Pakistan Journal of Commerce and Social Sciences
2026, Vol. 20(1), 152-182
https://doi.org/10.64534/Commer.2026.671

The impact of Foreign Direct Investment, Institutional Quality, and Industrialization on Carbon Emissions: Evidence from High-Income and Upper-Middle-Income Countries

Umaal Ahmed Khan [1]*, Rofaida Benotsmane [2], Merve Şahin [3], Mustafa Kemal Yilmaz 4, Bülent Güloğlu [5], Selim Zaim [6]

[1,3,4 & 6] Department of Management, School of Business, Ibn Haldun University, Istanbul, 34480, Turkey
[2 & 5] Department of Economics, Management Faculty, Istanbul Technical University, Istanbul 34485, Turkey

*Corresponding author's email: umaalkhan@ihu.edu.tr

Article History

Received: 13 Dec 2025 Revised: 19 Mar 2026 Accepted: 26 Mar 2026 Published: 31 Mar 2026

Abstract

This study investigates the relationship between foreign direct investment (FDI), institutional quality, industrialization, and carbon emissions across 48 high-income and 37 upper-middle-income countries for the years 2002 to 2022 by employing panel quantile regression analysis using R software. The results show that inward FDI has increased pollution in high-income countries by the coefficient of 0.016 to 0.026 while it has reduced carbon emissions in upper-middle-income countries by the coefficient of -0.012 to 0.01. In outward FDI, although it is expected that upper-middle income countries will end up with low carbon emissions, the results show that carbon emissions increase in these countries by the coefficient of -0.025 to 0.08. Industrialization has significantly raised pollution in both groups, while institutional quality has a positive impact in high-income countries and a negative influence in upper-middle-income nations, implying the mixed impact of good governance in environmental management. The findings highlight the dual effect of FDI on carbon emissions, indicating that its environmental impact varies according to the extent of policy interventions, i.e. carbon taxation, environmental regulation, designed to balance economic growth with environmental protection. The results offer valuable insights for companies and policymakers seeking to align economic growth with environmental sustainability across different stages of economic development.

Keywords: Foreign direct investment, carbon emissions, industrialization, institutional quality.

1. Introduction

Foreign direct investment (FDI) plays a vital role in enhancing global development and supporting the achievement of environmental sustainability. It stimulates economic growth by facilitating capital inflows, transferring advanced technologies, and enhancing productivity through the adoption of effective management practices. These processes enhance efficiency, encourage structural transformation, and strengthen economic integration at the global level. However, development driven by FDI may also cause environmental degradation, particularly through CO_2 emissions and weak regulatory standards, especially in pollution-intensive industries.

A key debate in the literature concerns whether FDI harms or improves environmental quality. Empirical studies examining the environmental consequences of FDI have led to the development of two contrasting hypotheses: the Pollution Haven Hypothesis (PHH) and the Pollution Halo Hypothesis (PHLH). The PHH suggests that countries with less stringent environmental regulations tend to attract pollution-intensive industries, as multinational companies relocate their environmentally harmful production to jurisdictions with weaker regulatory frameworks (Bommer, 1999; Mani & Wheeler, 1998). In contrast, the PHLH argues that FDI can improve environmental performance by introducing cleaner technologies, advanced management practices, and higher environmental standards, thereby enhancing the host countries' ability to manage environmental challenges more efficiently (Neves et al., 2020; Paramati et al., 2017). Recent studies confirm this duality. Pham et al. (2025) find that FDI inflows significantly increase carbon emissions globally, with low- and middle-income nations disproportionately affected, while Jinapor et al. (2024) identify that institutional quality directly moderates the harmful effects of FDI and industrialization on environment in sub-Saharan Africa.

Grounded on this debate, FDI offers promising economic benefits as well as harmful outcomes for environment, pushing countries to ensure that economic development and environmental sustainability are balanced. Although there are numerous studies on FDI and its environmental impact (Abozriba & Khalifa, 2026; Kutlu Furtuna & Atis, 2024; Musa et al., 2024), many of them focus on either a single country or region, leaving a gap in understanding how the impact of FDI, institutional quality, and industrialization on carbon emissions differ across countries having different income levels. On this context, there is a need to understand the scale of FDI and the nature of governance and policies that address the adverse impact of FDI on environment (Niemeier et al. 2015). To address this issue, this research examines the following questions:

- RQ1: How do inward and outward FDI affect carbon emissions across high-income and upper-middle-income countries?
- RQ2: Does institutional quality strengthen or weaken the relationship between FDI and carbon emissions, and does this role vary by income level of countries?

- RQ3: How does industrialization contribute to carbon emissions across high-income and upper-middle-income countries?

In this regard, this study makes a significant contribution to literature by analyzing the effect of inward FDI (IFDI), outward FDI (OFDI), institutional quality, and industrialization on CO_2 emissions. It covers 48 high-income and 37 upper-middle-income countries over the period of 2002–2022 and employs panel quantile regression analysis. The results indicate important asymmetries across income groups, with FDI increasing carbon emissions in high-income countries while reducing it in upper-middle-income countries, and institutional quality producing contrasting effects across the two groups. In this frame, this study presents novel evidence that enables countries of different income levels to set up a balance between economic development and environmental performance. As the pace of globalization intensifies with more capital moving across boundaries, the findings offer valuable insights for companies, and policymakers, seeking to design income-group-specific strategies that reconcile economic development with environmental sustainability.

The remaining part of the article is organized as follows: The next section reviews the literature and develops the hypotheses. Section 3 describes the data, variables and methodology. Section 4 presents the findings and finally, the last section concludes and discusses the implications of the study.

2. Literature Review and Hypotheses Development

2.1. Theoretical Background

Numerous studies have examined the interaction between economic development, institutional frameworks, and environmental performance. In this context, the combined effects of FDI, institutional quality, and industrialization on carbon emissions are complex and often country specific. These relationships are commonly interpreted through two contrasting yet complementary theoretical perspectives: the pollution haven hypothesis (PHH) and the pollution halo hypothesis (PHLH). These approaches lead to different interpretations about the factors that impact carbon emissions generated by FDI, the quality of institutions, and industrialization in high-income and upper-middle-income countries.

Pollution Haven Hypothesis (PHH) asserts that emerging markets, characterized by poor environmental management, are attractive destinations for countries that are large emitters of pollutants but aim at reducing their environmental expenses (Balsalobre-Lorente et al. 2019; Bommer, 1999; Mani & Wheeler, 1998; Mert and Caglar, 2020). Abdullahi et al. (2023) examine how FDI influences emissions across different economic development levels, often finding that FDI can either exacerbate pollution, supporting pollution haven hypothesis, or promote cleaner technology transfer depending on the country's income. Relocation of environmentally destructive investments comes in the form of exporting dirty production practices to other countries, increasing environmental degradation. Thus, the importing countries become “havens” for environmentally damaging nations that aim to meet sustainable development goals. In contrast, PHLH claims that FDI is a channel for transferring clean technologies and best environmental practices to the recipient nations (Balsalobre-Lorente et al., 2022). This diffusion may lead to improvement in environmental performance. By adopting this perspective, FDI help countries "leapfrog" to more environmentally sustainable industrial development pathways through the integration of high-tech, less hazardous production technologies, particularly if supported by good institutional environment (Brinkley, 2014). The validity of both hypotheses is still debatable, with outcomes changing substantially by country income level, institutional context, and estimation methodology (Kutlu Furtuna & Atis, 2024; Pham et al., 2025). Building on this discussion, this study formulates eight hypotheses addressing the relationship between FDI (both inward and outward), institutional quality, industrialization and carbon emissions, by analyzing two distinct income groups: high-income and upper-middle-income countries. The classification of countries is provided in table 1A in the appendix.

2.2. Hypotheses Development

2.2.1. Institutional Quality and CO_2 Emissions

Strong institutions with robust regulatory framework have an influential role in lowering carbon emissions in developed countries. Abid (2016) proves that good governance in decoding the enforcement of environmental regulation and lowering pollution levels is important. Haldar and Sethi (2021) indicate that good governance improves energy efficiency and resource use, while Zhang et al. (2016) demonstrate the strong role of corruption control in preventing environmental degradation in unregulated industries. On this context, the impact of institutional quality in lowering emission levels might be mediated by governance processes like green building certification to improve environmental performance in rapidly developing countries (Han, 2019). Recently, Xaisongkham and Liu (2024) confirm that institutional dimensions significantly decrease carbon emissions, reinforcing the key role of governance in environmental outcomes.

