4304	0.00
G	0.0046	0.00
Inf	-0.0005	0.00

The negative and significant coefficient for control of corruption highlights the central role of institutional quality in environmental protection. Strong corruption control reduces regulatory evasion, increases compliance with environmental standards, and limits rent-seeking interactions between firms and public officials. This finding is consistent with the institutionalist literature showing that governance quality significantly mitigates environmental degradation (Pellegrini & Gerlagh, 2006; Fredriksson & Svensson, 2003). It implies that institutional reforms can substantially reduce the environmental costs of growth, globalization, and foreign investment.

GDP per capita exhibits a strong positive effect on CO_2 emissions. This result reflects the early stages of the Environmental Kuznets Curve (EKC), where economic expansion relies heavily on industrial activity, fossil-fuel consumption, and low energy efficiency (Grossman & Krueger, 1995; Dinda, 2004). In this phase, growth tends to aggravate emissions until income levels rise sufficiently to allow investments in cleaner technologies and stricter environmental policies.

Public expenditure also increases emissions, suggesting that government spending is mainly directed toward infrastructure development and energy-intensive public services rather than green investment. This aligns with studies showing that without environmental budgeting frameworks, public expenditure may indirectly intensify pollution (Shahbaz et al., 2013; Halkos & Paizanos, 2013).

Finally, inflation shows a negative but economically small effect, possibly reflecting a contractionary impact whereby reduced production and consumption slightly suppress emissions. Overall, the results reveal that economic globalization (FDI, trade), institutional quality, and structural characteristics of development are the key drivers of long-run environmental performance. Strengthening governance institutions, reforming regulatory frameworks, and redirecting public expenditure toward green infrastructure appear essential to mitigating CO_2 emissions in developing economies.

B. Short-Term Dynamics

The short-run ARDL results indicate that FDI has no immediate effect on CO_2 emissions, suggesting that its environmental impact emerges mainly through longer-term structural adjustments rather than short-term fluctuations. Trade openness shows a small positive effect, reflecting temporary increases in industrial and trade-related activity that modestly raise emissions.

TABLE 4
ESTIMATION RESULTS OF ARDL MODEL

	Developing	
	Short run coefficients	
	Coef	Pro
D(CO_2(-1))	-0.0192	0.67
D(FDI)	0.0002	0.95
D(Trade)	0.0005	0.32
D(CC)	0.0601	0.07
D(Lgdp)	0.8073	0.02
D(G)	-0.0031	0.50
D(Inf)	-0.0007	0.32
C	-0.2756	0.00
CointEQ01	-0.1665	0.00

GDP per capita exerts a strong positive short-run influence, indicating that economic expansion in developing countries quickly translates into higher pollution levels due to reliance on carbon-intensive production. By contrast, control of corruption has only weak short-run effects, which is consistent with the idea that institutional improvements require time before influencing environmental performance.

The error-correction term (–0.1665) is significant and negative, confirming that deviations from long-run equilibrium are corrected relatively quickly. This suggests that short-term disturbances in emissions or economic variables tend to converge back toward stable long-run environmental dynamics.

C. Causality Analysis (Toda–Yamamoto)

The causality analysis for developing countries indicates a **unidirectional causal relationship running from FDI to CO_2 emissions**, significant at the 5% level. This result suggests that foreign investment actively drives changes in environmental quality rather than responding to them. Such evidence supports the **pollution haven hypothesis**, whereby multinational enterprises export polluting activities to countries with weaker regulatory frameworks (Cole et al., 2006; Baek & Koo, 2009). In line with Omri (2013), these findings imply that FDI plays a leading role in shaping long-term environmental trajectories in developing economies.

TABLE 5
CAUSALITY TEST

	Developing Countries		
	Chi-sq	**df**	**Prob**
FDI	15.93	8	0.04
CC	7.70	8	0.46
	Chi-sq	**df**	**Prob**
CO_2	4.15	8	0.84
CC	3.68	8	0.88
	Chi-sq	**df**	**Prob**
CO_2	2.29	8	0.97
FDI	2.05	8	0.97

The absence of causality between corruption and CO_2 emissions—neither from corruption to pollution nor from pollution to corruption—suggests that the influence of institutional quality operates predominantly through **long-term structural channels**, such as regulatory capacity and enforcement, rather than through short-run dynamic interactions. Previous studies similarly report that institutional effects tend to manifest

over extended periods rather than producing immediate causal responses (Pellegrini & Gerlagh, 2006; Fredriksson & Svensson, 2003).

Furthermore, the absence of feedback from CO_2 emissions to FDI indicates that environmental quality does not affect foreign investors' location decisions in developing countries. This is consistent with earlier findings suggesting that multinational firms prioritize factors such as market size, labor costs, or resource availability over environmental conditions (Javorcik, 2004; Xing & Kolstad, 2002). Consequently, environmental degradation does not deter FDI inflows, reinforcing the idea that FDI shapes environmental outcomes but does not adapt to them.

Overall, the causality results imply that FDI acts as a **driving, non-reactive force** in determining environmental degradation in developing countries. Without strong institutional frameworks and environmental regulations, foreign investment may continue to exert a unilateral, pollution-intensive influence on environmental sustainability.

VI. CONCLUSION

This study demonstrates that FDI, trade openness, public expenditure, and economic growth significantly worsen environmental quality in developing countries. The positive effects of FDI on CO_2 emissions confirm the Pollution Haven Hypothesis, highlighting the structural vulnerabilities of countries with weak governance. Corruption control emerges as a crucial determinant of environmental protection, although its effects are primarily long-term.

The causality findings underline the leading role of FDI as a driver of environmental degradation. These results call for the adoption of governance reforms, environmental regulation, and green investment strategies to ensure sustainable development.

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