The significance of the role of institutional quality in upper-middle-income countries is multifaceted. According to Salman et al. (2019), good governance could contribute to the depletion of carbon emissions through effective regulations in the environment and transparency. Nevertheless, the available evidence shows that good governance could contribute to the promotion of industrialization, which may contribute to an increase in carbon emissions (Godil et al. 2020; Phuc Nyugen et al. 2018). According to Jinapor et al. (2024), in the sub-Saharan Africa region, FDI and industrialization contribute negatively to the environment, but good governance helps mitigate the adverse effects of FDI on the environment. Therefore, with regard to the above discussions, the following hypotheses are proposed:

- H1a: There is a negative relationship between institutional quality and carbon emissions in high-income countries.
- H1b: There is a negative relationship between institutional quality and carbon emissions in upper-middle-income countries.

2.2.2. Inward Foreign Direct Investment and CO_2 Emissions

In the context of the OECD countries, IFDI plays a significant role in improving the environment by helping the diffusion of environmentally friendly technologies. The evidence provided by the study of Paramati et al. (2017) validates the pollution halo hypothesis (PHLH), suggesting that FDI can yield positive environmental outcomes through new technologies and production techniques. Furthermore, the nonlinear relationship between FDI and carbon emissions was established by Alshubiri and Elheddad (2020), which suggests that although the scale effect of FDI initially increases carbon emissions, new technologies subsequently leads to the reduction of carbon emissions over time. By employing the analysis of the carbon-intensive countries from the year 1996 to 2022, Kutlu Furtuna and Atis (2024) find a U-shaped nonlinear relationship between FDI and carbon emissions, suggesting that the direction of the FDI–environment nexus depends on the FDI intensity.

In upper middle-income countries, the environmental consequences of IFDI are more dependent on institutional and regulatory factors. PHH is supported by many academic works (Destek & Okumus, 2019; Mert & Caglar, 2020). These studies suggest that in emerging markets, FDI is linked with increased levels of pollution. Moreover, Sapkota and Bastola (2017) and Singhania and Saini (2021) claim that in the absence of proper institutional and regulatory frameworks, investors may opt for activities that are more pollution-prone. However, in the presence of proper institutional factors, FDI may contribute positively towards cleaner production technology, as indicated in the study done by Paramati et al. (2017). In recent times, using global evidence, Pham et al. (2025) suggest that FDI inflows are significant contributors towards increased levels of carbon emissions in the global economy. Moreover, low and middle-income countries are more adversely affected. However, institutional factors, financial development, and technology have a two-edged effect on the economy. They are beneficial in the case of growth but contribute to increased levels of carbon emissions in the absence of proper environmental regulations. Similarly, in the case of the Indian economy, Tripathy et al. (2025) suggest that IFDI is related with increased levels of carbon emissions in the economy. However, this relationship is established through indirect mediating factors and not directly. These contradictory views lead us to propose the following hypotheses:

- H2a: There is a positive relationship between IFDI and carbon emissions in high-income countries.
- H2b: There is a positive relationship between IFDI and carbon emissions in upper-middle-income countries.

2.2.3. Outward Foreign Direct Investment and CO_2 Emissions

Outward foreign direct investment (OFDI) from high-income countries often involves relocating pollution-intensive production activities to nations with comparatively weaker environmental regulations. This may raise global carbon emissions, an aspect that is normally termed as carbon leakage. As indicated in the empirical evidence provided by Paramasivan et al. (2022), developed nations may externalize environmental degradation through outward investment, where the pollution in the home country is exported to the foreign country. The domestic emission-reducing effect of OFDI in developed nations was recently investigated by Abozriba and Khalifa (2026). They find that OFDI is related to higher carbon emissions in the home country in the short and medium terms, implying that the carbon leakage mechanism may operate.

In the upper-middle-income countries, the relationship between OFDI and carbon emissions is shaped by distinct structural dynamics. As these countries slowly transition towards becoming capital exporters, OFDI are matched with increased domestic industrial activities instead of the transfer of pollution-intensive industries, which leads to increased domestic emissions (Nathaniel et al., 2021; Wu & Wang, 2023). Recently, Nguyen and Duong (2025) find asymmetric effects of FDI inflows on carbon emissions, where positive FDI shocks lead to higher emissions while negative shocks have no significant impact, pointing to the importance of directional asymmetries in FDI-emissions relationships in developing countries. Drawing on these arguments, we propose the following hypotheses:

- H3a: There is a negative relationship between OFDI and carbon emissions in high-income countries.
- H3b: There is a negative relationship between OFDI and carbon emissions in upper-middle-income countries.

2.2.4. Industrialization and CO_2 Emissions

Industrialization is a major driver of carbon emissions in high-income countries, as industrial expansion involves significant energy consumption and the burning of fossil fuels. In these countries, industrial activity remains a significant contributor to carbon footprints (Parveen et al. 2023). Grossman and Krueger (1995) explain this issue through the scale effect, stating that economic activities that increase productivity led to an increase in pollution in the absence of composition and technique effects overwhelming it. Based on a study of 40 Sub-Saharan African countries, Ibrahim and Law (2016) state that higher institutional quality reduces carbon emissions, demonstrating the essential role of effective regulations to mitigate pollution from trade openness. Musa et al. (2024) confirms that industrialization and FDI exert adverse effects on short-term carbon emissions, with causal linkages persisting across short, medium, and long-term, reinforcing the view that industrialization-driven emissions are a structural challenge for developing economies at earlier stages of transformation. Building on these arguments, we propose the following hypotheses:

- H4a: There is a positive relationship between industrialization and carbon emissions in high-income countries.
- H4b: There is a positive relationship between industrialization and carbon emissions in upper-middle-income countries.

Figure 1 displays the research framework.

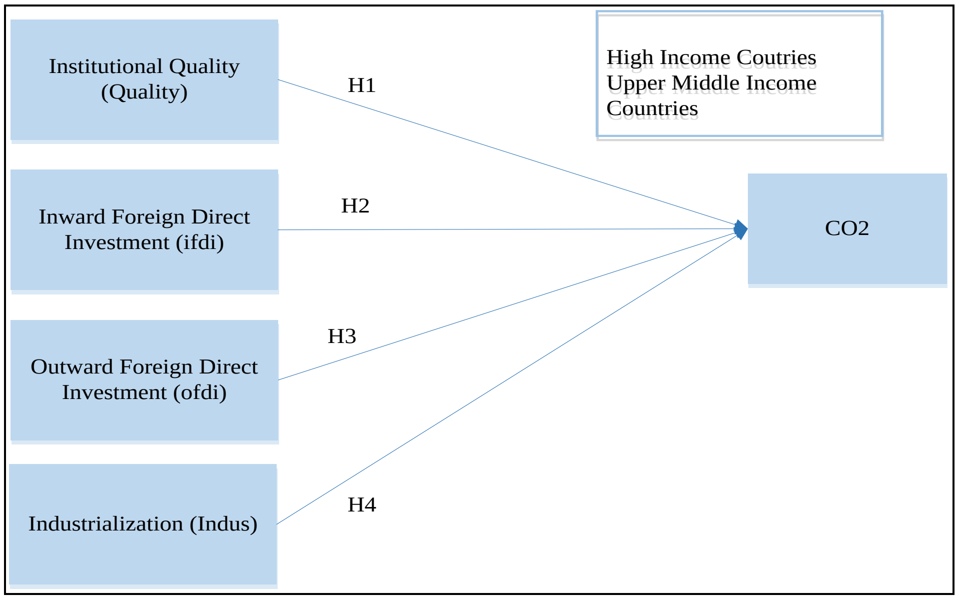

Figure 1: The Conceptual Framework

3. Research Methodology

3.1. Data Sample

In this study, we used secondary data obtained from the World Development Indicators (WDI), United Nation Development Program, and Emissions Database for Global Atmospheric Research. Our sample consists of 48 high-income countries and 37 upper-middle-income countries identified by World Bank classification (World Bank, 2024). Our timeframe covers the years of 2002 to 2022. The list of the countries is provided in Table 1A in Appendix. Countries are categorized based on their development level measured by Gross National Income (GNI) per capita. Countries having a per capita income of USD 4,086 to USD 12,615 fall into the upper middle-income, while countries having a per capita income of more than USD 12,615 fall into the high-income.

3.2. Variables

We use carbon emissions as a dependent variable, and IFDI, OFDI, industrialization, and institutional quality as independent variables. The definition and measurement of the variables are given in Table 1.

3.2.1. Dependent Variable

Carbon emission (CO_2) is measured in metric tons per capita from the Emissions Database for Global Atmospheric Research (EDGAR).

3.2.2. Independent Variables

IFDI is measured by using FDI inflows as a percentage of GDP, while OFDI is calculated by using FDI outflows as a percentage of GDP.

Institutional quality (Quality) is derived from the compilation of six factors that define the essence of good governance: control of corruption, government effectiveness, political stability, and regulatory quality, rule of law, and voice and accountability. These factors are compiled into one variable by applying the factor analysis process. Prior to factor extraction, the reliability and adequacy of the data were checked. The Cronbach's alpha coefficient for the six governance indicators is 0.965. Additionally, the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy is 0.91, suggesting that the data are highly suitable for factor analysis. Bartlett's test of sphericity further confirms the appropriateness of the factor model ($\chi^2 = 27.350.71$, df = 15, $p < 0.001$), rejecting the null hypothesis that the correlation matrix is an identity matrix.

The factor analysis results reveal that all governance indicators load strongly on a single factor, with factor loadings ranging from 0.765 to 0.983. The extracted factor explains approximately 82.8% of the total variance. Based on these findings, a one-factor solution is retained, and the factor scores obtained using the principal component method are used to construct the institutional quality.

Industrialization (Indus) is calculated by using industry value added as a percentage of GDP.

Table 1: The definitions and measurements of the variables

Variables	Abbreviation	Definition	Source
Carbon emissions	CO_2	Metric tons per capita	EDGAR
Inward FDI	IFDI	Inflows as a percentage of GDP	WDI
Outward FDI	OFDI	Outflows as a percentage of GDP	WDI
Institutional quality	Quality	Voice and Accountability Rule of Law Regulatory Quality Political Stability Government Effectiveness Control of Corruption	WDI
Industrialization	Indus	Industry value added as a percentage of GDP	WDI

3.3. Methodology

In this study, we employed the QMG estimator developed by Harding et al. (2020), which is the quantile extension of Pesaran's (2006) CCEMG estimator. Guloglu et al. (2023) examined the effects of LCF on different variables in 26 OECD countries using the static QMG estimator. Quantile regression was first introduced by Koenker and Bassett (1978) as an alternative to traditional regression techniques. In panel context, many approaches exist, including the approach of Koenker (2004) in which he develops a panel quantile estimator with fixed effects. Harding and Lamarche (2014) introduced a quantile estimator that includes interactive effects for a static panel. Recently, Machado and Silva (2019) introduced a new methodology named the method of moments quantile regression with fixed effect, to address the heterogeneity between individuals in a panel. Unlike the OLS, quantile regression offers several advantages. First, quantile regression is less affected by the extreme outliers and does not assume normality. Another advantage is that it enables us to estimate the effects of IFDI, OFDI, industrialization, and institutional quality at different points of carbon emissions. This provides a picture of the effects of IFDI, OFDI, industrialization, and institutional quality at low, moderate, and high levels of emissions.

In addition to distributional heterogeneity, QMG estimator accounts for slope heterogeneity and cross-section dependency. As reported by Pesaran (2006), biased estimates could result from neglecting cross-section dependency. For example, the mean group (MG) estimator developed by Pesaran and Smith (1995) assumes slope heterogeneity, but it ignores CSD. The above-mentioned features make the QMG estimator a robust and appropriate choice for the heterogeneous, cross-sectionally dependent panel structure. However, QMG does not address endogeneity directly. Therefore, we employed a system two-step GMM as a robustness check.

Drawing on theoretical background, to explain the interplay between IFDI, OFDI, industrialization, institutional quality, and CO_2 emission, the model can be described by Equation (1):

$$CO_{2\ it} = \alpha_0 + \beta_1 IFDI_{it} + \beta_2 OFDI_{it} + \beta_3 Indus_{it} + \beta_4\ Quality_{it} + \varepsilon_{it} \quad (1)$$

Based on the work of Pesaran (2006), Equation (2) is given as:

$$y_{it} = c'_i d_t + H'_i x_{it} + \gamma'_i f_t + \varepsilon_{it} \quad (2)$$

y_{it} denotes the observation for country i at time t, and X_{it} , it is a vector of explanatory variables. d_t represents a vector of common effects, while f_t denotes a vector of unobserved factors, and γ'_i is the factor loading.

Following Harding et al. (2020) and Guloglu et al. (2023), and given the parameters vector as $\theta_i(\tau) = (c_i(\tau), H'_i(\tau), \gamma'_i(\tau))'$, the set of information as $I_{it} = \left(x'_{it}, \theta_i(\tau)', f'_t\right)'$, τ is a quantile that ranges between 0 and 1. However, unlike Harding et al. (2020) which considers a dynamic quantile panel regressions, we use a static panel regression. We multifactor error as conducted by Guloglu et al. (2023). Equation (2) can be approximated by Equation (3), where $\bar{z}_t = (\bar{y}_t, \bar{x}_t')'$:

$$Q_{y_{it}}(\tau|I_{it}) := c_i' d_t(\tau) + H'_i x_{it}(\tau) + \phi' \bar{z}_t(\tau) \quad (3)$$

Hence, our QMG estimator will be given as in Equation (4), where the trimmed mean was calculated instead of the arithmetic mean to reduce the effects of outliers.

$$\hat{Q}(\tau) = \frac{1}{N} \sum_{i=1}^{N} Q_i(\tau) \quad (4)$$

Prior to making estimation, we conducted a structured sequence of diagnostic tests in the following order:

Cross-sectional dependence (CSD) test: We apply the Pesaran (2004; 2015) CD test to detect interdependence among cross-sectional units. Evidence of CSD suggests that countries' carbon emissions or investment behaviors can be influenced by common shocks, thereby justifying the use of second-generation econometric methods.

Slope homogeneity test: This test is utilized to check if slope coefficients are homogeneous across nations. Rejection of the null implies slope parameter heterogeneity.

Unit root tests: We initially examine the stationarity characteristics of variables via second-generation panel unit roots tests that account for specific cross-sectional dependence. These consist of CIPS test (Pesaran, 2007) as well as structural break unit root test (Karavias & Tzavalis, 2014), which is designed to detect possible changes in time series from crises, policy reforms, or other structural adjustments.

Panel cointegration tests: If the variables are ordered as integrated of order, then we proceed to test long-term relationships by applying the Westerlund (2008) panel cointegration test. This test is especially appropriate if the dependent variable is I(1) and independent variables consist of both I(0) and I(1) processes. As a robustness check, the Westerlund (2007) test is also used. The choice between these tests is guided by the outcomes of the slope homogeneity and CSD diagnostics, since ignoring slope heterogeneity and cross-section dependency result in biased results regarding the long–run relationship between the variables.

The high-level integration between countries results in cross section dependence across countries, implying that a shock in one nation has an influence on other nations. Additionally, the presence of CSD implies that there are common shocks and unobserved factors that are included in the error of the regressions (De Hoyos & Sarafidis, 2006). Consequently, this requires the utilization of second-generation panel unit root, co-integration and second-generation panel models (Baia & Kaob, 2006). Traditional panel models such as fixed effects and random effects may result in biased results. The mean group estimator developed by Pesaran and Smith (1995) assumes slope heterogeneity, but it ignores CSD. Hence, it is not a good choice.

QMG Estimator: Finally, the QMG estimator is used to investigate the effects of IFDI, OFDI, industrialization, and institutional quality along the carbon emissions distribution, while taking account cross section dependency and slope heterogeneity. The model is estimated across multiple quantiles ranging from the lower to the upper tails of the distribution (Q0.1–Q0.9, in increments of 0.1), allowing for a comprehensive assessment of how the effects of the explanatory variables vary across different levels of carbon emissions.

Robustness Analysis (System GMM): Although the QMG estimator effectively accounts for cross-sectional dependence and heterogeneity, it does not explicitly address potential endogeneity issues. Therefore, as a robustness check, the two-step System GMM estimator is employed. This approach helps control potential endogeneity arising from reverse causality, omitted variables, and dynamic persistence by using internal instruments. The validity of the instruments is evaluated through the Sargan test, while the Arellano–Bond tests are used to examine first- and second-order serial correlation.

4. Empirical Findings

4.1. Descriptive Statistics and Correlation Matrix

Table 2 reports the summary of the descriptive statistics. The data includes 48 high-income and 37 upper middle-income countries for the years of 2002 to 2022. In high-income countries, the average CO_2 emissions is 9.467 units, with a median of 7.988, suggesting a right-skewed distribution where some countries emit considerably more than the average. Carbon emissions range from 1.379 to 30.908, reflecting substantial heterogeneity in environmental performance across high-income economies. The mean IFDI is 8.604, with a median of 3.24, and values ranging from −394.472 to 449.083. The widespread difference between the mean and median indicates that inward FDI flows are heavily concentrated in few countries. Similarly, outward FDI has a mean of 6.45 and a median of 2.018, with values ranging from −324.53 to 300.421, suggesting that OFDI is unevenly distributed, with some countries being dominant capital exporters. The average industrialization score is 26.085, with a median of 24.133, ranging between 5.989 and 68.187, indicating moderate variation in industrial composition. Institutional quality has a mean of 1.4 and a median of 1.062, with values ranging from −0.411 to 46.536. The exceptionally high skewness (10.212) and kurtosis (110.654) imply that while most high-income countries maintain stable institutional environments, a few exhibit disproportionately high scores. IFDI and OFDI also display heavy-tailed distributions (kurtosis of 82.842 and 49.588, respectively), reinforcing the concentration of FDI flows among a subset of economies.

In upper-middle income countries, the average CO_2 emissions is 4.16, with a median of 3.434, considerably lower than the high-income group, which is consistent with lower levels of industrial output and energy consumption. Carbon emissions range from 0.652 to 16.632, showing less dispersion than in high-income countries. The mean IFDI is 3.995 with a median of 2.945, with values ranging from −37.173 to 55.073. Compared to the high-income group, the narrower range suggests that IFDI is more evenly distributed, though still positively skewed. OFDI has a mean of 0.902 and a median of 0.409, with values ranging from −5.516 to 30.329, indicating that upper-middle-income countries are predominantly FDI recipients rather than significant outward investors. The average industrialization score is 31.34 with a median of 29.249, slightly higher than the high-income group, suggesting that manufacturing remains a large share of economic activity in these economies. Institutional quality averages 0.653, with a notably lower median of −0.506, with values ranging from −1.927 to 55.685. The negative median indicates that more than half of the countries in this group have below-average institutional quality, while few outliers drive the mean upward. OFDI and institutional quality exhibit high skewness (8.172 and 6.252) and kurtosis (82.916 and 40.623), confirming non-normal distributions with heavy tails across this income group.

Additionally, we computed correlation matrix to check the relationships between the variables. Table 3 reports the results. In high-income countries, carbon emissions exhibit a moderate positive correlation with industrialization, while its associations with IFDI, OFDI, and institutional quality remain relatively weak. A similar pattern is observed for the upper-middle-income countries, where most of the pairwise correlations with carbon emissions are low in magnitude. The correlation coefficients are generally below thresholds, suggesting that multicollinearity is not a serious concern. Although the correlation between IFDI and OFDI is relatively high in high-income countries, this does not necessarily indicate a multicollinearity problem.

Table 2: Descriptive Statistics

Variable	Mean	Median	Min	Max	Skewness	Kurtosis
High-Income Level Countries						
CO_2	9.467	7.988	1.379	30.908	1.278	1.172
IFDI	8.604	3.24	-394.472	449.083	4.675	82.842
OFDI	6.45	2.018	-324.53	300.421	3.393	49.588
Indus	26.085	24.133	5.989	68.187	1.431	2.673
Quality	1.4	1.062	-0.411	46.536	10.212	110.654
Upper-Middle-Income Level Countries						
Variable	**Mean**	**Median**	**Min**	**Max**	**Skewness**	**Kurtosis**
CO_2	4.16	3.434	0.652	16.632	1.427	2.035
IFDI	3.995	2.945	-37.173	55.073	3.742	40.041
OFDI	0.902	0.409	-5.516	30.329	8.172	82.916
Indus	31.34	29.249	15.013	66.121	0.952	0.531
Quality	0.653	-0.506	-1.927	55.685	6.252	40.623

Table 3: Correlation Matrix

High-income Countries					
Variables	**CO_2**	**IFDI**	**OFDI**	**Industrialization**	**Quality**
CO_2	-				
IFDI	-0.05	-			
OFDI	0.01	0.82	-		
Industrialization	0.561	-0.13	-0.12	-	
Quality	0.19	-0.01	0.00	0.06	-
Upper-Middle-Income Countries					
CO_2	-				
IFDI	-0.02	-			
OFDI	0.10	0.52	-		
Industrialization	0.17	-0.04	0.30	-	
Quality	0.02	0.02	-0.03	0.11	-

4.2. Regression results

We start the analysis with preliminary diagnostic tests—the unit root test, test for slope homogeneity, and cross-sectional dependence test—and subsequent panel cointegration test results. Diagnostic tests serve as a base for applying the quantile common correlated effects mean group (QMG) estimator so that differential effects at all points along the distribution in CO_2 emissions are taken into consideration. The results are structured with distinct discussions pertaining to low, median, and high quantiles, offering comprehensive insights regarding relationships between IFDI, OFDI, industrialization, institutional quality and carbon emissions. We run the analyses separately for high-income and upper-middle-income countries to ensure that the dynamics pertaining to both groups are reflected. Table 4 presents the results.

The findings for high-income group reveal significant relationship across panel units (CD statistic significant at the 1% level), indicating that countries in the sample are influenced by common shocks or global factors, justifying the application of second-generation econometric techniques. For high-income countries, we confirm the presence of CSD across all variables. This indicates that industrialization, FDI, institutional quality and carbon emissions in a single high-income country influence other country, implying interconnection between income countries. On the other hand, for the upper-middle income group, we fail to reject the null hypothesis for institutional quality, implying that an upper-middle country's institutional quality does not affect other countries. However, countries are interconnected in terms of FDI, industrialization, and carbon emissions. This indicates that an exploration of the impacts of these variables on emissions should consider CSD. The presence of CDS leads us to decide which unit root test should be employed. Overall, the presence of CSD justifies the second-generation unit-root and co-integration tests, not assuming that the errors are uncorrelated (Adeneye et al., 2021).

Table 4: The Results of the Cross-Section Dependency Test

Variables	Statistics (Pearson Test)	
	High Income	Upper-Middle Income
CO_2	46.807***	21.479***
IFDI	19.582***	16.998***
OFDI	18.378***	7.273***
Industrialization	56.031***	30.745***
Institutional Quality	2.584***	-0.283

***$p < 0.01$

Next, test results for slope homogeneity are presented in Table 5. The null hypothesis assuming homogeneous slopes is rejected for both groups and thus, validates that cross-country variation in slope coefficients is statistically significant. Thus, the resulting heterogeneity indicates that it is critical to employ estimation techniques accounting for cross-country differences in estimates of parameters.

Table 5: The Results of the Slope Homogeneity

Models	Statistics
High Income Group	
Delta	7.970***
Adjusted Delta	10.081***
Upper-Middle Income Group	
Delta	7.180***
Adjusted Delta	8.926***

***p < 0.01

In the presence of cross-section dependency, second generation unit-root and cointegration tests should be employed. The Levin and Chu (LCC) test (2002) and Im-Pesaran-Shin (IPS) test (2003) are not appropriate. Therefore, we conducted the CIPS panel unit root test held by Pesaran (2007). The results as presented in Table 6 for high-income countries group, and in Table 7 for upper-middle income countries group. The results of high-income countries show that IFDI, OFDI, and institutional quality are stationary in levels, but CO_2 emissions and industrialization are not stationary. Likewise, from CIPS panel unit root test results for upper-middle income countries group, it is obvious that IFDI, OFDI, and industrialization are also stationary in levels, but CO_2 emissions and institutional quality are not stationary.

Table 6: The Results of CIPS Panel Unit Root Test (High-Income Countries)

Variables	**CIPS (intercept) (Level)**	**CIPS (Intercept +trend) (Level)**	**CIPS (First Difference)**
CO_2	-1.482	-2.223	-4.206 ***
IFDI	-3.074 ***	-3.181 ***	-5.249 ***
OFDI	-3.123***	-3.398***	-5.398 ***
Industrialization	-2.067 **	-1.996	-3.779 ***
Institutional Quality	-1.481	-2.398	-4.316 ***

Notes: ***p<.01,** p<.05, * p<.1

Table 7: The Results of CIPS Panel Unit Root Test (Upper-Middle Income Countries)

Variables	**CIPS (intercept) (Level)**	**CIPS (Intercept +trend) (Level)**	**CIPS (First Difference)**
CO_2	-1.834	-2.351	-4.152***
IFDI	-3.495***	-3.621***	-5.306***
OFDI	-3. 894***	-3.929 ***	-5.480***
Industrialization	-2.11**	-2.505	-4.140 ***
Institutional Quality	-1.801	-2.534	-4.265 ***

Notes: ***$p< 0.01$,** $p< 0.05$, * $p < 0.10$

To supplement the CIPS unit root test, we employed the panel unit root test of Karavias and Tzavalis (2014). The results for high-income group in Table 8 indicate that IFDI, OFDI, and institutional quality remain non- stationary. However, CO_2 emissions and industrialization are stationary. For the upper-middle-income group, the results show that CO_2 emissions, OFDI, and institutional quality are not stationary, whereas IFDI and industrialization remain stationary. Potential variation such as economic recessions or large shifts in policy strengthens the assessment of stability. Although the two tests reveal different outcomes, the overall results show that all the non-stationary variables, in both income groups, become stationary after first difference, implying that they are I(1). Accounting for potential structural breaks such as economic crises or policy changes, this test increases the robustness of stationarity determination.

Table 8: **The Results of Unit Root Test with Structural Breaks**

	High income countries	**Upper middle-income countries**
Variables	Constant with breaks (NB=1)	Constant with breaks (NB=1)
CO_2	-3.8288***	-0.1652
IFDI	-18.5126	-11.7653*
OFDI	-15.1974	-2.2907
Industrialization	-8.3999***	-14.4582***
Institutional Quality	-0.2124	-0.2055

Notes: ***$p<.01$,** $p<.05$, * $p<.1$

In the subsequent phase, the enduring relationship among the variables is evaluated through the panel cointegration tests. The outcomes of the Westerlund (2007) test, as displayed in Table 9, reveal inconclusive evidence regarding cointegration. In the high-income group, the "Pt" statistic rejects the null hypothesis of no cointegration on the panel level, indicating that there is a long-run equilibrium relationship with respect to the entire panel. Similarly, in the upper-middle-income group, partial evidence supports cointegration as the "Pt" statistic rejects the null hypothesis implying that there is no cointegration on the panel level.

H0: All panel time series are unit root processes.

H1: Some or all of the panel time series are stationary processes.

Table 9: The Results of the Co-Integration Tests

Westerlund (2007) This co-integration test is based on Bootstrapped error correction.		
Statistic	**Value**	
	High Income	**Upper-Middle Income**
Gt	-1.323	-1.685
Ga	-1.650	-3.787
Pt	-11.704***	-10.621***
Pa	-1.679	-3.548

Notes: ***p<.01

As the dependent variable is I(1) but the independent variables include I(0) and I(1) variables, this makes it more suitable to apply tests by Westerlund (2008). The results in Table 10 highlight that for both groups, the null hypothesis of no cointegration between variables is rejected, meaning that cointegration between variables exists. The results of DHg also reject the null hypothesis as this statistic is calculated due to the existence of differences in the respective slopes between variables. The results of the cointegration tests show the presence of a long-run relationship between our variables. Hence, this allows us to examine the effect of IFDI, OFDI, Institutional quality, and industrialization on emissions.

Table 10: The Results of Westerlund (2008) Co-Integration Test

Statistic	**Test statistic**	
	High Income	**Upper-Middle Income**
DH_g	11.173***	156.490***

Notes: ***p<.01

Finally, the QMG estimator is employed to capture the heterogeneous effects of IFDI, OFDI, industrialization, and institutional quality across different points of carbon emissions distribution. The results in Table 11 and 12 are reported for low (0.1), median (0.5), and high (0.9) quantiles. In advanced economies, IFDI exhibits a significant adverse impact in lower quantiles, suggesting that capital flows from abroad assist in integrating clean technologies in countries with low carbon emissions. However, at higher quantiles, it exhibits a positive impact that may reflect rising industrialization's scale effect. OFDI exhibits variable impact across quantiles with the highest positive impact being at the median quantile. Industrialization shows that there exists a positive significant correlation in the quantiles, in line with its status being the biggest contributor to CO_2 emissions. Institutional quality indicates that there is a negative relationship, especially in higher quantiles, implying that good institutional frameworks curb the level of carbon emissions in intensive emission zones.

Table 11: The Results of the CCEMG Estimator for the High-Income Countries

Quantiles	$Q_{0.1}$	$Q_{0.2}$	$Q_{0.3}$	$Q_{0.4}$	$Q_{0.5}$	$Q_{0.6}$	$Q_{0.7}$	$Q_{0.8}$	$Q_{0.9}$
Constant	-2.589***	-2.697***	-2.423***	-2.574***	-1.579***	-1.098***	-1.009**	-0.566	-0.098
IFDI	0.016***	0.007***	0.013***	0.007***	0.019***	0.013***	0.015***	0.016***	0.026***
OFDI	-0.002	-0.005	-0.005	-0.005**	-0.007***	-0.019***	-0.018***	-0.028***	-0.04***
INDUS	0.171***	0.168***	0.155***	0.17***	0.176***	0.166***	0.171***	0.185***	0.181***
QUALITY	1.222***	1.041***	0.662***	0.748***	0.646***	0.748***	0.856***	0.853***	0.794***

Significance levels: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 12: The Results of the CCEMG Estimator for the Upper-Middle Income Countries

Quantiles	$Q_{0.1}$	$Q_{0.2}$	$Q_{0.3}$	$Q_{0.4}$	$Q_{0.5}$	$Q_{0.6}$	$Q_{0.7}$	$Q_{0.8}$	$Q_{0.9}$
Constant	-0.367	-1.171	-0.933***	-0.869***	-0.450***	-0.378**	-0.671***	-0.776***	-0.818***
IFDI	-0.012***	-0.006***	0.0006	-0.009***	-0.008***	-0.007***	-0.009***	-0.009***	-0.010***
OFDI	-0.025***	-0.042**	0.0006	0.0297***	0.047***	0.041***	0.101***	0.0841***	0.080***
INDUS	0.040***	0.040***	0.053***	0.0479***	0.048***	0.037***	0.0364***	0.041***	0.040***
QUALITY	-0.112***	-0.051	-0.035	-0.039	-0.119***	-0.112**	-0.045	-0.130***	-0.175***

Significance levels: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

4.3 Robustness Checks

Endogeneity is a common concern in studies examining the relationship between FDI and environmental outcomes. Reverse causality may arise because nations with high levels of carbon emissions may either attract or deter certain types of foreign investment. Moreover, omitted variables such as technological innovation, environmental policy stringency, energy structure, and global economic shocks may simultaneously impact both FDI flows and carbon emissions. Ignoring these factors may lead to biased and inconsistent coefficient estimates.

To assess the robustness of the baseline results, we conducted an additional analysis using the two-step System GMM estimator. Table 13 reports the results. The findings indicate that the lagged carbon emissions is positive and significant for both country groups, indicating strong persistence in carbon emissions over time. The coefficients of IFDI and OFDI remain insignificant in the System GMM estimation, which is consistent with the main findings obtained from the QMC estimator results. Industrialization shows a weak positive effect in upper-middle-income countries, while institutional quality does not exhibit a significant direct impact on CO_2 emissions in the dynamic specification.

The diagnostic tests further confirm the validity of the dynamic panel model. The Sargan test does not reject the null hypothesis of instrument validity, suggesting that the selected instruments are appropriate. The Arellano–Bond serial correlation tests show that the AR(1) statistic is significant, which is expected in first-differenced models. More importantly, the AR(2) test does not reject the null hypothesis of no second-order serial correlation, confirming that the model is correctly specified. Overall, the robustness analysis indicates that the findings obtained by the QMG estimator remain stable when an alternative dynamic panel estimator is employed.

Table 13: The Results of the Two-Step System GMM Estimator

Variables	**High-income countries**	**Upper-middle income countries**
lag(CO_2)	0.996***	0.950***
IFDI	0.0017	0.017
OFDI	-0.0012	-0.024
Industrialization	0.010	0.016*
Quality	-0.0028	-0.0002
AR(1) p-value	0.002	0.018
AR(2) p-value	0.066	0.834
Sargan test p-value	1.000	1.000

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

5. Discussion and Conclusion

The results in Table 11 have significant implications since it provides useful insights on the linkage between FDI, industrialization, institutional quality, and carbon emission within the context of high-income countries. The FDI coefficients are high and positive in all the quantiles with values ranging from 0.007 in the second quantile to 0.026 in the ninth quantile. This pattern is harmonious with the Pollution Haven Hypothesis from the recipient's side — even in the high-income group, countries with greater industrial intensity and higher baseline emissions attract FDI that further fuels energy-intensive production rather than displacing it with cleaner alternatives. In other words, IFDI in high-income countries seems to reinforce existing emission-intensive structures rather than triggering a structural shift toward green production. This finding aligns with prior studies (Kar, 2022; Pham et al., 2025), showing that higher institutional quality and technological innovation can paradoxically amplify the FDI-emissions link by facilitating greater economic activity and energy use. It boosts energy-intensive sectors, leading to higher carbon emissions in high-income countries. The results are consistent with the findings of prior studies (Kayani et al., 2023; Li & Lin, 2023). The magnitude effect is more pronounced for higher quantiles of emissions, as countries that generate more carbon emissions are more prone to environmental damage due to FDI (Shahbaz et al., 2015).

The OFDI results tell a different story. They indicate that the coefficients are more inclined to display negative values with respect to most quantiles, particularly from the fourth quantile onwards (-0.005 to -0.04). This finding corroborates the hypothesis that industrially advanced countries tend to relocate harmful activities to other countries through overseas investment, and these activities reduce harmful emissions in their countries. This is in line with the findings of prior studies (Lin & He, 2023). The Pollution Haven Hypothesis argues that the increase in FDI flow from industrially advanced nations to developing countries result in higher carbon emissions in these countries since emerging markets are viewed as pollution havens due to lenient environment laws.

Industrialization (INDUS) records strong positive effects across all quantiles with coefficients ranging from 0.155 to 0.185. These results are underscored by the general presupposition about high-income nations as post-industrial economies. The uniform positive connection implies that dominant industrial activity in these countries remains large carbon emission contributors (Parveen et al. 2023). Middle-income countries usually make massive structural adjustments to get closer to industrialized economies (Sohag et al. 2017). However, our results unveil industrialized nations having large industrial activities carbon footprints.

The institutional quality (QUALITY) has positive coefficients across all quantiles ranging from 0.646 to 1.222. This finding contradicts with the general belief that institutional quality would translate into environmental protection. Recent studies have identified complex institutional quality-environmental relationships across different levels of development (Abid et al. 2022; Zhang et al. 2022). The positive sign implies that high-income countries with strong institutional settings have high consumption rates and energy-intense lifestyles, eroding environmental performance (Yang et al., 2022).

The results in Table 12 for the upper-middle-income countries present remarkable variation from high-income nations due to the different development paths of economic growth and the complexities involved in environment. In most of the quantiles, the IFDI coefficients have negative values. The coefficients range from -0.012 from the first quantile to -0.010

of the second quantile. The mechanism underlying this pattern is most plausibly the technology transfer channel: multinational companies entering upper-middle-income countries typically bring cleaner production technologies, energy-efficient equipment, and superior environmental management systems compared to the carbon-intensive local industrial plants they displace or compete alongside. In this way, IFDI acts as a vehicle of environmental modernization — upgrading the production frontier of the host country and reducing its overall emission intensity even as it expands economic activity. This interpretation aligns with the findings of Jinapor et al. (2024), indicating that stronger institutional quality amplifies the emission-reducing potential of IFDI in developing economies, and with the findings of Tripathy et al. (2025), demonstrating that FDI affects emissions primarily through structural and technological mediating channels rather than through direct scale expansion. The negative association implies that FDI for the upper-middle-income economies may bring an end to the diffusion of knowledge as well as that of environmentally friendly practices, thereby entrenching the pollution halo effect (Nguyen-Thanh et al., 2022). FDI and green technologies relationship reveals positive indications towards enhancing the quality of environment (Shahzad et al., 2021). This holds true across the developing economies.

The OFDI coefficient in the upper-middle income countries ranges from -0.025 to 0.08. Specifically, after the fourth quantile, it becomes positive and significant, implying that as these nations become capital-exporting, OFDI have an accelerating impact on domestic emissions due to institutional abilities and their share in global value chain. This corroborates the findings of prior studies (Nathaniel et al., 2021; Wu and Wang, 2023). This apparently paradoxical results (negative and significant at lower quantiles while positive and significant from fourth quantile to ninth) can be explained by the structural characteristics of upper-middle-income countries at this stage of development: unlike high-income economies where OFDI reflects the export of pollution-intensive industries, OFDI from upper-middle-income countries are accompanied by intensified domestic industrial activity, as companies expand their global value chain participation while simultaneously scaling up home-country production capacity (Nathaniel et al., 2021; Wu & Wang, 2023). In other words, outward investment at this income level reflects industrial deepening rather than industrial relocation — countries become more embedded in global production networks without shedding their domestic emission-intensive base, resulting in a net increase in emissions that is strongest among the highest-emitting countries in this group. In the upper middle-income countries, the effects of industrialization are positive but at a lower magnitude than high-income nations with coefficients ranging from 0.0364 to 0.053. One potential explanation is that upper middle-income nations undergo intensive structural upgrades to catch industrialized nations (Sohag et al. 2017).

The institutional quality produces ambiguous findings in the upper middle-income countries with most of the data producing negative coefficients in the higher quantiles, such as -0.175 in nine quantiles. This is in line with the theory that asserts that institutional quality and governance have a significant impact on reducing emissions in these countries

(Nair et al., 2021). The robustness of the institutional framework helps to mitigate any negative effects of other factors on environmental conditions (Rahman et al., 2023). Our findings support the theory that asserts that institutional quality positively impacts environmental conditions in emerging markets.

The coexistence of the Pollution Haven effect (from the view of high-income capital exporters) and the Pollution Halo effect (from the view of upper-middle-income capital recipients) may appear contradictory at first glance, yet the two are not mutually exclusive — rather, they operate through different mechanisms simultaneously. While high-income countries relocate pollution-intensive production abroad through OFDI, what happens in upper-middle-income host countries is not simply dirty industry in isolation, but a package of foreign capital that also carries advanced managerial practices, cleaner production technologies, and efficiency standards embedded in multinational operations. Therefore, the critical question is not whether polluting industries relocate, but whether the technology transfer and knowledge spillover effects accompanying IFDI — the Halo mechanism — outweigh the pollution-intensifying scale effects of relocated industries — the Haven mechanism.

The evidence in this study suggests that in upper-middle-income countries, the Halo effect dominates: the net impact of IFDI on CO2 emissions is negative, indicating that the modernization and efficiency gains brought by FDI more than offset the environmental costs of any pollution-intensive activities that relocate. This is in line with the findings of Tripathy et al. (2025), showing that FDI affects emissions predominantly through structural mediating channels such as industrial composition and technology adoption rather than through direct scale expansion, and with the results of Jinapor et al. (2024), identifying that strong institutional framework amplifies the emission-reducing potential of IFDI in developing economies. In other words, what determines whether a country experiences the Haven or the Halo outcome is not simply the industry that it enters, but the institutional capacity of the host country to absorb, regulate, and redirect foreign capital toward cleaner pathways.

5.1 Conclusion

The purpose of this study is to examine the impact of institutional quality, foreign direct investment, and industrialization on carbon emissions in high-income and upper-middle-income countries from 2002 to 2022. The impact of FDI on the environment cannot be completely analyzed without considering the developmental conditions. Evidence from high-income countries shows a persistent positive relationship between inward FDI and carbon emissions, challenging the conventional assumption that post-industrial economies lead to environmental sustainability. Instead, the findings suggest that high-income countries have continued to increase emissions, largely due to the carbon-intensive nature of capital-driven economic activities. The negative relationship in upper-middle-income countries supports the pollution halo hypothesis, suggesting that FDI can contribute to improved environmental outcomes. This finding indicates that technology transfer and knowledge spillovers associated with FDI may serve as channels for enhancing environmental quality in emerging markets

The results concerning governance quality in high-income countries, i.e. the positive impact of institutional quality on carbon emissions, reflect an intricate interplay between institutional framework and carbon emissions. The positive relationship suggests that institutions are likely to encourage consumption- and energy-intensive lifestyles that may undermine environmental performance. The negative impact of institutional quality on pollution in upper-middle-income countries highlights the role of good governance in ensuring environmental protection in every stage of development. This is an important outcome for companies and policymakers.

5.2. Implications of the Study

The results of this study have important implications for companies and policymakers. The divergent effects of FDI on carbon emissions in different socioeconomic groups should lead companies to ensure that international environmental policy should be shaped by cultural realities. The positive significant relationship between carbon emissions and FDI call for change in business models adopted by multinational companies in high-income countries. The increase in emission quantiles and the intensification of the environmental impact caused by the traditional growth approach increase carbon emissions in highly polluting countries. Therefore, in expanding the operations to new countries, companies should investigate green technology and carbon-neutral models with integrated environmental impact analysis.

Institutional investors must assess FDI considering its diverse environmental implications in developing countries. Quantile-specific emission implications must be integrated into risk assessment models to avoid fallacies about the implications derived from the quality of institutions in every income group. To leverage the environmental benefits of overseas investment, multinational companies must collaborate with the high-income countries governments of countries to develop a carbon pricing mechanism and incentives for clean technology adoption. Simultaneously, institutional strengthening in upper-middle income countries is essential. Together, these approaches ensure corporate environment accountability while positioning companies to capitalize on the ongoing transformation of the global economy.

5.3. Limitations and Future Research Avenues

The study has some limitations that suggest scope for future research in the area. First, even though the cross-country analysis provides an idea of the general trends, it does not provide the necessary details to understand firms' behavioral changes in response to FDI inflows. One way to overcome this issue would be to use firm-level data to get a more refined impact of FDI inflows on businesses, and environment. Second, the study shows that the quantile regression model relies on group-wise variation in FDI inflows to estimate their impact on carbon emissions. However, the model fails to account for time-varying country-specific factors related to FDI inflows and carbon emissions. Future research should use natural experiments, e.g., policy changes, trade agreements, etc., to obtain more reliable results. Third, the study did not use any control variables to examine the research questions. Future research should use control variables such as GDP, environmental stringency, green innovations, etc., to obtain more reliable results. Finally, the study considers only national-level CO2 emissions, whereas the impact of FDI inflows on sectoral emissions across different country groups warrants further exploration.

Research Funding

The authors received no research grant or support for this research study.

Availability of Data

The dataset is available from the corresponding author upon reasonable request.

Declaration of AI Use

We have used AI software to rephrase some of the paragraphs in the Literature Review and Discussions sections to a limited extent. No AI tool was used to generate ideas, data analysis, empirical results, or interpretations, etc.

REFERENCES

Abdullahi, A. D. U. S., Ibrahim, S., Saini, W. N. W. A., & Law, S. H. (2023). Foreign direct investment and its impact on CO_2 emissions at various levels of economic development. *International Journal of Economics and Management, 17*(3), 293-303. https://doi.org/10.47836/ijeam.17.3.01

Abid, M. (2016). Impact of economic, financial, and institutional factors on CO_2 emissions: Evidence from Sub-Saharan Africa economies. *Utilities Policy, 41*, 85-94. https://doi.org/10.1016/j.jup.2016.06.009

Abid, M. Y., Khan, M. T., & Rehman, H. ur. (2022). Does institutional quality improve environmental quality? New evidence from NARDL approach. *Review of Economics and Development Studies, 8*(2), 439. https://doi.org/10.47067/reads.v8i2.439

Abozriba, A. S., & Khalifa, W. M. (2026). Unveiling the connection between outward foreign direct investment and environmental quality in Turkey: A frequency domain causality analysis. *Sustainability, 18*(3), 1189. https://doi.org/10.3390/su18031189

Adeneye, Y. B., Jaaffar, A. H., Ooi, C. A., & Ooi, S. K. (2021). Nexus between carbon emissions, energy consumption, urbanization and economic growth in Asia: Evidence from common correlated effects mean group estimator (CCEMG). *Frontiers in Energy Research, 8,* 610577. https://doi.org/10.3389/fenrg.2020.610577

Alshubiri, F., & Elheddad, M. (2020). Foreign finance, economic growth and CO_2 emissions nexus in OECD countries. *International Journal of Climate Change Strategies and Management, 12*(2), 161-181. https://doi.org/10.1108/IJCCSM-12-2018-0082

Baia, J., & Kaob, C. (2006). On the estimation and inference of a panel cointegration model with cross-sectional dependence. Contributions to Economic Analysis. In: Panel Data Econometrics Theoretical Contributions and Empirical Applications, pages 3-30, Emerald Group Publishing Limited. https://doi.org/10.1016/S0573-8555(06)74001-9

Balsalobre-Lorente, D., Gokmenoglu, K. K., Taspinar, N., & Cantos-Cantos, J. M. (2019). An approach to the pollution haven and pollution halo hypotheses in MINT countries. *Environmental Science and Pollution Research*, *26*(22), 23010-23026. https://doi.org/10.1007/s11356-019-05446-x

Balsalobre-Lorente, D., Ibáñez-Luzón, L., Usman, M., & Shahbaz, M. (2022). The environmental Kuznets curve, based on the economic complexity, and the pollution haven hypothesis in PIIGS countries. Renewable Energy, 185, 1441-1455. https://doi.org/10.1016/j.renene.2021.10.059

Bommer, R. (1999). Environmental policy and industrial competitiveness: The pollution-haven hypothesis reconsidered. *Review of International Economics, 7*(2), 342-355. https://doi.org/10.1111/1467-9396.00168

Brinkley, C. (2014). Decoupled: Successful planning policies in countries that have reduced per capita greenhouse gas emissions with continued economic growth. *Environment and Planning C: Politics and Space*, *32*(6), 1083-1099. https://doi.org/10.1068/c12202

De Hoyos, R. E., & Sarafidis, V. (2006). Testing for cross-sectional dependence in panel-data models. *The Stata Journal*, 6(4), 482-496. https://doi.org/10.1177/1536867X0600600403

Destek, M. A., & Okumus, I. (2019). Does pollution haven hypothesis hold in newly industrialized countries? Evidence from ecological footprint. *Environmental Science and Pollution Research*, *26*(23), 23689-23695. https://doi.org/10.1007/s11356-019-05614-z

Dufrenot, G., Mignon, V., & Tsangarides, C. (2010). The trade-growth nexus in the developing countries: A quantile regression approach. *Review of World Economics, 146*(4), 731-761. https://doi.org/10.1007/s10290-010-0067-5

Godil, D. I., Sharif, A., Agha, H., & Jermsittiparsert, K. (2020). The dynamic nonlinear influence of ICT, financial development, and institutional quality on CO_2 emission in

Pakistan: New insights from QARDL approach. *Environmental Science and Pollution Research*, *27*(19), 24190-24200. https://doi.org/10.1007/s11356-020-08619-1

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *The Quarterly Journal of Economics, 110*(2), 353-377. https://doi.org/10.2307/2118443

Guloglu, B., Caglar, A. E., & Pata, U. K. (2023). Analyzing the determinants of the load capacity factor in OECD countries: evidence from advanced quantile panel data methods. *Gondwana Research, 118*, 92-104. https://doi.org/10.1016/j.gr.2023.02.013

Haldar, A., & Sethi, N. (2021). Effect of institutional quality and renewable energy consumption on CO_2 emissions-An empirical investigation for developing countries. *Environmental Science and Pollution Research, 28*(12), 15485-15503. https://doi.org/10.1007/s11356-020-11532-2

Han, H. (2019). Governance for green urbanisation: Lessons from Singapore's green building certification scheme. Environment and Planning C: Politics and Space, 37(1), 137-156. https://doi.org/10.1177/2399654418778596

Harding, M., & Lamarche, C. (2014). Estimating and testing a quantile regression model with interactive effects. *Journal of Econometrics, 178*, 101-113. https://doi.org/10.1016/j.jeconom.2013.08.010

Harding, M., Lamarche, C., & Pesaran, M. H. (2020). Common correlated effects estimation of heterogeneous dynamic panel quantile regression models. *Journal of Applied Econometrics, 35*(3), 294-314. https://doi.org/10.1002/jae.2753

Ibrahim, M. H., & Law, S. H. (2016). Institutional quality and CO_2 emission-Trade relations: Evidence from Sub-Saharan Africa. *South African Journal of Economics, 84*(2), 323-340. https://doi.org/10.1111/saje.12095

Jinapor, J. A., Abor, J. Y., & Graham, M. (2024). FDI, industrialisation and environmental quality in SSA-the role of institutional quality towards environmental sustainability. *Humanities and Social Sciences Communications, 11*(1), 1-15. https://doi.org/10.1057/s41599-024-04000-6

Kar, A. K. (2022). Environmental Kuznets curve for CO2 emissions in Baltic countries: an empirical investigation. *Environmental Science and Pollution Research, 29(*31), 47189-47208. https://doi.org/10.1007/s11356-022-19103-3

Karavias, Y., & Tzavalis, E. (2014). Testing for unit roots in short panels allowing for a structural break. *Computational Statistics & Data Analysis, 76*, 391-407. https://doi.org/10.1016/j.csda.2012.10.014

Kayani, U. N., Sadiq, M., Aysan, A. F., Haider, S. A., & Nasim, I. (2023). The impact of investment, economic growth, renewable energy, urbanisation, and tourism on carbon emissions: Global evidence. *International Journal of Energy Economics and Policy, 13*(2), 1-12. https://doi.org/10.32479/ijeep.14042

Koenker, R., & Bassett, G., Jr. (1978). Regression quantiles. *Econometrica, 46*(1), 33-50. https://doi.org/10.2307/1913643

Koenker, R. (2004). Quantile regression for longitudinal data. *Journal of Multivariate Analysis, 91*(1), 74-89. https://doi.org/10.1016/j.jmva.2004.05.006

Kutlu Furtuna, O., & Atis, S. (2024). Does foreign direct investment affect environmental degradation: Evidence from largest carbon intense countries. *PLOS ONE, 19*(11), e0314232. https://doi.org/10.1371/journal.pone.0314232

Li, J., & Lin, B. (2023). Reexamining the impact of foreign direct investment on carbon emissions: Does per capita GDP matter? *Humanities and Social Sciences Communications, 10*(1), 403. https://doi.org/10.1057/s41599-023-01895-5

Lin, X., & He, L.-Y. (2023). 'Going global' and pollution in home country: Evidence from Chinese industrial firms. *Economics of Transition and Institutional Change, 31*(1), 123-145. https://doi.org/10.1111/ecot.12370

Machado, J. A., & Silva, J. S. (2019). Quantiles via moments. *Journal of Econometrics, 213*(1), 145-173. https://doi.org/10.1016/j.jeconom.2019.04.009

Mani, M., & Wheeler, D. (1998). In search of pollution havens? Dirty industry in the world economy, 1960 to 1995. *Journal of Environment & Development, 7*(3), 215-247. https://doi.org/10.1177/107049659800700302

Mert, M., & Caglar, A. E. (2020). Testing pollution haven and pollution halo hypotheses for Turkey: A new perspective. *Environmental Science and Pollution Research, 27*(26), 32933-32943. https://doi.org/10.1007/s11356-020-09469-7

Yang, B., Ali, M., Hashmi, S. H., & Jahanger, A. (2022). Do income inequality and institutional quality affect CO2 emissions in developing economies?. *Environmental Science and Pollution Research, 29*(28), 42720-42741. https://doi.org/10.1007/s11356-021-18278-5

Musa, M., Gao, Y., Rahman, P., Albattat, A., Ali, M. A. S., & Saha, S. K. (2024). Sustainable development challenges in Bangladesh: An empirical study of economic growth, industrialization, energy consumption, foreign investment, and carbon emissions-using dynamic ARDL model and frequency domain causality approach. *Clean Technologies and Environmental Policy, 26*(6), 1799-1823. https://doi.org/10.1007/s10098-023-02680-3

Nair, M., Arvin, M. B., Pradhan, R. P., & Bahmani, S. (2021). Is higher economic growth possible through better institutional quality and a lower carbon footprint? Evidence from developing countries. *Renewable Energy, 162*, 1784-1796. https://doi.org/10.1016/j.renene.2020.11.056

Nathaniel, S. P., Yalçiner, K., & Bekun, F. V. (2021). Assessing the environmental sustainability corridor: Linking natural resources, renewable energy, human capital, and ecological footprint in BRICS. *Resources Policy*, *70*, 101924. https://doi.org/10.1016/j.resourpol.2020.101924

Neves, S. A., Marques, A. C., & Patrício, M. (2020). Determinants of CO_2 emissions in European Union countries: Does environmental regulation reduce environmental pollution? *Economic Analysis and Policy*, *68*, 114-125. https://doi.org/10.1016/j.eap.2020.09.005

Nguyen, T. P., & Duong, T. T. T. (2025). Asymmetric effects of fiscal policy and foreign direct investment inflows on CO_2 emissions-an application of nonlinear ARDL. *Sustainability*, *17*(6), 2503. https://doi.org/10.3390/su17062503

Nguyen-Thanh, N., Chin, K.-H., & Nguyen, V. T. (2022). Does the pollution halo hypothesis exist in this "better" world? The evidence from STIRPAT model. *Environmental Science and Pollution Research*, *29*(35), 53158-53172. https://doi.org/10.1007/s11356-022-21654-4

Niemeier, D., Grattet, R., & Beamish, T. (2015). Blueprinting and climate change: Regional governance and civic participation in land use and transportation planning. Environment and Planning C: Government and Policy, 33(6), 1600-1617. https://doi.org/10.1177/0263774X15614181

Paramati, S. R., Mo, D., & Gupta, R. (2017). The effects of stock market growth and renewable energy use on CO_2 emissions: Evidence from G20 countries. *Energy Economics*, *66*, 360-371. https://doi.org/10.1016/j.eneco.2017.06.025

Paramasivan, M., Kumar, N. S., & Jothimani, S. (2022). Do greater amounts of FDI cause higher pollution levels? Evidence from OECD countries. *Journal of Policy Modeling*, *44*(1), 147-169. https://doi.org/10.1016/j.jpolmod.2021.10.004

Parveen, S., Khan, S., Kamal, M. A., Abbas, M. A., Syed, A. A., & Grima, S. (2023). The influence of industrial output, financial development, and renewable and non-renewable energy on environmental degradation in newly industrialized countries. *Sustainability*, *15(*6), 4742. https://doi.org/10.3390/su15064742

Pesaran, M. H. (2004). General diagnostic tests for cross-sectional dependence in panels (Cambridge Working Papers in Economics No. 435). University of Cambridge.

Pesaran, M. H. (2006). Estimation and inference in large heterogeneous panels with a multifactor error structure. *Econometrica*, *74*(4), 967-1012. https://doi.org/10.1111/j.1468-0262.2006.00692.x

Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics*, *22*(2), 265-312. https://doi.org/10.1002/jae.951

Peseran, M. H., & Smith, R. (1995). Estimating long-run relationships from dynamic heterogeneous panels. *Journal of Econometrics*, *68*, 79-113. https://doi.org/10.1016/0304-4076(94)01644-F

Pham, P. M., Nguyen, T. D., Nguyen, M., & Tran, N. T. (2025). FDI inflows and carbon emissions: New global evidence. Discover *Sustainability*, *6*(1), 432. https://doi.org/10.1007/s43621-025-01292-9

Phuc Nguyen, C., Ai Nguyen, N., Schinckus, C., & Dinh Su, T. (2018). The ambivalent role of institutions in the CO_2 emissions: The case of emerging countries. *International Journal of Energy Economics and Policy, 8*(5), 7-17. http://hdl.handle.net/11159/2609

Rahman, M. M., Nepal, R., & Alam, K. (2023). Does institutional quality influence the relationship between urbanization and CO_2 emissions? *PLOS ONE, 18(*10), e0291930. https://doi.org/10.1371/journal.pone.0291930

Salman, M., Long, X., Dauda, L., & Mensah, C. N. (2019). The impact of institutional quality on economic growth and carbon emissions: Evidence from Indonesia, South Korea, and Thailand. *Journal of Cleaner Production*, *241*, 118331. https://doi.org/10.1016/j.jclepro.2019.118331

Sapkota, P., & Bastola, U. (2017). Foreign direct investment, income, and environmental pollution in developing countries: Panel data analysis of Latin America. *Energy Economics*, *64*, 206-212. https://doi.org/10.1016/j.eneco.2017.04.001

Shahbaz, M., Nasreen, S., Abbas, F., & Anis, O. (2015). Does foreign direct investment impede environmental quality in high-, middle-, and low-income countries? *Energy Economics*, *51*, 275-287. https://doi.org/10.1016/j.eneco.2015.06.014

Shahzad, U., Lv, Y., Doğan, B., & Xia, W. (2021). The impacts of FDI inflows on carbon emissions: Economic development and regulatory quality as moderators. *Frontiers in Energy Research*, *9*, 820596. https://doi.org/10.3389/fenrg.2021.820596

Singhania, M., & Saini, N. (2021). Demystifying pollution haven hypothesis: Role of FDI. *Journal of Business Research*, *123*, 516-528. https://doi.org/10.1016/j.jbusres.2020.10.007

Tripathy, P., Brahmi, M., Pallayil, B., & Mishra, B. R. (2025). Mediating effects of foreign direct investment inflows on carbon dioxide emissions. *Economies*, *13*(1), 18. https://doi.org/10.3390/economies13010018

Westerlund, J. (2007). Testing for error correction in panel data. *Oxford Bulletin of Economics and Statistics*, *69*(6), 709-748. https://doi.org/10.1111/j.1468-0084.2007.00477.x

Westerlund, J. (2008). Panel cointegration tests of the Fisher effect. *Journal of Applied Econometrics*, *23*(2), 193-233. https://doi.org/10.1002/jae.967

World Bank. (2024). World Bank country classifications by income level for 2024-2025. https://blogs.worldbank.org/en/opendata/world-bank-country-classifications-by-income-level-for-2024-2025

Wu, H., & Wang, H. (2023). Will trade protection trigger a surge in investment-related CO_2 emissions? Evidence from multi-regional input-output model. *Sustainability, 15*(13), 10033. https://doi.org/10.3390/su151310033

Xaisongkham, S., & Liu, X. (2024). Institutional quality, employment, FDI and environmental degradation in developing countries: Evidence from the balanced panel GMM estimator. *International Journal of Emerging Markets, 19*(7), 1920-1939. https://doi.org/10.1108/IJOEM-10-2021-1583

Sohag, K., Al Mamun, M., Uddin, G. S., & Ahmed, A. M. (2017). Sectoral output, energy use, and CO2 emission in middle-income countries. Environmental Science and Pollution Research, 24(10), 9754-9764. https://doi.org/10.1007/s11356-017-8599-z

Zhang, H., Wang, P., & Wood, J. (2022). Does institutional quality matter for the nexus between environmental quality and economic growth? *In Environmental Economics and Sustainable Development* (pp. 45-68). Routledge. https://doi.org/10.4324/9781003153580-3

Zhang, Y., Jin, Y., Chevallier, J., & Shen, B. (2016). The effect of corruption on carbon dioxide emissions in APEC countries: A panel quantile regression analysis. *Technological Forecasting and Social Change, 112*, 220-227. https://doi.org/10.1016/j.techfore.2016.05.027

APPENDIX

(Table 1A)

High-Income Countries
Australia, Austria, Bahamas, Bahrain, Belgium, Bulgaria, Canada, Chile, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Oman, Panama, Poland, Portugal, Romania, Saudi Arabia, Singapore, Slovenia, South Korea, Spain, Sweden, Switzerland, Trinidad and Tobago, United Arab Emirates, United Kingdom, United States, Uruguay.
Upper-Middle-Income Countries
Albania, Algeria, Argentina, Azerbaijan, Belarus, Bosnia and Herzegovina, Botswana, Brazil, China, Colombia, Costa Rica, Dominican Republic, El Salvador, Fiji, Gabon, Georgia, Guatemala, Indonesia, Iran, Iraq, Jamaica, Kazakhstan, Malaysia, Mauritius, Mexico, Moldova, Mongolia, Namibia, North Macedonia, Paraguay, Peru, Russia, Serbia, South Africa, Thailand, Türkiye, Ukraine.

Note: Our sample contains 48 high-income countries, where three countries, Kuwait, Qatar, and Guyana were excluded due to missing values. The upper-middle-income sample includes 37 countries, where two countries, Armenia and Libya, were excluded due to missing values.